Adaptive Water Governance and Climate Change Resilience among Rural Communities in Kilosa District, Tanzania

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Research Report 2023/24

Published by:

REPOA
157 Migombani/REPOA Streets, Regent Estate,
P.O. Box 33223
Dar es Salaam.

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Copy-editing & initial layout: Vincent Nalwendela | REPOA

Suggested citation:
Theodory, T.F., Massoi, L (2023). Adaptive Water Governance and Climate Change Resilience among Rural Communities in Kilosa District, Tanzania. REPOA, Dar es Salaam.

Research Report 2023/24

Suggested Keywords:
Climate change, adaptive governance, adaptive water governance, Tanzania.

ISBN 978-9987-753-16-1

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ACKNOWLEDGMENTS

We appreciate the utmost cooperation we received from different people as well as public and private institutions, without forgetting the respondents in the studied wards of Parakuyo and Mabwerebwere. Their cooperation is highly appreciated. We are grateful to REPOA not only for funding this research project, but also for furnishing us with the introduction letter that helped us to acquire the community entry protocol from Kilosa District Council (KDC).

ABSTRACT

While climate change and its associated impacts on water resources continue to take their toll across the globe, rural communities in Tanzania are increasingly facing water-related problems, such as access to clean and safe water as well as water shortage. Effective governance is needed to sustainably respond to changes in water resource availability and to advance community resilience to the impacts of climate change. This study assessed adaptive water governance and climate change resilience among farmers and pastoral communities in Parakuyo and Mabwerebwere Wards, Kilosa District. This study adopted a cross-sectional research design, whereas both qualitative and quantitative data collection methods were applied. About 10% of the total households per selected village were chosen to form the sample size for this study. Thus, 174 households were selected by the researchers for household questionnaires. The results indicate that climate change is not a new phenomenon in the study area. Rural communities have lived with it and observed extreme climatic events such as reduced precipitations, long drought seasons and shifting of seasons, to mention a few. Rural communities in Parakuyo and Mabwerebwere Wards enhance their climate change resilience through adaptive water governance. Adaptive governance operates in such a way that there is great cooperation between actors in governing water resources, which contributes to climate change resilience. This study recommends programmes that focus on capacitating rural communities with climate change knowledge to enhance their resilience to climate change. Furthermore, this study recommends an integration of informal institutions on water resources governance to complement government efforts in managing water resources.

INTRODUCTION

Background Information

Climate change refers to long-term changes in temperatures and weather patterns. These changes can be natural and usually happen through variations in the solar cycle (Cubasch et al., 2013). It greatly impacts livelihoods and, in the extreme, poses significant threats to the survival of humankind (Araya et al., 2015). Among the groups more vulnerable to the impacts of climate change, are rural communities from developing countries (IPCC, 2014; Barbier 2015; Hallegatte et al. 2015). Rural communities in these countries are vulnerable not only to the hazards that cause extreme impact, such as drought, storms and flooding, but also to long-term climatic events, such as reduced precipitation and increases in temperature (Barbier and Hochard, 2018). Severe climate events such as drought, pose greater threats on water resources leading to governance challenges. In recent times, the uncertainties and complexities of climate change and its associated impacts on governance of water resources, are increasingly gaining widespread recognition across the globe, including Tanzania (Kangalawe, 2017; Theodory, 2017; NASA, 2019; Näschen et al., 2019). The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has noted that 93% of the impacts associated with climate change will be felt in the water sector (IPCC, 2014). The anticipated impacts of climate change, coupled with the interactions among the multiple social, ecological and technological components of water resource systems, add to these complexities (Noel, 2011; Massoi, 2015). For example, availability of renewable surface and groundwater resources is significantly decreasing in most arid and semi-arid (ASALs) regions, creating an increase of competition among different water users (MacAlister and Subramanyam, 2018), thus affecting the availability of water resources for different uses (URT, 2007; Massoi, 2015). It is observed that two thirds of major rivers in Tanzania have experienced reduced water flow because of decreasing regional rainfall (URT, 2012). In this context, the concept of climate resilience is increasingly receiving attention in efforts to enhance the adaptive governance of water resources in the face of uncertainties from climate change.

Two dominant strands dominate literature connecting water governance to climate change. These are conventional command and control of water governance paradigms, as well as the adaptive water governance paradigm (Li et al., 2020). The former assumes that the ability to control and predict governance of water resources lies in economic efficiency, dominance of rational-comprehensive planning processes, and top-down institutional mechanisms (Bhadwaal et al., 2018). This assumption overlooked the human dimensions and the need for adaptations (Floress et al. 2015). Adaptive water governance, on the other hand, emphasises the need for adaptation in order to deal with uncertainties in resources governance, even though with less emphasis on the human dimensions (such as stakeholder values, interests and decision-making processes) required for its successful implementation (Walters, 2007).

Thus, ongoing efforts aimed at integrating human dimensions into water management processes and goals have not adequately accounted for the need to adapt to uncertainties, whereas those efforts focused on reducing uncertainties have not considered the human dimensions. We argue that the adaptive governance approach to water resources is the most effective approach to advance community resilience and eventually support the achievements of Sustainable Development Goals (SDGs) 6 and 13, linked to ensuring availability of clean water and take urgent action to climate change, respectively. In this study, we plan to examine the prospects of adaptive governance as a conceptual foundation for adaptive and integrated water resource governance, thereby providing a framework for integrating the human dimensions into the governance of water resources, while simultaneously dealing with anticipated impacts of climate change.

Kilosa District is among the districts in Morogoro Region affected by the impacts of climate change. This has triggered continued human mobility and conflicts between farmers and pastoralists competing for water resources and grazing land. In view of Benjaminen et al. (2009), the conflicts between these groups culminated in the killing of thirty-eight (38) farmers in Rudewa Mbuyuni Village in the year 2000. The Kilosa conflicts are mentioned as the worst conflict between farmers and pastoralists that Tanzania has ever experienced (Msasanuri, 2012). Addressing persistent climate change impacts on water resources in Kilosa District requires effective integration of local communities in water resources governance. This study, therefore, will assess the adaptive water governance used by the rural communities in Kilosa District to enhance their resilience to climate change.

Problem Statement

Water is among those vulnerable resources which are expected to be felt hardest by the impacts of climate change. Few studies in Tanzania have assessed, even partially, the effectiveness of water governance at the local level, which aims to enhance community resilience to climate change (see Kangalawe, 2017; Kassian et al, 2017; Kishiwa et al, 2018). As a result, much of the information concerning how adaptive water governance may contribute to climate change resilience is not well known. In its most basic form, adaptive water governance determines flexible institutions for sharing water across multiple stakeholders from sources whose stock and/or flow may vary over time. The proposed project therefore sheds light and documents effective water resources governance that may enhance the resilience of rural communities in Kilosa District to withstand climate change impacts.

Research Objectives

General Objectives

The overarching objective is to examine water resources governance that enhances the resilience of rural communities in Kilosa District to adapt to the impacts of climate change.

Specific Objectives

The specific objectives of the study are:

1. To characterise the impacts of climate change on water resources in Kilosa District.
2. To identify existing water resources governance systems at local level.
3. To assess the role of different stakeholders on adaptive governance in improving coordination and collective actions in managing the impacts of climate change on water resources.

Research Questions

1. What are the impacts of climate change on water resources in Kilosa District?
2. How do existing water resources governance systems function at the local level?
3. How do different stakeholders on adaptive governance improve coordination and collective action in managing the impacts of climate change on water resources?

Significance of the Study

The study is in line with the Tanzania Development Vision 2025, Sustainable Development Goals (SDGs) particularly 6 and 13 (UN, 2016), which focus on ensuring the availability of clean water and promote urgent action to address climate change, respectively. Nationally, the project will contribute to the achievement of The Third Tanzania Five Year Development Plan (FYDP III) 2020/2021-2025/2026, and the country's efforts to address climate change (URT, 2021). The study reinforces all project villages to promulgate comprehensive village bylaws governing water resources at local level. This goes together with conducting outreach programs on adaptive governance of water resources to different stakeholders. The study also alerts policymakers, community and other stakeholders to review policies and guidelines governing water resources, as a result of policy briefs on adaptive governance of water resources in Tanzania.

THEORETICAL AND EMPIRICAL LITERATURE REVIEW

Conceptual and Theoretical Underpinning

Water Governance Concept

Governance, in the discourse of water resources management remains a highly contested concept of the global water community (Jimenez et al., 2020), owing to the concept being referred to as both a process and an outcome (Lautz et al., 2011). Water governance is process-oriented and is concerned with how the institutional and legislative frameworks dictate who participates in formulating strategies, implements the plan and how different actors interact (Zwarteveen et al., 2017). In addition, water governance is a set of systems that control decision-making regarding water resource development and management. Therefore, water governance is much more about the way in which decisions are made – in terms of how, by whom and under what conditions the decisions are made – than about the decisions themselves (Moench et al., 2003).

Dominant literature on water governance divides this concept into four categories: *social, economic, political, and environmental* (Theodory, 2022). The social dimension of water governance suggests an equitable use of water resources (Plekhov, 2021). The economic dimension of good water governance focuses on water efficiency and water's role in overall economic growth. The political dimension of good water governance emphasizes the inclusion of all stakeholders in decision-making, not just those who are politically powerful (Zwarteveen et al., 2017), but also those who are socially, economically and politically disadvantaged. The environmental dimension of water governance focuses on the sustainable use of water and associated ecosystem services, with an emphasis on its critical importance (Jacobson et al., 2013). Therefore, water governance can best be viewed through political, social, economic, and environmental lenses at different societal levels that help develop, manage and deliver water services. Thus, water governance is simply a political, social, economic and administrative system at different societal levels that helps to develop, manage and deliver water services (Villholth et al., 2017).

Water Governance Systems

Water governance and institutions are linked (Jacobs-Mata et al., 2021) because water governance focuses on understanding how water governance systems operate and how institutions influence policymakers' and implementers' decisions to manage water resources in practice (Theodory, 2022). The system examines ways in which allocative and regulatory politics are exercised in managing water through formal and informal institutions, social relations, and so on. As a result, the critical elements of water governance are laws, policies, institutions and implementation mechanisms. However,

for these elements to function, an enabling environment is required (Foster and Ait-Kadi, 2012). Clear policies, consistent laws, strong institutions and stakeholder-driven enforcement mechanisms are all required for good water governance (Jacobs-Mata et al., 2021).

Adaptive water governance: Collective action, climate change impacts and water resources

The challenges of water governance are enormous in the context of bureaucracy, public participation, sustainable water management and water service provision. Competing interests among various stakeholders, power dynamics and a lack of capacity-building are just a few of the issues at hand. Water decisions are grounded in governance systems at three levels: government, civil society and the private sector. Facilitating dynamic interactions among them – dialogues and partnerships – is critical for improving water governance reform and implementation (Theodory, 2022). Successful adaptive water governance can be best implemented with a home-grown approach that provides a structured foundation for implementing through the political and legal frameworks (Grigg, 2016). This mechanism allows stakeholders' participation as a precondition to improving water governance (Kanyepi and Tanyanyiwa, 2021). Stakeholders' involvement improves coordination and collective action in managing climate change's impacts on water resources. Simply put, adaptive governance is a continuous problem-solving process that verifies and reviews institutional arrangements and ecological knowledge in a dynamic and self-organized process of learning by doing (Grigg, 2016).

The concept of collective action has long been a factor to consider in development theory and practice, and it has also emerged in discussions about climate change adaptation. Collective action refers to a group of people who voluntarily participate in a common action to pursue a common interest. It can take the form of resource-mobilization, activity coordination, information sharing or institutional development (Poteete and Ostrom, 2004). Collective action is at the heart of adaptation decisions relating to the impacts caused by climate change on environmental resources, including water resources (Adger, 2003). It is rooted in a larger socioeconomic and political constellation, which is shaped and reshaped by scalar politics involving many stakeholders. Collective action is vital in addressing the governance challenges of water resources as a strategy to enhance resilience of the rural communities against the impacts of climate change. Embedded in existing power relations and structures across scales, this approach is most often hard to establish and sustain (Mosse, 2006). Successful collective action would require balancing interests and focusing on common goals of different actors.

Empirical Literature Review

Water governance and climate change

Water and climate change have a critical relationship in the context of sustainable development (Floress et al., 2015). Water is indeed threatened by climate change. As a result, good water governance is critical to enhance climate resilience. Climate change influences and is influenced by global water resources. It decreases the predictability of water availability and has an impact on water quality. Climate change also increases the frequency and severity of extreme weather events such as hurricanes, floods and droughts. This harms ecosystems and societies, particularly those whose livelihoods rely on climate-sensitive resources, endangering biodiversity and long-term social-economic development (Massoi, 2015). Naturally, this has significant implications for water resources and their management, both within and across.

Increased weather uncertainties necessitate a new type of resilient governance approach that is more adaptable and focused on addressing 'everyday risks', particularly for those most vulnerable to vulnerability (Theodory, 2022). As droughts worsen and water becomes scarcer, technical solutions and supply augmentation will be insufficient. Instead, we need more efficient water use (and reuse) and more equitable water-sharing processes. This necessitates a participatory, just and transparent approach, particularly when dealing with trade-offs between competing interests. Water governance research has highlighted the importance of citizen, local governments and private sector participation in addressing complex water issues. Stakeholders' participation is key.

The literature that connects water governance and CC is dominated by two strands: the conventional command and control water governance paradigm and the adaptive water governance paradigm (Li et al., 2020). The former presumes that the ability to control and predict water resource governance is based on economic efficiency, the dominance of rational-comprehensive planning processes, and top-down institutional mechanisms (Bhadwaal et al., 2018). This assumption ignores the human dimensions and the requirement for adaptations (Floress et al., 2015). Adaptive water governance, on the other hand, emphasizes the need for adaptation to deal with uncertainties in resource governance, while placing less emphasis on human dimensions (such as stakeholder values, interests and decision-making processes) required for its successful implementation (Walters, 2007). Thus, ongoing efforts to integrate human dimensions into water management processes and goals have not adequately accounted for the need to adapt to uncertainties, whereas efforts to reduce uncertainties have not adequately considered human dimensions. We argue that an adaptive governance approach to water resources is the most effective way to advance community resilience and ultimately support the achievement of Sustainable Development Goals (SDGs) 6 and 13, which are related to ensuring clean water availability and urgent action to combat climate change, respectively.

Climate change impact on water resources

Climate change presents a wide range of new challenges for communities across the world, including rising sea levels, changing weather patterns and a greater intensity and frequency of climate-related hazards. This is consequently affecting the quality and quantity of available water resources (Warburton, 2010). Early approaches to climate change adaptation have drawn upon a range of existing strategies (Adger, 2003). Much of this threat will be transmitted through more frequent extreme events (e.g. floods, water scarcity and droughts) and temporal and spatial shifts in rainfall patterns. The overall effect will be to exacerbate risk and vulnerability, threatening the livelihoods, health and security of millions of people. This situation will result in two broad, possible outcomes. The first one is that dry areas will get drier and wet areas wetter, with remarkable consequences on patterns and levels of agricultural production. The second expected outcome is an increase in the unpredictability of water flows, linked to more frequent and extreme weather events. Therefore, such societies as the pastoralists and agrarian, whose livelihoods are pegged to climate-sensitive resources, will be the most affected by extreme and unpredictable rainfall patterns (Schulze et al., 2012).

On the African continent, climate change affects rural populations the most. The continent's climate has warmed more than the world average since pre-industrial times (1850–1900) (WMO, 2022). More impacts of climate change are apparent on water resources. Changes in continental water bodies have greatly affected the agricultural sector, biodiversity and ecosystems (Ray, 2021). According to the State of the Climate in Africa Report (2021), high water stress is projected to affect around 250 million people in Africa and is estimated to displace up to 700 million people by 2030. Moreover, four countries in Africa out of five are improbable to have sustainable water resources management by 2030 (WMO, 2022).

Tanzania is already affected by a series of climate change impacts, particularly in its arid and semi-arid areas (Jemal, 2014). Studies in Tanzania have shown great concerns on the impacts of climate change on water resources (Kangalawe, 2017; Näschen, 2019; Melchioly, 2021). Most of the impacts are observed on the decrease of water flows as well as increased seasonality of streams and rivers alongside drying up of some wetlands. According to Kangalawe (2017), climate change is perceived by the local communities in the Southern Highlands of Tanzania as the main driver of the decrease of water resources due to declining amounts of rainfall, prolonged drought, late onset of rains, early cessation of rainy seasons and increasing temperatures. Critically, Tanzania's water resources, such as rivers and reservoirs are crucial for harnessing hydroelectric power for industrial and household activities (Mdemu and Magayane, 2005). Changes in water flow greatly affect the capacity of the Tanzania Electric Supply Company (TANESCO) to produce and supply sufficient electricity, hence adversely affecting the socio-economic activities of the population. This is evident through

frequent power rationing across the country due to decreased water flow (Mgandu et al., 2020).

Over the years, Kilosa District has experienced changes in weather conditions. These changes are linked to changes in climatic conditions. The observable changes include early cessation of rainy seasons, long dry spells and increased average temperatures (URT, 2012). According to Kitasho et al., (2020), Kilosa District has recorded adverse impacts of climate change. The recorded impacts of climate change include shortage of water resources, the prevalence of droughts, low maize production and floods. Climate change is increasingly affecting the availability of water resources, leading to insufficient water for both people and the environment, making it difficult to meet the needs of both. Action to improve governance of water resources would enhance rural communities' resilience to the impacts of climate change. Adaptive governance is not a remedy to climate change, but given the need for available water resources, immediate action is required to enhance community resilience.

RESEARCH DESIGN AND METHODOLOGY

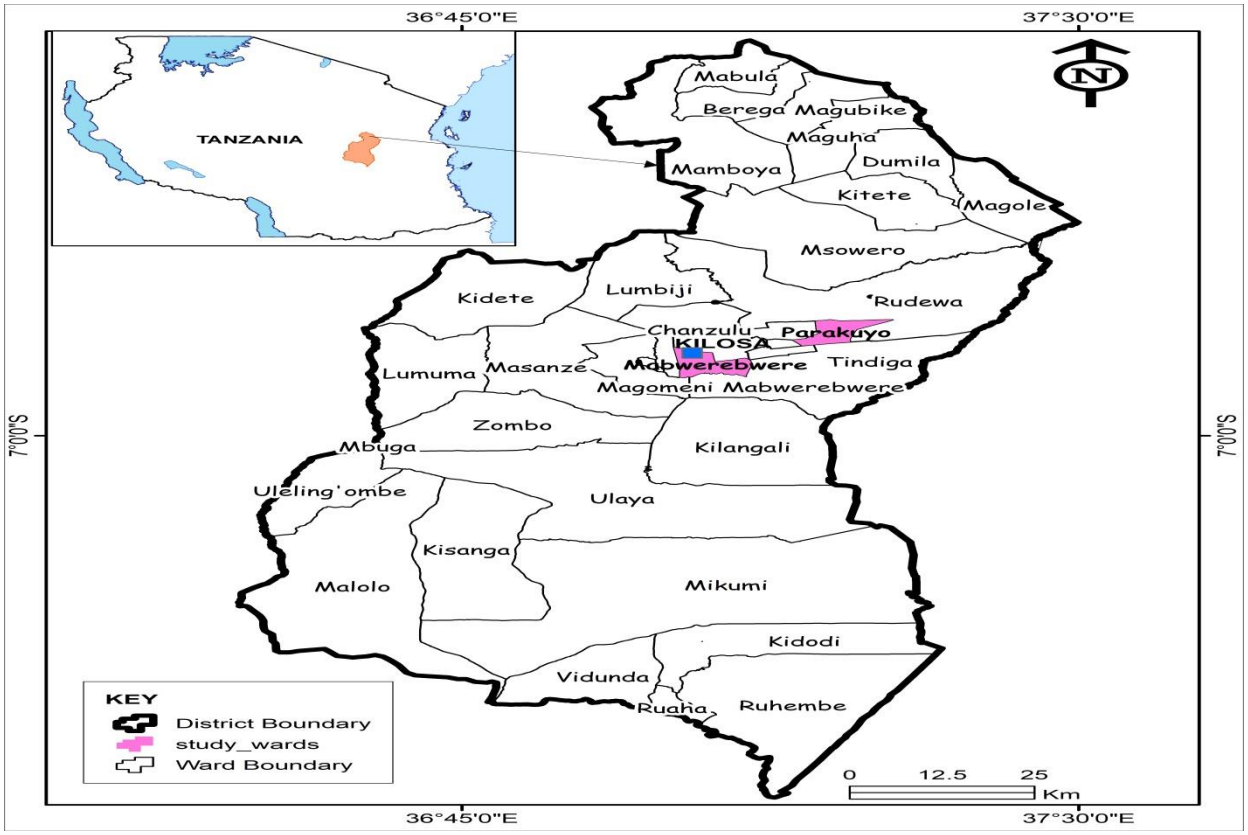
Research Design

This study used a cross-sectional research design that ensures high degree of accuracy in social science research, compared to other designs (Casley and Kumar, 1998). The rationale for using a cross-sectional design was because it allows easy collection of in-depth data from diverse groups of respondents at one point of time (Ritchie and Lewis, 2003; Given, 2008). This design is also important in social science research because it allows the use of different survey methods to gather a body of both qualitative and quantitative data within a short period of time (Agresti and Finlay, 2009).

Selection of the Study Area and Justification

This study was conducted in Kilosa District, Tanzania in 2022. The study district (Kilosa) is among five administrative districts of Morogoro Region which manifests unique impacts of climate change. Kilosa District has major land use systems in the country co-existing in the area. These include national ranches, leased estate farms, reserved catchment forests, smallholder subsistence farming, pastoralism and agro pastoralism (Kilasho et al., 2020). The selection of the study area was relevant because of increased issues relating to water resource governance and climate change impacts, which are evident in the area. This made it a relevant case in understanding the role of adaptive governance on local water resource for enhancing community resilience to climate change. This district has three agro-ecological zones including the plateau, the flood plain and the mountains, or upland zones. The landform of Kilosa District is generally controlled by its geology. The flood plains mainly consist of a flat and undulating topography that extends to the foothills at about 550M. Its biophysical environment is categorised into soil type, climate and topography. This district receives average annual rains ranging from 600–1200mm and temperatures between 25–30° centigrade. In the flood plain, the average annual rainfall ranges from 1000–1400mm. The soils of Kilosa District vary from poorly drained vertisols in the central part of the flood plains to alluvial fans in the western part that consists of black fertile soils (Mwasha, 2016). Figure 1 indicates the location of the study areas.

Figure 1: Location of the Study Area



Unit of Analysis

The unit of analysis was the head of the household. Moreover, the study population constituted all households that were engaged in farming and livestock keeping activities in the district. Moreover, two division officers, two ward executive officers, four village executive officers and four village chairmen were also involved in this study, to supplement the information collected.

Selection of Study Participants (Sample Size)

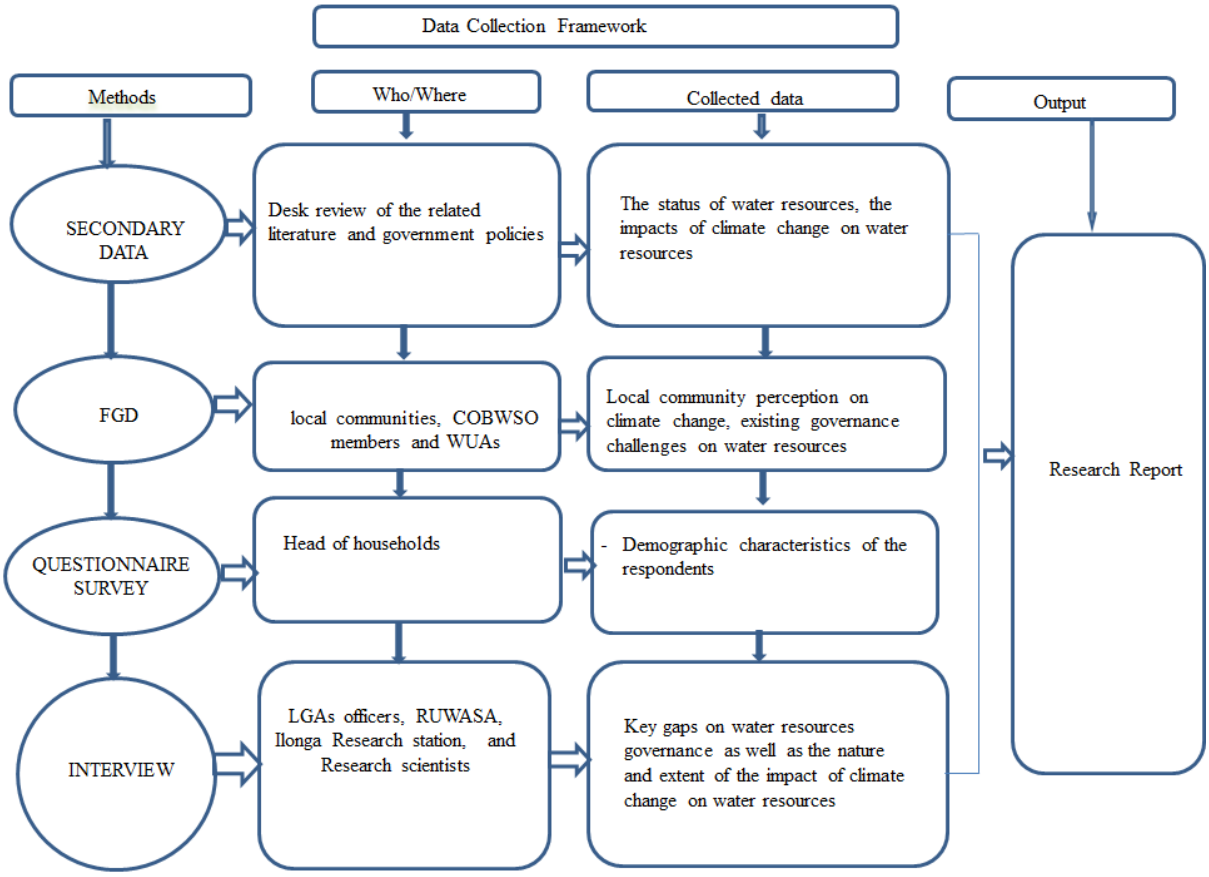
This study was conducted in Kilosa District, Morogoro Region. Kilosa District has 35 administrative wards and only two wards (Parakuyo and Mabwerebwere) were purposely selected for this study. Four villages, including Parakuyo and Twatwatwa (Parakuyo Ward) as well as Mamoyo and Mabwerebwere (Mabwerebwere Ward) were randomly selected for this study. About 10% of the total households per selected village were chosen to form the sample size for this study. Thus, 174 households were selected by the researchers for household questionnaires. Non-probability sampling involved purposive sampling to select key participants for interviews from the District Council, Ward and at village levels. The purpose of doing so was to ensure that all key actors who are involved in water resources governance were included in the study. The study participants included government officials from the National Environmental Management Committee (NEMC), Kilosa District Council officials responsible for the

environment, officers from the Rural Water Supply Agency (RUWASA), community development and extension officers, as well as Ilonga Research Station. The selection of respondents was guided by their familiarity with the issues of water governance, climate change and their involvement in climate change issues. Focus group discussions (FGDs) involved 6–12 people, including village leaders, gender representation, elders and youth.

Types of Data

Both primary and secondary data were collected in this research project. Primary data was collected using structured questionnaires and interview guides. Interview guides were used to collect qualitative data through FGDs and in-depth interviews. Structured questionnaires were used to collect quantitative data. Secondary data was collected through reviews of various documents, including policies, previous related studies and various countries' development plans. Figure 2 presents the data collection processes.

Figure 2: Data Collection Framework



Primary Data: Qualitative data collection

In-depth interviews

In-depth interviews were conducted to gain insight into adaptive water governance as a strategy to enhance climate change resilience among the local communities in Kilosa District. This research technique involved conducting intensive individual interviews with key actors to explore their perspectives on how effective water governance may enhance climate change resilience among the local communities. Respondents included were research scientists with long track records on climate science and water governance, RUWASA officers, key government officials in the Ministry of Water and Irrigation, as well as well-known people with knowledge of climate change and water resources governance. About thirty (30) interviews were conducted with different key actors. An interview guide was developed and translated into Swahili. During interviews the researcher used different probe techniques to make sure that the interviewees provided the relevant information to address the research objectives. More probes were done when a new insight emerged from principal questions. All interviews were recorded using a voice recorder and were also subsequently transcribed. Prior appointments were made with key participants, especially government officials who had tight schedules. Interviews with key informants helped to collect valuable information about adaptive water governance and climate change resilience.

Focus Group Discussions

Focus group discussions (FGDs) were conducted with selected farmers and pastoralists. The FGDs strived to probe the extent to which local communities were effectively responding to climate change impacts on water resources through adaptive governance. Moreover, the researchers strived to gain insights on whether adaptive water governance enhanced climate change resilience among the farmers and pastoralists in the study area. About twelve (12) FGDs were conducted with groups of farmers and pastoralists in Mabwerebwere and Parakuyo Villages, respectively. All FGDs were conducted in the Swahili language and recorded with a voice recorder. Researchers were very cognizant of the issue of gender, and ensured both women and men were involved in the discussions.

Questionnaire Surveys

Questionnaire surveys were conducted among the farmers and pastoralists to obtain contextual and demographic data about the respondents, including the respondents' age and level of income. The questionnaire had both closed and open-ended questions. Questionnaires were administered to 174 heads of households who were required to provide thorough information concerning the type of crops that they grow, and numbers of livestock kept by each household. Other information associated with local perceptions of the status of water sources, household water needs, local climate as well as causes and the impacts of climate change, was collected using this technique.

Secondary Data: Documentary Review

The researchers used this technique to get clear context of the study. This involved a desk review of all relevant documents, including government documents such as the National Climate Change Strategy (2021), the National Water Policy (2002), the National Environmental Policy (2021) as well as the Water Supply and Sanitation Act, 2019. Other documents included previous related studies on water governance and climate change conducted between 2010–2021. A summary of the wide range of documents that were reviewed was identified by the researchers.

Triangulation of Data

In this study, the data triangulation involved a collection of data at different scales of analysis, starting from the community to government duty bearers who are responsible for facilitating the implementation of various government strategies. This was important to gain insights into the achievements made and challenges encountered in the due process of implementing different strategies, for example the implementation of climate change strategy (2021). Information collected from interviews, questionnaires surveys and documentary reviews were compared to cross-validate the data and to capture different dimensions of the same phenomenon. If major contradictions were found, they were addressed, and any inconsistencies in reporting were sorted out. Feedback and discussions with the research team and other stakeholders were conducted to validate information collected. Data triangulation was adopted to maintain clarity of the study results, in which all interviews with government duty bearers and selected stakeholders were compared and cross-checked with questionnaire surveys and records of interviews.

Quality Assurance and Control Measures

In any study, there are always possible situations that might interfere with the study and affect internal and external validity. For the consultant team to maintain objectivity, bias must be controlled. There are also possible participant roles that can affect the study, such as the 'good participant role' (attempting to provide information and responses that might be helpful to the study), the 'negativistic participant role' (trying to provide information that might confound or undermine it), the 'faithful participant role' (trying to act without bias) and the 'apprehensive participant role' (trying to distort his or her responses in a way that portrays him or her in an overly positive or favourable light). For purposes of controlling bias and participants' effects, the following techniques were adopted, in efforts to ensure confidence in the accuracy and relevance of the results.

a) Randomisation was adopted to ensure that extraneous sources of artefact and bias do not confound the validity of the results of the study. Randomisation helped to ensure the internal validity of the study by helping to eliminate alternative rival hypotheses that might explain the results of the study.

b) Deception was used in the form of providing participants with misinformation about the true interest or the focus of the study. Without knowledge of the true hypotheses, it is much more difficult for participants to alter their behaviour in ways that might interfere with the results of the study. Potential ethical issues were considered before proceeding. At a minimum, deception did not jeopardise the well-being of the study participants.

a) Each enumerator was trained on the approaches to be used in the data collection and sampling of target population.

b) The enumerators were involved in carrying out the pre-test of the tool to ensure not only validity and reliability, but also familiarisation of the tools.

c) The enumerators were supervised in the field by the consultant during data collection.

d) The consultants conducted a validation exercise in the areas that were visited by the enumerators to ensure that there was consistency and accuracy of data.

e) At the end of each day of data collection, there was a meeting to discuss the challenges, lessons learned (what worked and what didn't work), emerging issues and for completeness, and overall accuracy before submission for data entry.

f) All qualitative interviews were recorded using digital voice recorders to ensure accurate information was collected. All transcriptions were checked by a different person in comparison with the recording, for accuracy.

Data Analysis

Data obtained was analysed through content analysis. Content analysis was used to determine the presence of certain words, themes or concepts from the interviews conducted. The analysis involved reading all documents from beginning to end, then re-reading them carefully, while highlighting the text fragments which appeared to describe the adaptive water resources governance. All textual materials collected were analysed, starting with the transcription of the audio-recorded information. This was followed by coding, data display and interpretation of different patterns. The coding referred primarily to predetermined themes from the theoretical models and themes emerging from the data collected. Transcription of the recorded information was done within twenty-four hours after the interviews and FGDs. The transcription was done in Swahili, since the interviews and FGDs were conducted in Swahili as well. Then afterwards, all transcribed text was translated into English. This was followed by repeatedly reading the transcripts to cross-check the quality and to acquire an overall sense of the data. Thereafter, the transcribed text was subjected to the Atlas.ti programme for further analysis. Within Atlas.ti, all data was coded inductively, using predetermined themes and patterns from the operational research questions. In

addition, emerging themes and patterns were deductively captured from the data. A team coding strategy was deployed. Every researcher coded the transcripts separately, followed by a meeting to discuss all developed codes and families. In area where there were differences, the discussion was conducted to arrive at a consensus. Afterwards, one Atlas.ti project was created. This was followed by identifying patterns in the reviewed documents and transcribed interviews. Similar codes were grouped together in families that reflect sections. This grouping was based on the units of analysis discussed in the preceding sections. Lastly, the output was created with all attached codes and quotations, memos and families, and transferred to word documents. A descriptive report was created and used to write a full research report.

Quantitative Data

For quantitative data, the completed survey questionnaires were automatically edited and coded by the mobile data collection system (ODK) that functions online and offline. The mobile data collected was uploaded into IBM Statistics for Social Sciences Software Version 26. Demographic characteristics of the respondents were analysed descriptively by using a frequency table to provide brief information about the respondents who participated in the study.

For inference analysis, the study used factor analysis to offer insight into the interrelationship between variables and the fundamental structure of data. Factor analysis was used to reduce the number of variables, by merging two or more variables into a single factor. In this study, the dependent variable (water resources) possesses three attributes which were reduced to form a single variable, which presents the meaning of all attributes. Thus, factor analysis was adopted on both independent and dependent variables. After assessment of individual factor loading for dependent and independent variables, the attributes with loading above 0.5 were transformed to form new defined variables representing the dependent and independent variables.

A multiple regression model was adopted to assess the causal relationship between the impacts of climate change (independent variable) on water resources (dependent variable). The equation i illustrates the relationship.

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots i$$

Whereby:

α = Constant Variable (The value of water resource in the absence of independent variables).
β_1 and β_2 = Coefficient of independent variables.
x_1 and x_2 = Impact of Climate Changes and Impact of Climate Changes on Livelihood respectively.

To evaluate the goodness of fit of the model used, the study deployed R-Square and Analysis of Variance.

Ethical Clearance

The researchers obtained permission to carry out the study from responsible authorities, including the Morogoro Regional Secretariat as well as the Prime Minister's Office, Regional Administration and Local Government (PO-RALG). Clarifications of research tools (in Swahili) were clearly made to all interviewees, and their consent was sought to ensure that they understand that their participation in data collection was voluntary. Participants were informed that they should not answer questions which make them uncomfortable, and they could stop their participation at any time. All respondents were informed that their discussions/interviews would be used as quotes in the report to add context to the findings. Critical to note, during data collection exercises, names of the participants were kept anonymous. Protection of research participants was vital during the survey and the consultants minimised any risks associated with participation in data collection activities. Confidentiality procedures were explained to all participants involved in data collection.

RESULTS AND DISCUSSIONS

Perceived Climate Change in the Study Area

The findings have shown that climate change in the study area is not a new phenomenon. Rural communities in the studied wards perceive and elucidate their local climate conditions in different ways. Over long periods of time, they have been perceiving some periodic changes in weather events, especially rainfall and temperature. Local perceptions are significant, as they predict and indicate the state of the local climate in the future. As put forward by Maddison (2006), perception has a strong impact on adaptation measures at the individual or community level. It affects the specific nature of the community's behavioural responses, and shapes adaptation decisions, outcomes and processes (Pauw, 2013). The findings have shown that there were changes in the local climate that largely affect the overall livelihood activities of the community. The perceived changes that were mostly mentioned by the respondents include shortage of rains, erratic rainfall and long dry spells, which were unusual in the study area. Most of the respondents in both studied wards had the view that temperatures had increased at an unusual rate in recent years, hence causing huge impacts on their livelihood activities. The following remarks support this argument:

> We have observed early onsets of dry seasons that have affected our livelihood activities, especially livestock keeping. Long dry spells greatly affect pastures and contribute to drying of water resources surrounding this village. We are pastoral communities who depend on livestock-keeping. If the situation continues, our cattle and goats will die because there are scarcities of pastures[1].

Temperature increase has been evident not only in Parakuyo and Mabwerebwere but has been observed throughout Tanzania. A study by Theodory (2016) in Missenyi and Muleba Districts indicated that temperatures had increased, leading to crop failure and drying of water sources in the area. Moreover, Kangalawe et al. (2011), in the Great Ruaha River Catchment Area, indicated that farming activities had been greatly affected by extremely high temperatures due to long dry spells. In the views of one of the climate change experts at the Ministry of Water, in recent years the whole country has experienced long dry seasons, and temperature increases at an unusual rate. Regarding the state of rainfall, respondents were of the views that rainfall has been decreasing from time to time, leading to poor performance of farming activities. There is also a shifting of rainy seasons, late onset of rains and early ceasing of rains. The results indicate that the decrease of rain has affected the agricultural almanac. This is supported by the following quote:

> Rainy seasons have changed. In the past, it was raining on time, and we could plan our planting calendar accordingly. This year, as you can see,

[1] Interview with old respondent in Parakuyo Village

> rains were not sufficient, and they lasted for only a short period of time. We tried to prepare our farms early enough, but it did not rain on time[2].

According to rural communities in the study area, climate change has contributed to changes of rainy seasons in recent years. In the past, the study area used to have two periods of rains (long rains and short rains) that supported livelihood activities. Recent experience indicates that such rains are no longer available or do not happen regularly as it used to be in the past. It was noted from the interviews with rural communities that the long rains that traditionally used to start in March, have also been observed coming earlier and heavier, leading to extreme floods and destruction of land as well as crops. The Agriculture Extension Officer in Mabwerebwere Village confirmed that in recent years there have been changes in yearly rainfall patterns and rain distribution has also changed. This becomes difficult for farming communities to make decisions about planting dates. In the following remarks, the extension officer explained that:

> Kilosa District used to have bimodal rainfall pattern, staring from early March to May (long rains) and from November to early January (short rains). But recent experience indicates that short rains have disappeared or are very low, leading to extended long dry spells. This, to a great extent, has affected the farming activities of the community in this village[3]

The above evidence of climate change indicates a paradigm shift in rainfall patterns from bimodal to unimodal rainfall regimes in the study areas. In certain instances, some respondents had a view that the weather was becoming more unpredictable. For example, in Twatwatwa Village, it was stated during the FGDs that about 20 years ago, weather prediction was very possible as there were specific periods of temperatures and rainfall levels in a year. In recent years, weather forecasting has become complicated in the study area. One of the interesting quotes vindicates this argument:

> It is difficult to make predictions about these unpredictable weather events. In the past it was easy to predict the beginning of the rainy seasons and to start preparations of our farms. Things have changed, as we cannot make predictions anymore. Sometimes rainfall happens even during dry seasons, making it difficult to prepare our farms because we are unsure if it will last.[4]

The Impacts of Climate Change on the Availability of Water Resources and Community Livelihoods

Analysis of the quantitative data reveals that ongoing climate change has negative impacts on the availability of water resources and community livelihoods. The analysis

[2] Interview with respondents in Mabwerebwere Village
[3] Interview with the Agriculture Extension Officer in Mabwerebwere Ward
[4] Interview with respondent in Mamoyo Village (Own translation)

indicates that in the absence of any factor, water resources are decreasing by a factor of 2.74. This can be witnessed by the drying of water catchments in the study area, increase of water-borne diseases as well as increases the price of water for household uses. The findings further revealed a negative relationship between increases in temperature and the availability of water resources. When other factors are constant, a unit increase in temperature will result in decrease in water resources by -0.69. These findings are statistically significant with the probability value of 0.051. These findings are apparent in the study area, following the spontaneous increase in temperature, which leads to water user conflicts and prolonged droughts. The findings have shown that rainfall has a positive relationship with the availability of water resources, as the unit increase in precipitation results in 2.37, because the type of agriculture is rainfed and majority of households depend on agricultural activities.

Furthermore, the findings have shown a significant relationship between the impacts of late onsets of rains on the agricultural productivity, with p-value of 0.000. The late onset of rains has affected agricultural production, leading to food insecurity. Moreover, the findings reveal a decrease of agricultural production by -3.02 (three times) when a unit increases in changes of the seasonal calendar.

Table 1: Impact of Climate Changes on the Availability of Water Resources

Model		**Unstandardized Coefficients**	**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	-2.74	0.231		9.429	0.000
Increase in temperature	-.69	0.350	0.73	1.970	0.051
Reduced precipitation	2.37	0.310	1.31	2.341	0.021
Late onsetting of rains	0.72	0.043	0.58	16.744	0.000
Changes on seasonal calendar	-3.02	0.750	0.98	4.024	0.008

a. **Dependent Variable:** Water resources availability

Furthermore, the findings reveal a direct relationship between the decrease of agricultural production and the drying of water catchments. These findings are statistically significant with the probability value of 0.003. However, the results reveal unpredictable seasons and drying of water catchments leading to decrease in agricultural production and eventually increase in food price.

Table 2: Impact of Climate Change on Community Livelihood

Model		**Unstandardized Coefficients**	**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	3.60	0.231		8.624	0.003
Decrease of agricultural products	2.54	0.645	0.73	3.940	0.029
Food price increase	1.92	0.442	1.31	4.340	0.023
Incidences of pests and diseases	3.01	0.374	0.58	8.044	0.004

a. **Dependent Variable:** Water resources availability

Most of the interviews with local communities support the data from the questionnaires regarding the impacts of climate change on the availability of water and community livelihoods. The findings revealed that climate change has had several impacts on the available water resources and overall livelihood activities, leading to community vulnerability in the study area. The study has noted that climate change cannot be isolated from the different on-going water use conflicts and land use pressures that co-exist in the study area. Different respondents had different opinions on the impacts caused by climate change in the study area. The RUWASA District Manager in Kilosa District observed that there were increased scarcities of water due to long dry seasons.

> In areas like Mabwerebwere, the availability of water resources has been a prolonged challenge caused climate change. Water has decreased tremendously, resulting in water use conflicts in some areas, particularly along Mkondoa River where irrigation is most practiced. The observed conflicts are between farmers and livestock keepers[5].

Increased water shortage during long dry seasons has contributed to the hiking of water prices, the study has found. In view of the Village Chairman in Mamoyo, access to clean and safe water for household consumption has been a recurrent problem, especially during dry seasons. The findings have shown that the study area has very few deep boreholes that produce clean and safe water. Many of the boreholes in this village produce salt water, which is not safe for drinking and sometimes even cooking. It was noted that during the dry season, the situation tends to become worse, as the price of safe and clean water increases at alarming rates. The community has to rely on water sold by water vendors, which is very expensive. The price of one jerrycan stood at 500-600 TZS at the time when this study was conducted. This recorded price was significantly higher compared to the price of water in areas where there is availability of clean and safe water. In those areas, one jerrycan of clean and safe water is sold between 50-100 TZS[6]. The following sentiments attest this claim:

> Water is life, because without water nothing can be done. We all need water for cooking, drinking, washing and irrigation, to mention a few. Due to long dry seasons, availability of clean and safe water is becoming a prolonged problem in this village. We spend a lot of money to access water. Sometimes we are forced to walk long distances and spend a lot of time searching for water[7].

Climate change affects agricultural production through temperature increases, changes in rainfall patterns as well as increased incidences of extreme events, such as prolonged droughts and floods. Changes in rainfall patterns and temperatures will

[5] Interview with RUWASA manager, Kilosa District

[6] 1 USD is equivalent to 2,300 TZS.

[7] Interview with village chairman, Mamoyo

have a profound impact on water resources and other livelihood activities that people depend on. In the study area, the impacts of climate change are evident to farmers and livestock keepers, as well as the entire community. In the views of water and agricultural experts, along the catchments of Mkondoa and Mkata Rivers, crop production has decreased substantially because of water shortage. Farmers inhabiting in these areas along the catchments had the view that in the past, undertaking agricultural activities along the catchments was done because it was perceived as place with abundant water for irrigation throughout the year. Currently, water has decreased tremendously due to increased temperatures, thereby threatening irrigation of crops along the catchments.

> For many years, I was engaged in horticultural farming along the Mkondoa River. It was possible to undertake farming throughout the year because the river had enough water. In recent years, the situation has changed as water flow keeps on decreasing. Crop irrigation is largely affected by the recurrent, long, dry spells that create water shortages along the catchment[8].

Rain-fed agriculture is also vulnerable to the changing climate in the study area due to changes of precipitation patterns and seasonal shifts. Increased warming will culminate in increased water-related stress that will have even greater impact on crop and livestock production. It was also reported that increased rains may contribute positively to crop production, leading to decrease of market prices affected by demand and supply forces. There is a need to enhance farmers' adaptive capacity to climate change to improve crop and livestock production.

The livestock sector is yet another sector threatened by climate change in the study area. Among the challenges experienced by this sector due to the changing climate include, incidences of pests and diseases for animals; inadequate pastures resulting in loss of body weight; decrease of milk production and loss of large herds of cattle. Pastoralists in Parakuyo Village claimed that during dry seasons, huge number of cows experienced weight loss and reduced milk production due to shortages of pastures and drinking water. This greatly affected household incomes among pastoral communities, as it was difficult to sell a weak animal at a good price. One of the elder respondents in Twatwatwa Village observed that, long dry spells are responsible for the loss of large herds of cows in recent years. The following remarks substantiate the above claim:

> One of the most memorable, long dry seasons was in the year 2020. In this particular year, we witnessed a huge loss of cows because of long dry seasons. All the major catchments that this village depends on, for

[8] Interview with respondent in Mabwerebwere Village

> instance, Mkata River, dried up completely for more than a month. Our cows were really suffering as they could not get drinking water[9].

In Parakuyo Village, among notable climate change impacts reported, was the invasion of the village by wild animals. This situation was mostly observed during long dry seasons, when there was a decrease in precipitation. Wild animals such as elephants were reported to have invaded the village and killed people. Few people were reported to have been killed by the elephants that invaded the villages for the sake of getting food due to shortage of pastures, because of decrease in precipitation.

> When it is extremely dry, elephants invade our village and move around. Two years ago, they killed a young boy who was grazing a cow in the rangeland. This is mostly observed during long dry seasons, when it is hard for elephants to secure good pastures due to shortages of precipitation.[10]

Adaptive Water Governance Systems in Kilosa District

Water is a crucial resource that plays a pivotal role in sustainable development. Increased shortage of water in the study area has intensified dramatically over recent years, to the extent that the future of the community is seriously threatened. The importance of water to poverty reduction, human and ecosystem services and governance of this precious resource becomes of central significance. As noted in the previous section, majority of people in the study area have no access to clean and safe water. Some of the water sources are largely the community's own making. The results indicate that shortage of water in Parakuyo and Mabwerebwere Wards is due to natural limitations or lack of appropriate technologies and financing that would have enhanced availability of water resources. The interviews with RUWASA technicians in Kilosa District revealed that climate change poses significant threats to water resources. Much of these threats are transmitted through recurrent weather events (i.e., droughts) and temporal and spatial shifts in precipitation patterns. These major impacts are exacerbating vulnerability and risk, threatening the livelihoods and health of rural communities and increasing unpredictability of water flows.

Adaptive water governance systems were examined through in-depth interviews and FGDs to gain crucial insights on how rural communities in Kilosa District enhance climate resilience. The results indicate a number of governance systems, including the Wami-Ruvu Basin, COBWSO, Village Water Committees established by the Village Councils and Water Users Associations (WUAs). The study has noted that there is great collaboration among sectors, focusing on addressing acute water shortages aggravated by climate change. During interviews with the Manager of RUWASA, Kilosa District, it was reported that there is great cooperation among actors to ensure

[9] Interview with respondent in Parakuyo Village
[10] Interview with one elder in Parakuyo Village

effective governance of water resources. The study has found that RUWASA has been working with different actors, including non-governmental organisations (NGOs), different village committees such as land, environment and forest, with the aim of ensuring effective governance of water resources in the district. The following remarks form the base of this argument:

> To ensure effective water governance, RUWASA has been working together with different actors. We have managed to establish COBWSOs in some villages that manage the supply of water in the community[11].

> The village government, in collaboration with the RUWASA District Office, has managed to formulate village by-laws to govern water resources in our village. This is a great achievement, as we can manage our own water resources and ensure effective water supply services in our village[12].

The above findings concur with a study by Theodory (2022) in Mgeta Sub-catchments, whereby water governance systems were effective due to the great collaboration between formal and informal institutions. These institutions co-exist and perform all tasks relating to water governance. Moreover, Kabote and John (2017) revealed that effective water governance in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) was possible due to great collaboration among actors, including the Lake Rukwa Basin, Water Users Associations (WUAs), Village Water Committees formed by Village Governments, Community Water Use Supply Organizations (COWSOs) and District Councils.

The findings have shown that all studied villages have governance systems in place, responsible for water resources management. For instance, in Parakuyo and Twatwatwa Villages, there were COBWSOs established and mandated to manage the supply of water resources at the community level. This local institution ensured that water was always available for the community. They coordinated collection of all levies and ensured trustworthiness of the revenues accrued from the use of water services. An interview with the village chairman in Parakuyo Village revealed that water governance in his village was appropriately done by the COBWSO, which operates under the Village Council. This COBWSO has ensured effective supply of water to all households that need direct water connection in their houses. The study has established that Village Water Committees in Parakuyo and Twatwatwa Villages were also responsible for the management of water sources through established by-laws to govern water resources in their premises. In view of the Maasai elders from both villages, there was an integrated approach of water resources management, whereby both formal and informal institutions were involved in water resources management.

[11] Interview with RUWASA Manager, Kilosa

[12] Interview with Village Chairman, Parakuyo Village

For instance, in Parakuyo Village, governance of water resources was handled traditionally through the established rules that must be followed by community members. In case of any misconduct or breach of these rules, the responsible person was punished. The following quote demonstrate as follows:

> In this village there is one water dam for harvesting rainwater that can be used for different purposes during the dry season. Elders have been closely involved in managing this dam. They have set traditional rules over the use of this dam. For example, no one is allowed to swim in the dam. If you are found swimming in the dam, elders provide severe punishment, and at times the responsible person can even be 'cursed' (*kuligitwa* in Maasai language)[13].

The involvement of Maasai elders in water resources governance is conceived by the pastoral communities in Parakuyo and Twatwatwa Villages to have enhanced climate change resilience during the long, dry seasons. Maasai elders have demonstrated a bold commitment in maintaining societal ethics, which in turn contributed to water resources governance. The traditional rules of the Maasai society have proved to be more effective in governance of water resources. It was interesting to note during the FGDs in Twatwatwa Village that these traditional rules have been transmitted through generations and found to be relevant in the governance of water resources. Figure 3 is a photo which shows a man-made dam in Parakuyo Ward, which is used for different purpose.

Figure 3: A Man-Made Dam in Parakuyo Village

A different situation was observed in Mabwerebwere Ward, whereby water governance was done by the NGOs and Village Governments. In this ward, there was no COBWSO to address the recurrent governance challenges of water resources. The study has

[13] FGD in Parakuyo Village

noted that the available water sources in this ward were not clean or safe for human use or consumption. The community relies on shallow boreholes constructed by an NGO known as Islamic Society. These water sources were found to be contaminated, leading to health risks, particularly prevalence of waterborne diseases. According to Theodory (2013: 2022), unimproved water sources were linked to prevalence of waterborne diseases, such as diarrhoea, cholera, dysentery and typhoid in Mgeta Sub-catchments and Kinondoni Municipal Council, respectively. An interview with the Water Technician at RUWASA, Kilosa District revealed that water resources governance in Mabwerebwere Ward was plagued by incidents of waterborne diseases due to the absence of improved water sources. He further emphasized that RUWASA has included wards without improved water sources among the top priorities in the next financial year 2022/2023.

> RUWASA is responsible to supply water in every ward/village. With the available merger budget, we have been trying to work with some interested partners in the rural water subsector to ensure effective and efficient supply of water. In the forthcoming financial year 2022/2023, we have set aside a budget to facilitate the establishment of water supply projects in areas where such service does not exist[14].

The study has established that there are contradictions which raise several questions regarding power demarcations between COBWSO and Village Councils on water resources governance at local level. For instance, in Parakuyo Village, there were no clear guidelines regarding the areas of COBWSO's responsibilities. This raises questions as to where and to what extent COBWSO should be responsible. Should it be responsible to the Village Council or to the district authority? The RUWASA Manager, Kilosa District clarified that COBWSO should be responsible to the Village Council. In his view, the Village Council promotes the establishment of COBWSO, and the District Council facilitates its registration. This is clearly stated by the Water Resources Management Act (WRMA) no 12 of 2009 (URT, 2009). The Village Council is also mandated to coordinate the budget submitted by the COBWSO and transmit the requested budget to the RUWASA Manager, with the minutes of the meeting attached. Moreover, COBWSO is responsible for resolving water use conflicts at local level.

Collective Actions on Water Resources Governance

Collective action is more powerful in influencing government actions to ensure community access with clean and safe water, to enhance climate change resilience. The study revealed that the use of collective community action in seeking for access to water services was legally considered as action taken by a group of people to advance their common interests. In the views of the respondents in Mamoyo Village, the awareness created by NGOs has empowered the communities to demand their

[14] Interview with Water Technician, RUWASA, Kilosa District.

rights in accessing clean and safe water. One of the key informants in Mabwerebwere Village revealed that collective action enabled their voices to be heard by different stakeholders, and they eventually managed to get water projects from Islamic Society. The study further established that the community in Mabwerebwere Village used the spirit of collective community action to demand a village meeting, where they could discuss water governance issues. Such action has proved very helpful in addressing most of the pressing issues revolving around the rural water sub-sector.

In Parakuyo and Twatwatwa Villages, collective community action was taken against those people who were misusing water. In such cases, if any household was found misusing water, the action of the community was to ban that household from accessing the services for a while, as punishment. More community collective action was reported in Twatwatwa Village, whereby pastoral communities decided to act against those who were degrading the Mkata River. It was interesting to note that villages located upstream of Mkata River were blocking the river's flow, leading to water shortages downstream. The following sentiments vindicate this statement:

> The community is very much concerned with governance of water resources. In case of decrease of river runoff, we usually undertake patrols of the entire catchment to find where the upstream communities have blocked the river's flow.[15]

> Collective community action has been helpful to water resources governance. Water supply in this village has been effective since the year 2015 because of the communities being actively engaged in demanding their rights of access to clean and safe water. Without this collective action, water would have been a challenge in this village.[16]

The findings have shown that women were more actively engaged in initiating collective community action than men, while seeking solutions to water problems. It was noted that women were among the primary target population of the established water projects in all studied villages, hence actively engaged in collective community action. The study has established that among pastoral communities in Parakuyo Village, women were more engaged in collective community action compared to men. This is because women are responsible for household responsibilities such cooking, washing dishes and clothes. All these activities need sufficient water, but men also need water for their animals.

[15] FGD with rural communities in Twatwatwa Village
[16] FGD with rural communities, Parakuyo

CONCLUSION AND RECOMMENDATIONS

Summary of Findings and Policy Recommendations

The study has shown how rural communities in Parakuyo and Mabwerebwere Wards enhance their climate change resilience through adaptive water governance. It has shown the perceived changes of local climate, which are decreased precipitations, erratic rainfall and long, dry spells. Most of the respondents in both the wards studied were of the view that temperatures were increasing at an unusual rate in recent years, hence causing huge impacts on available water resources and livelihood activities. Regarding the state of rainfall, the study has shown that rainfall has been decreasing over time, leading to poor performance of farming activities. In recent years, there has been a shifting of rainy seasons, late onset of rains and early ceasing of rains, which affect the agricultural almanac. It was noted from interviews with rural communities that the long rains that traditionally used to start in March are also observed as coming early and heavier than expected, leading to extreme floods and destruction of land as well as crops. This indicates that there is a paradigm shift of the rainfall patterns from bimodal to unimodal rainfall regimes in the study areas.

The overall policy implication from the results of this study is that strengthening climate change resilience among pastoral and farming communities is of great significant. Achieving this requires effective information dissemination, communication strategy and education on climate change issues. Therefore, this study recommends programmes that focus on capacitating rural communities with climate change knowledge, to enhance their resilience to climate change.

Increased water shortage during long, dry seasons has contributed to the hiking of water prices, especially in Mabwerebwere Ward. In the view of the Village Chairman in Mamoyo, access to clean and safe water for household consumption has been a recurrent problem, especially during dry seasons. The findings have also shown that, the study area has very few deep boreholes that produce clean and safe water. Many of the boreholes in this village produce salt water, which is not safe for drinking and at times even cooking. The policy recommendation from the findings of this study is that more investments be done in the rural water sub-sector, as they are very much needed to address the problem of water scarcity in rural areas, which aggravates water-borne diseases.

The study has observed different governance systems that have enhanced climate change resilience among farmers and pastoral communities. The integration of Maasai elders into water resources management has addressed pressing issues on water governance in Parakuyo Village. This study recommends an integration of informal institutions into water resources governance to complement government efforts in managing water resources.

Research for Further Studies

This study examined the existing governance systems on water resources. It also examined the dominant climate change impacts and how it affects the water resources of the farmers and pastoral communities in Parakuyo and Mabwerebwere wards. The study concludes that there is a paradigm shift of the rainfall patterns from bimodal to unimodal rainfall regimes in the study areas. Considering the persistent conflicts between farmers and pastoralists, investigating their terms on water resources governance is great importance. Thus, future research should investigate the farmers–pastoralist nexus on water resources governance.

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