BARRIERS TO ADAPTING WATER SUPPLY MANAGEMENT TO CLIMATE CHANGE IN NZOIA RIVER BASIN, KENYA.

ABSTRACT

Water is projected to be the most affected by climate change. Many national and county governments are now developing adaptation policies and plans in response to climate change; however, many factors could stop, delay or divert these adaptation strategies if they are not adequately identified and addressed. Research on adaptation barriers is increasing as the need for climate change adaptation becomes evident, but studies regarding identification and classification of barriers into cartegories and establishing strategies for overcoming such barriers remain limited. This research identified barriers to adapting water supply management to climate change, classified them into cartegories and went ahead to establish strategies for overcoming such barriers in adapting water supply management to climate change in Nzoia River Basin. The study used a cross-sectional survey design and a qualitative technique since major sector players' perspectives are critical in deciding the path of climate change adaptation in the basin. Three counties were randomly selected from Nzoia River Basin for study with Busia representing the lower catchment, Kakamega middle catchment and Trans Nzoia upper catchment. The study was carried out from May, 2017 to September, 2017. Stakeholders were carefully selected and consisted of water and climate change expert decision makers, practitioners, managers, scientists, academia, technology adopters, etc. Stakeholders were chosen based on their work portfolios or by other respondents' recommendations. Data collection involved questionnaires, in-depth expert-interviews, brainstorming sessions, focus group discussions, field observations and literature review. This study identified and ranked in order of priority the barrier clusters/cartegories for adapting water supply management to climate change in Nzoia River Basin as: Institutional and governance; Resources and funding; Leadership; Politics; Adaptation options/process; Science; Understanding; Technology/structural; Expertise; Attitudes, values and motivations of actors; Communication; and Personality issues. Individual barriers are seen to be highly interconnected and interdependent, allowing for the discovery of leverage areas for actions to maximize barrier elimination. This study provides valuable information for the national and county governments as they strive to develop climate change adaptation policies and plans in the basin.

Keywords: Nzoia River Basin, Climate change, Water supply management, Adaptation barriers.

1.0 INTRODUCTION

The climate of the Nzoia River Basin is changing, and scientific data predicts it will continue to change in the following decades and centuries. Temperatures will steadily climb, and precipitation patterns will shift. Extreme weather events' location, frequency, and intensity are expected to vary as a result of these changes, according to projections. Climate change will have a wide range of effects on life in the basin, resulting in considerable economic, social, and environmental costs. Challenges for successful adaptation are being uncovered as climate change adaptation studies proceed from impact assessment to policy, planning, and implementation [1]. Adaptive capacity is not enough to achieve intended adaptation goals; many other variables, such as socioeconomic and cultural factors, influence decision makers' risk perceptions and willingness to act or prioritize actions [2]. With the increased recognition for the need to understand the factors and circumstances that stop, delay or reduce adaptation effectiveness, barriers to adaptation have been defined from various perspectives with terms such as limits (Dow et al., [3], challenges, Fünfgeld, [4], obstacles, Bedsworth and Hanak, [5], and constraints, Klein et al. [6], often being used synonymously.

According to the IPCC's fifth assessment report, adaptation barriers are variables that make it more difficult to plan and implement adaptation activities or limit options [7]. Barriers are obstacles that make adaptation less efficient, less effective, or may necessitate modifications that lead to missed opportunities or greater costs [8]. Individual or collective action with concerted effort, creative management, changing ways of thinking, political will, and reprioritization of resources, land uses, and institutions can overcome, prevent, or decrease them. Barriers can originate from three sources: the actor(s) making adaptation-related decisions, the context (for example, social, economic, or biophysical) in which the adaptation occurs, or the system at risk of being affected by climate change (referred to as the "system of concern"). Barriers are related to the adaptive actions that are being considered, the individuals that might use them, and the unique situation in which they might be used.

There could be barriers that are seen as problematic by one player and viewed as beneficial by others [8]. Others would most likely work with these barriers strategically, whereas the actor would wish to remove them. Taking account of these considerations, we propose the following refined definition here: a ‘barrier to adaptation’ is (1) an impediment (2) to specified adaptations (3) for specified actors in their given context that (4) arise from a condition or set of conditions. A barrier can be (5) valued differently by different actors, and (6) can, in principle, be reduced or overcome. In this definition, conditions are the attributes of adaptations, actors, and their context. Klein et al.[6], distinguished adaptation constraints from limits by defining the former as "factors that make it more difficult to plan and implement adaptation actions," and the latter as "the point at which an actor's objectives or system's needs cannot be secured from intolerable risks through adaptive actions," as defined by Islam et al. [9]. Barriers, on the other hand, were defined by Moser and Ekstrom [8] as "obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritizing, and concomitant modifications in resources, land uses, institutions, and so on." As a result, experts are beginning to agree on the term "limit" to refer to the "threshold beyond which existing adaptation strategies cannot overcome it." IPCC, [7] and research on the 'barrier' to adaptation frequently concentrate on the obstacles posed by socioeconomic and

institutional variables [10, 11]. Limits (and barriers), according to Adger et al. [12], are endogenous and originate from 'inside' society, and hence are dependant on ethics, risk attitudes, knowledge, and cultural values, depending on the ultimate aims of adaptation. As a result, Eisenack et al. [1] highlighted the contextual aspect of adaptation barriers, defining them as "an impediment to specified adaptations for specified actors in their given environment that arises from a condition or collection of factors" (Eisenack et al. [1].

Water management institutions' ability to adapt to a new and changing climate is determined by how decision-makers within those institutions perceive and interpret potential threats [13]. However, external influences such as laws, rules, and the socio-cultural-politico-economic milieu in which they operate affect public organizations like water supply departments [14]. Furthermore, institutions working in various areas, such as the environment, irrigation, hydropower, and residential water supply, each play a unique and complementary role in formulating and executing adaptation plans. This is especially true for basin-level management organizations, regional and national governments, and local municipal authorities adjusting water management to climate change [15,16]. In developing economies, barriers arising from a lack of coordination between and within organizations responsible for planning and implementing adaptation methods are particularly apparent [17]. However, research about the hurdles that institutions face in adapting to change, particularly in developing economies, is sparse, and impediments arising from socioeconomic, political, and cultural variables are little understood [18].

There are few studies that attempt to explain the fundamental causes of barriers and the interdependencies between them [1], making developing viable adaptation methods difficult [11]. Although there is an increasing interest in adaptation barriers in general, research on adaptation barriers for institutions is still limited [19]. This study aims at identifying barriers to adapting water supply management to climate change in Nzoia River Basin, classifying them into cartegories/clusters and establishing strategies for overcoming such barriers. County governments in Nzoia River Basin play an important role in managing the risks of climate change in local communities. They are responsible for a broad range of assets and services as assigned through the Constitution of Kenya 2010. A number of barriers exist that could limit the County governments' ability to plan for and implement adaptation measures. There is lack of clarity regarding the roles and responsibilities of County governments in relation to adaptation. Many Counties do not have the capacity to effectively plan for and implement adaptation responses, many face financial constraints and shortages of professional and technical expertise. Coordination and collaboration among County governments could address some of the capacity constraints they face through the establishment of regional organisations/alliances, to undertake common/joint activities such as resource sharing.

2.0 MATERIALS AND METHODS

2.1 Study area

Nzoia River Basin extending from longitudes 34^0 E to 35^0 $45^{'}$ E and latitudes 1^0 $30^{'}$ N to 0^0 $05^{'}$ S, is located in the Republic of Kenya along the boarder with Uganda (Figure.1).

Originating from the Cherengani hills and Mount Elgon, Nzoia river is one of the major rivers in Western Kenya emptying its waters into Lake Victoria. It has a total length of 334 km with 12,959 km^2 drainage area. The topography of Nzoia River basin is varied with hilly (Cherangan hills) and mountainous (Mt. Elgon) landscapes at elevations of 4,300m above mean sea level from where the fastest flowing streams of Kuywa, Sioso Ewaso, Rongai and Koitobos are found. Flowing in a north-easterly to south-westerly direction from its upper catchments, we arrive at the lower reaches into Lake Victoria at an elevation of about 1,000 m. This zone is exposed to periodic flooding. Climate in the basin is tropical humid. Day temperature varies from 16 °C in the highground areas to 28 °C in the lowland areas around Lake Victoria.

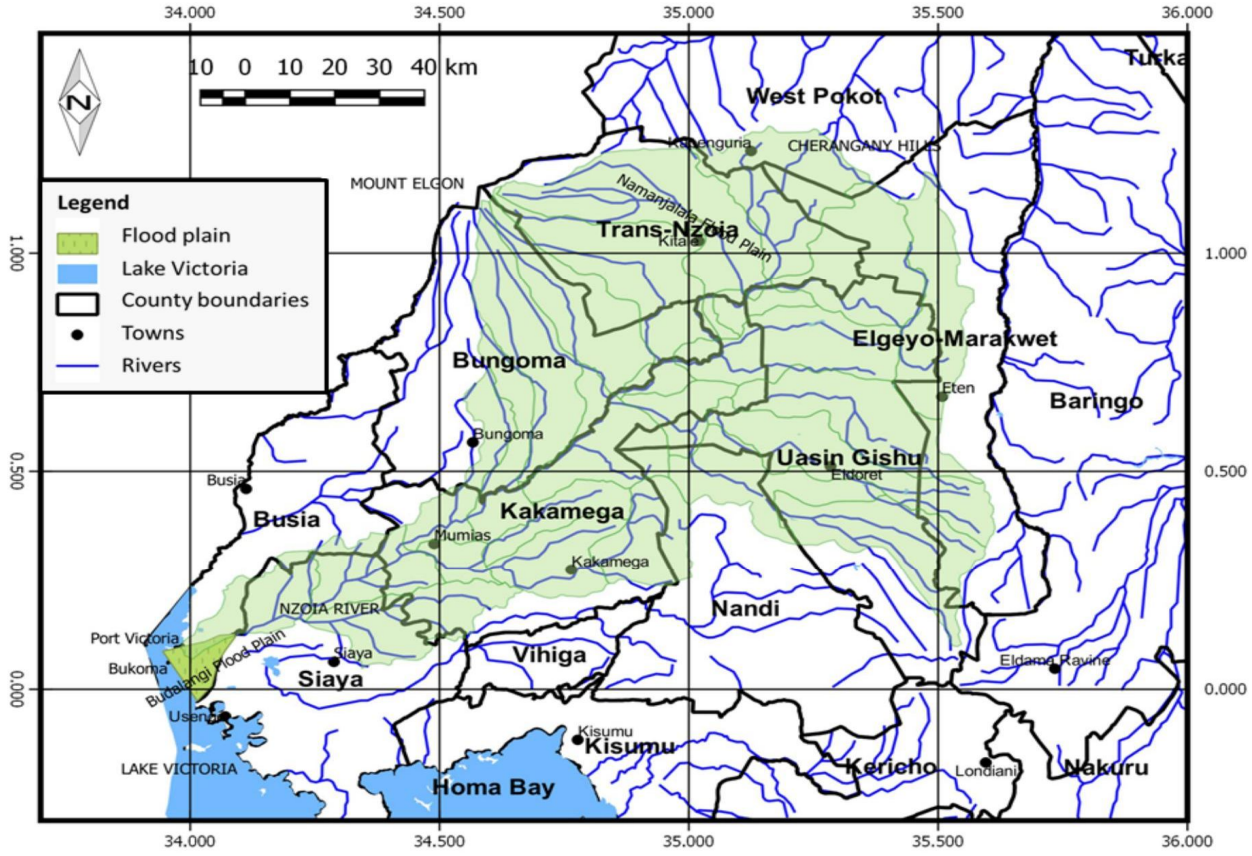

Figure 1: Map of Nzoia River Basin, Kenya

Annual rainfall is 600-2700 mm. The most common soil types are light clays with good drainage and good moisture capacity high in fertility. The dominant landuse is agriculture.

Kenya is a party to the United Nations Framework Convention on Climate Change (UNFCCC) and has committed to implementation of policies to adapt to climate change and effectively develop climate risk management measures. The country has a number of national policies, strategies and plans on climate change which include the National Climate Change Response Strategy (NCCRS), National Climate Change Action

Plan (NCCAP) and National Adaptation Plan (NAP).

2.2. Methodology

The study adopted a cross-sectional survey design and a qualitative approach based on the fact that the perceptions of key sector stakeholders play a crucial role in determining the direction of climate change adaptation in the basin. Three counties were randomly selected from Nzoia River Basin for study with Busia representing the lower catchment, Kakamega middle catchment and Trans Nzoia upper catchment. The study was carried out from May, 2017 to September, 2017, lasting for approximately one hour. Literature review and pilot study were conducted. Stakeholders were carefully selected and consisted of water and climate change expert decision makers, practitioners, managers, scientists, academia, technology adopters, etc. Stakeholders were identified based on their work portfolio or by recommendation of other respondents. Data collection involved questionnaires, in-depth expert-interviews, brainstorming sessions, focus group discussions, field observations and literature review among others. Interviewees were mid-level and senior officers from County Governments, National Government institutions, Development partners and donor organizations, Consulting firms, Non - governmental organizations, Civil society organizations and Faith based organizations, Academia and Research organizations. Respondents were coded by acronyms along with a numerical figure to anonymise yet retain traceability. Interviews were conducted in English and audio recorded, apart from one case in Busia county where permission was not granted. The Researcher employed rigorous methods of content analysis, which included classifying, organising and examining the data to make inferences about the patterns as given in Graneheim and Lundman [20]; and Strijbos et al., [21].

3.0 RESULTS AND DISCUSSION

3.1 Barriers to adapting water supply management to climate change in Nzoia River Basin

In an earlier study, Odwori [22], the strategies for adapting water supply management to climate change in Nzoia River Basin, Kenya had been identified and ranked using the total weighted scores in order of priority as: Water storage, Water efficiency and demand management, Water augmentation, Alternative water sources, Water allocation, Urban storm water management, Riverine flood protection, Hazard and risk assessment, Vulnerability assessment, Disaster response, and Early warning. Theses are the adaptation strategies that have been used to generate barriers to climate change adaptation in the present study. This study has identified barriers to adapting water supply management to climate change in Nzoia River Basin as shown in Table. 1.

Table 1: Barriers to adapting water supply management to climate change in Nzoia River Basin.

Adaptation strategy	Classification of barriers based on Ekstrom, J.A. and Moser, S.C, (2014)	Adaptation barriers	Ranking
➢ Water storage ➢ Water efficiency and demand management ➢ Water augmentation ➢ Alternative water sources ➢ Water allocation ➢ Urban storm water management ➢ Riverine flood protection ➢ Hazard and risk assessment ➢ Vulnerability assessment ➢ Disaster response ➢ Early warning	Institutional and governance	➢ Inadequate and conflicting policies ➢ Gaps in implementation of policies ➢ Lack of consistent and clear policy guidelines from county and national governments; Unclear roles of actors ➢ Poor governance and mismanagement of resources ➢ Bureaucratic and systemic deficiencies ➢ High institutional fragmentation coupled with lack of internal collaboration and cooperation ➢ Lack of involvement of user communities ➢ Lack of flexibility or rigid institutions/arrangements	**1**
	Resources and funding	➢ Limited financial and human resources; Limited budget ➢ Economic crisis of recent years where National treasury is not giving county governments enough development funds ➢ Frequent cuts and freezing of budgets by National government ➢ Competing developmental priorities; Lack of access to credit ➢ Competition for existing funds; High poverty levels	**2**
	Leadership	➢ Poor leadership ; Lack of leadership; Incompetent leadership ➢ Competing leadership; Focus on short-term issues ➢ Problematic/dominant leadership	**3**
	Politics	➢ Lack of political will/awareness; Rivalry; Turfism; Ulterior motives; Fear of opposition; Distrust	**4**
	Adaptation options/process	➢ Lack of guidance on adaptation options ➢ Lack of feasible adaptation options; Low levels of technology ➢ Low levels of infrastructure development ➢ Lack of access to su□cient water resources ➢ Local geographical landscape barriers/challenges ➢ Erosion of local knowledge systems on adaptation	**5**
	Science	➢ Lack of data on climate change ➢ Lack of local specificity or access ➢ Uncertainty about climate change and social change	**6**
	Understanding	➢ Lack of understanding of climate change science and impacts ➢ Unfamiliarity with existing data on climate change	**7**
	Technology/structural	➢ No feasible acceptable technology/structural solutions ➢ No affordable acceptable technology/structural solutions ➢ No environmentally acceptable technology/structural solutions	**8**
	Expertise	➢ Lack of relevant expertise among involved actors	**9**
	Attitudes, values and motivations of actors	➢ Lack of interest; Narrow self-interest; Status quo mindset ➢ Inability to accept change; Greed/selfishness; Lack of concern ➢ Poor attitudes, values and motivations; Passive attitude ➢ Inability to think long term	**10**
	Communication	➢ Lack of or miscommunication on climate change ➢ Lack of clear messages on climate change ➢ Lack of trusted messengers/Lead agency	**11**
	Personality issues	➢ Conflict with personal interests	**12**

3.2 Clustering barriers to adapting water supply management to climate change in Nzoia River Basin

The study classified the identified barriers into cartegories/clusters. This was done by first, conducting a detailed literature review to summarize studies clustering barriers into

cartegories as shown in Table 2. A lot of similarities exist on the methods used in clustering/cartegorising barriers by various scholars and studies as shown in Table. 2. This study has adopted the barrier cartegorization method used by (Ekstrom and Moser, 2014) where barriers to adaptations to climate change are put into twelve categories as follows: (1) institutional and governance, (2) attitudes, values and motivations, (3) resources and funding, (4) politics, (5) leadership, (6) adaptation options/process, (7) understanding, (8) science, (9) expertise, (10) communication, (11) personality issues, and (12) technology/structural [1]. This study has adopted Ekstrom & Moser, [1] clustering because this approach was used in the urban areas in the San Francisco Bay, USA, on adaptation of drinking water supply to climate change; and that the twelve categories of barriers listed here are very relevant to the identified barriers in Table. 1.

The classification of identified barriers to adapting water supply management to climate change in Nzoia River Basin have been classified based on Ekstrom & Moser, [1] and the results are shown in Table.1. After clustering/cartegorizing the identified barriers to adapting water supply management to climate change in Nzoia River Basin as shown in Table.1; the Researcher through focus group discussants ranked the twelve clusters/cartegories in order of priority for implementation in adapting water supply management to climate change in Nzoia River Basin and the results are shown in Table.1. The focus group discussion concluded the ranking order priority of clusters/cartegories for adapting water supply management to climate change in Nzoia River Basin as;

(i) Institutional and governance
(ii) Resources and funding
(iii) Leadership
(iv) Politics
(v) Adaptation options/process
(vi) Science
(vii) Understanding
(viii) Technology/structural
(vii) Expertise
(viii) Attitudes, values and motivations of actors
(ix) Communication
(x) Personality issues

During interviews with the carefully selected team of water and climate change experts, some barriers were reported more frequently than others; however, this should not be regarded as a clear indication of "importance," as it does not show the difficulty of overcoming a particular barrier. Instead, it's a measure of the variety of unique barriers inside a bigger class of barriers (for example, distinct barriers within the "governance" class of barriers).

Table 2: Summary of literature review on clustering of climate change adaptation barriers

Research basis	**Examples**	**Context**

Categories derived from frameworks	Four types of barriers grouped along the dimension of the operator and the means: (1) missing operator, (2) missing means, (3) unemployed means and (4) complex actor relations **(Eisenack & Stecker, 2012)**	-
	Four barriers framed by empirically rooted analytical lenses: (1) governance as problem solving, (2) governance as competing values and interests, (3) governance as institutional interactions, and (4) governance as dealing with structural constraints **(Biesbroek *et al*., 2014)**	-
	Four crosscutting issues: (1) leadership, (2) resources, (3) communication and information, and (4) values and beliefs **(Moser & Ekstrom, 2010)**	-
Categories derived from literature review and empirics	Seven types of barriers: (1) conflicting timescales, (2) substantive, strategic and institutional uncertainty, (3) institutional crowdedness and institutional void, (4) institutional fragmentation, (5) lack of awareness and communication, (6) motives and willingness to act, and (7) lack of resources **(Biesbroek *et al.*, 2011)**	The Netherlands
	Four types of barriers: (1) regulatory, (2) structural or operational, (3) behavioural or cultural, and (4) contextual or capacitive **(Burch, 2010)**	Urban municipalities in Vancouver
	Three types of barriers: (1) divergent objectives, needs, scope, and priorities; (2) different institutional settings and standards, and timeframes; and (3) differing cultural values, understanding, and mistrust **(Huggel *et al.*, 2014)**	Focus on sciencepolicy interface in the Andes region in South America
Categories derived from results of case studies	Twelve categories of barriers: (1) institutional and governance, (2) attitudes, values and motivations, (3) resources and funding, (4) politics, (5) leadership, (6) adaptation options/process, (7) understanding, (8) science, (9) expertise, (10) communication, (11) personality issues, and (12) technology/structural **(Ekstrom and Moser, 2014)**	Urban areas in the San Francisco Bay area
	Five types of barriers: (1) leadership, (2) competing priorities, (3) planning process, (4) informational and (5) institutional constraints **(Measham *et al.*, 2011)**	Urban municipalities in Sydney
	Many more, though similar categorizations **(e.g. Mozumder *et al*., 2011; van Stigt *et al*., 2015)**	Several

Taking all cases together, the most highly ranked barriers in this study were the Institutional and governance barriers. This cartegory of barriers consisted: Inadequate and conflicting policies; Gaps in implementation of policies; Lack of consistent and clear policy guidelines from county and national governments; Unclear roles of actors; Poor governance and mismanagement of resources; Bureaucratic and systemic deficiencies; High institutional fragmentation coupled with lack of internal collaboration and cooperation; Lack of involvement of user communities; and Lack of flexibility or rigid institutions/arrangements. "The Governance and institutional cluster is made up of barriers that are linked to the governance structure and the institutional environment," Moser et al. [23] explains. Structural and regulatory barriers are bundled together under institutional constraints. As a result, barriers related to physical organizations, as well as

regulations, rules, and norms that influence behavior, are included in this cluster".

Resources and funding was ranked second, and this cartegory of barriers consisted: Limited financial and human resources; Limited budget; Economic crisis of recent years where National treasury is not giving county governments enough development funds; Frequent cuts and freezing of budgets by National government; Competing developmental priorities; Lack of access to credit; Competition for existing funds; and High poverty levels. Resources are a significant aspect throughout the entire climate change adaptation process, according to numerous research [8, 24, 25, 26, 1]. Furthermore, Fussel [27] emphasizes the importance of resources in the development of adaptive capacity.

Leadership was ranked third, and this cartegory of barriers consisted: Poor leadership; Lack of leadership; Incompetent leadership; Competing leadership; Focus on short-term issues; and Problematic/dominant leadership. Leadership concerns are cited by a number of authors as a major stumbling block [8, 24, 28, 25, 26, 1]. Leadership is critical in all domains; it generates interest in adaptation, raises awareness, and pushes for institutional change so that action may be taken [29]. For example, Burch [24] discovered that leadership in municipalities might contribute to unique governance processes and, as a result, transform the decision-making framework. Furthermore, leadership is important at all stages of the adaptation process, but it is especially important in getting things started and keeping momentum going [8]. Leadership that is ineffective or incompetent, as well as problematic or domineering, can stymie the adaptation process and prevent others from engaging in adaptive behavior [8, 1].

Politics was ranked fourth, and this cartegory of barriers consisted: Lack of political will/awareness; Rivalry; Turfism; Ulterior motives; Fear of opposition; and Distrust. Erikson and Lind [30], as well as Ekstrom and Moser [31], emphasize the importance of political obstacles in both emerging and established countries when it comes to adaptation (e.g. Kenya and USA). The local urban level, according to Revi et al. [29], is particularly vulnerable to political obstacles since a large number of powerful interests are concentrated in a limited region.

Adaptation options/process was ranked fifth, and this cartegory of barriers consisted: Lack of guidance on adaptation options; Lack of feasible adaptation options; Low levels of technology; Low levels of infrastructure development; Lack of access to su□cient water resources; Local geographical landscape barriers/challenges and Erosion of local knowledge systems on adaptation; whereas; Technology/structural was ranked eighth with barriers as: No feasible acceptable technology/structural solutions; No affordable acceptable technology/structural solutions and No environmentally acceptable technology and structural solutions. "The two barrier cartegories are closely intertwined," writes Klein et al. [6], "and actors may seek guidance on where to begin adaptation, or which particular measures to take." When strategic long-term thinking and a broad perspective are lacking, for example, the diversity of techniques for local adaptation not only creates opportunities, but it can also make it difficult for players to identify the most appropriate and efficient solution. Furthermore, adaption measures are difficult to transmit. "Very often, the adaption process is based on best-practices, even though their real added-value is limited due to the extremely context-specific character of climate change adaptation," according to Cortekar et al.,[32]. Limited financial resources or differing environmental legislation, for example, can stymie a one-to-one implementation

of best practices.

Science was ranked sixth, and this cartegory of barriers consisted: Lack of data on climate change; Lack of local specificity or access; and Uncertainty about climate change and social change whereas; Understanding was ranked seventh with the cartegory of barriers being; Lack of understanding of climate change science and impacts; and Unfamiliarity with existing data on climate change. Expertise was ranked nineth with the barriers as: Lack of relevant expertise among involved actors. The three barrier cartegories are intricately connected. Science and scientific understanding are two cartegories of barriers that are closely related. The importance of scientific knowledge in the process of urban development decision-making has been hotly disputed [24]. As a result, the sixth and seventh clusters are concerned with scientific knowledge and understanding. Barriers might result from the need for or uncertainty of expert knowledge, the fact that decision-makers and scientists belong to different epistemic communities, and the logic and linearity with which decisions are made [24]. As a result, data accessibility and availability, as well as comprehension are important [8, 31, 24]. Local information, in addition to professional knowledge, can be equally important, and disregarding it may be a barrier to adaptation [33, 24]. Many scientists and practitioners say that the uncertainty of predicting future climate is a barrier to climate change adaptation [34,31].

Attitudes, values and motivations of actors was ranked tenth with the barriers as: Lack of interest; Narrow self-interest; Status quo mindset; Inability to accept change; Greed/selfishness; Lack of concern; Poor attitudes, values and motivations; Passive attitude and Inability to think long term. Personality issues was ranked twelveth with the barriers as: Conflict with personal interests. These two types of barriers are inextricably intertwined. The Attitudes, Values, and Motivations cluster is based on multiple research that argue that social and cultural restrictions are a major factor in climate change adaptation. Burch [35] refers to behavioural obstacles that take into account the personalities of people in key positions as well as the cultures of different groups within the institution and municipality. Societal ideals, worldviews, cultural norms, beliefs, and behaviors are all influenced by social and cultural influences [6]. Deeply held characteristics, pre-existing values, conventions, and beliefs have a significant impact on the adaption decisions undertaken. These social and individual factors influence how people perceive risk, how they explain and think about climate impacts, what information and knowledge they consider, what adaptation options they choose, and, ultimately, why actors choose to engage in adaptive behavior and the factors that lead to or impede it [34,8], for example, review recent research findings, demonstrating that a variety of factors influence how knowledge is viewed, including the role of conventional knowledge, political affiliation, educational background, and trust placed in various information sources. As a result, cognitive filters influence actors' perceptions, constrain their attitudes toward adaptation measures, and so influence decision-making processes [23].

Communication was ranked eleventh with the barriers as: Lack of or miscommunication on climate change; Lack of clear messages on climate change; and Lack of trusted messengers/Lead agency. It is critical to inform the general public, as well as other organizations and levels of government, about the effects of climate change, adaptation methods, and their implications [8]. The public, stakeholders, and other

decision-makers are kept in the dark regarding their roles and adaptation efforts thus far due to a lack of communication. As a result, excellent communication is critical, as it will raise awareness and comprehension, provide consistency, and positively engage all policymakers, stakeholders, and the general public [8, 36]. The relevance of social and political awareness is strongly emphasized in climate change adaptation literature. Furthermore, diverse media have an impact on a society's degree of consciousness, which can be both positive and harmful [36].

3.3 Strategies used to overcome barriers to adapting water supply management to climate change in Nzoia River Basin

The study established strategies used to overcome barriers to adapting water supply management to climate change in Nzoia River Basin as shown in Table. 3. The strategies used to overcome barriers vary depending on the situation as well as the type of hurdles encountered. The communities in the Nzoia River Basin have specific resources, assets, and advantages that enable them avoid or overcome certain barriers. Existing science (research on climate change and adaptation is under way in a number of Kenyan universities and research institutes using existing data; vulnerability assessments are being done, and IPCC reports offer valuable support); ongoing climate change mitigation and/or sustainability (a number of water supply infrastructure was found to be under construction by both the national and county governments); strong leader (e.g. for upgrading infrastructure or bringing adaptation into the planning processes). These existing relevant policies and planning processes, as well as their current pace, are a strong evidence that adaptation is moving forward. Table 3 shows that there is no template or "one-size-fits-all" solution because local actors confront a unique set of challenges based on local variables and desired outcomes. In general, there is no such thing as a universal adaptation plan because local needs must be determined before actions can be tailored to the specific goal [32]. "Several solutions have been explored to overcome or circumvent barriers to adaptation," according to Moser & Ekstrom [31].

Prioritization of no-regrets and methods with co-benefits that are politically possible are the most important strategies used. Such tactics aid in the removal of a wide range of barriers (related to attitudes, lack of awareness, science, conflict of interests, resources, institutions and politics). The other most essential technique is to raise awareness among employees, the general public, agency executives, and politicians; education and training, as well as workshops and public events, can help to overcome barriers caused by a lack of understanding and attitudes. Actors ensure that climate change adaptation is not forgotten in their current duties by addressing such tactics on a regular basis, which creates support and acceptance for adaptation. Changes in structure and policy, collaboration and coordination, scientific research, leadership, and communication are all important complementary ways for overcoming a variety of barriers.

Table 3: Strategies used to overcome barriers to adapting water supply management to climate change in Nzoia River Basin

Classification of barrirs based on Ekstrom, J.A. & Moser, S.C, (2014)	Strategies for overcoming barriers
Institutional and governance issues	**Structural and policy changes** ➢ Reorganization of agencies/restructuring functions; Development of integrated approaches; Setting new standards ; Enacting new laws/legislation; Enforcing the new legislative framework. **Cooperation and networking** ➢ Cooperation among divisions/agencies/units (internal) ; Cooperation among Counties/ cities/across jurisdictions and scales (external); Networking (informal relationship-building); Setting up a bridging institution; Coalitions among agencies **Coordination** ➢ Bringing everyone to the round table; Involving everyone in the process and giving them the possibility to contribute; Timing
Resources and funding	**Funding and financing** ➢ Cost-sharing; Applying for funding programmes (writing and competing for grants) **Staffing** ➢ Employing new staff/adding capacity; Assigning staff to climate change activities **Lobbying activities** ➢ For additional resources and finances for climate change activities
Leadership	**Leadership** ➢ Taking the leadership; Identification with his/her work; Going beyond the call of duty
Politics	**Political manoeuvring** ➢ Showing possible opportunities for adaptation; Breaking big problems into smaller ones to convince politicians for greater support and resources; Attracting political support
Adaptation options/process Technology/structural	**Prioritization** ➢ Setting policy priorities; Focus on options which are economically, environmentally and politically feasible; Focus on strategies that provide added-value/that have adaptation co-benefits; Focus on no-regrets; Focus on synergies; Focus on win-win strategies; Focus on strategies within own jurisdiction **Lobbying activities** ➢ At the national and county levels for adaptation options
Science Understanding Expertise	**Scientific research** ➢ On climate change impacts/adaptation; Assess vulnerabilities/risks/local climate; Disseminating information, including free access to climatic data **Monitoring** ➢ Data gathering and monitoring climate change options **Self-education and learning**
Attitudes, values and motivations of actors Personality issues Communication	**Awareness raising (political, public and among staff)** ➢ Organizing public events; Information campaigns; Direct involvement of the public; Workshops; Education; Showing successful results and showcases; Projects, etc. **Communication** ➢ Strategic framing of climate change adaptation (linking global change to existing priorities, combining global problems to local interests, presenting chances of adaptation); Translation of scientific data into understandable language (for planners) **Information sharing**

Most strategies, according to the literature, are essentially solutions that address the stated barriers. Participation in research programs is seen as a key method for raising awareness among employees, the general public, and politicians, and it aids in the removal of barriers connected to a lack of knowledge and attitudes. To overcome many institutional barriers, climate change adaptation must be integrated into ongoing processes, activities, and networks. According to interviewees, climate change adaptation research programs generally encourage integrated approaches, and thus present a unique opportunity to involve everyone in the process, both inside and outside the administration, increasing cooperation, learning outcomes, and putting climate change adaptation at the top of the

priority list.

Political maneuvering and lobbying at higher levels of government to ensure that politicians are included in the adaptation process, as well as applying to financing programs and competing for grants, are all crucial steps in overcoming adaptation barriers. So far, only a few research have looked into how troublesome barriers can be addressed. Some analyses of situations where adaptation is already underway reveal enabling characteristics that either prevent barriers from arising or assist players in overcoming them [31]. Integration of adaptation into other policies (sometimes referred to as 'mainstreaming'), such as including climate change projections in water management, urban planning, or health, is a critical step toward overcoming barriers [6]. Adaptation planning might be sparked by major events or significant climatic variability. Extreme occurrences provided policy windows for adaptation in the United Kingdom, Sweden, and Finland, according to (Keskitalo, et al. [37]. Building internal capacity (for example, generating a knowledge base among staff, analyzing risks, increasing internal communication, and forming collaborative relationships) has been a common theme in much of the observed adaptation to date [31]. Barriers can be resolved by informal relationships, formal interagency working groups, national and international policies, defined duties assignments, and concomitant monitoring procedures.

Local adaptation can be stifled by top-down intervention. National policy must include local situations since they are likely to supplant local initiatives. Although most research advocate strategies to address barriers (e.g., Eisenack et al [1]), there are few empirical studies on interventions. Burch [35] is an outlier in that he offers five steps for overcoming barriers by transforming them into enablers of adaptive action, but he does not categorize techniques for doing so. The limitations of our existing understanding on overcoming barriers, according to Eisenack et al. [1], are linked to the restricted state of the art in systematically explaining barriers. Therefore, this study provides a first step towards identifying barriers to adaptation and formulating strategies to help circumvent or overcome those barriers.

4.0 CONCLUSION

Climate change is clearly affecting the management of water resources in the Nzoia River Basin, albeit this is backed up by other causes such as land use change, deforestation, mining, and increased water demand. Climate change impact research, farmer advice, high-quality hydrological data collection, long-term climatic variables trend analysis and preferring larger and perennial sources for new drinking water supply projects, and rejuvenation of catchments through watershed management are just a few of the water management adaptation activities undertaken by water sector stakeholders in the basin. These actions and programs are focused toward adapting the region's water resources to climate change, despite the fact that they are not specifically labled as adaptation. This study (1) identified barriers to adapting water supply management to climate change in the Nzoia River Basin, (2) classified the identified barriers into cartegories/clusters, and (3) identified strategies for overcoming such barriers to adapting water supply management to climate change. Despite the fact that these barriers are similar to those observed elsewhere, they have significant regionally contextual root causes. Individual barriers are shown to be highly interconnected and interdependent, allowing for the

discovery of leverage areas for actions to maximize barrier elimination.

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