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Application of Community Climate Change Adaptation Assessment Tools for Climate Adaptation Planning in Yala Wetlands Complex, Lake Victoria Basin, Kenya

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Abstract

Yala Wetland is a complex of Nzoia and Yala rivers that drain their waters into Lake Victoria, but face various pressure which is thought to originate from the impacts of climate change. The riparian communities are generally poor and use the wetland resources for small-holder livelihood activities. This paper describes how community climate change adaptation assessment (C3A2) tools were applied to identify resilient community-level adaptation options and would inform local climate adaptation planning. Eight participatory C3A2 tools were applied for data collection in which two (adaptation attributes and story-telling) were administered at the meso or local government (County) level while all the eight tools (community protocol, risk mapping, techno-transect, resilience ranking, community calendars, story-telling, adaptation attributes and give back) were administered at the micro or community level. Qualitative research method was adopted and 80 respondents (20 at meso and 60 at micro) were purposively selected for the study. Data were collected through interviews, focus group discussions (FGD), and plenary discussions. Data were analyzed at four levels: pre-analysis in situ, daily team triangulation, team conclusions, and cross-community reporting. The study found that communities experienced climate risks that tended to shift along with prolonged and irregular hydro-meteorological events, which affected their capacities for adaptation especially the resource-constrained individuals and vulnerable households. Drought (45%) and flood hazards (39%) were the most felt strongly. Drought was manifested mainly by prolonged dry-spell, increased atmospheric temperatures, and strong winds while floods were characterized by unpredictable and short but high-intensity rainfall with associated loss of lives and property damage. Women, children, and poor households were the most exposed to climatic hazards. Farm/agro-forestry was the most perceived adaptation strategy for drought, flood, and soil erosion while alternative livelihoods particularly ecotourism was the commonly perceived adaptation strategy for human-wildlife conflict (HWC). Three community-based adaptation action plans (CBAP) were prepared to guide future village-level planning and development. The CBAPs were used to identify three sample projects which were funded by the donor and implemented by the community. The C3A2 approach provides adequate participatory tools that can be applied in the lake and river basins, and potentially other ecosystems to guide the development of community-based adaptation plans and resilient community-based adaptation projects with wider local acceptance especially those geared towards designing programs for climate-smart livelihoods. However, the application of the methodology may be site-specific and the tools can be administered based on local scenarios and the availability of resources.

Keywords

Climate Change, Adaptation, Climate-Smart, Yala Wetlands, Lake Victoria, Livelihoods

1. Introduction

Global climate change is a threat to sustainable development and has brought adverse effects on the physical, biological, and human systems by altering the hydrological cycle resulting in temperature changes and rainfall patterns [1] [2]. Climate change is of considerable concern to economic development and human societies since it affects ecosystem productivity [3] and agricultural production [4]. Sub-Saharan Africa, for example, is highly vulnerable to the changing climate mainly because of its low adaptive capacity in relation to and exacerbated by recurring drought, inequitable land distribution, poverty, crop failures as a result of overdependence on rain-fed agriculture, water scarcity issues, and diseases [5] [6]. In East Africa where Lake Victoria, the second largest freshwater lake in the world is situated, high population densities and poverty rates have rendered the region a climate change hotspot making it most relevant for adaptation planning [3]. Already, East African countries are some of the most affected in the world in relation to food insecurity because of climate change and variability [4].

In Kenya, current climate change projections suggest that between 2000 and 2050 the temperature will rise by 2.5˚C while rainfall will be less predictable and more intense making the country very vulnerable [7]. This has the potential for major challenges for agricultural and ecosystem productivity with the slightest increase in the frequency of floods and drought events in many parts of the country hence impacting food security and livelihoods. The impacts pose inherent risks to the local population and natural resources. These risks include droughts, floods and mudslides, and economic losses in agriculture, energy, and infrastructure. Droughts and floods in particular have a direct impact on local livelihoods because they cause failure and damage to crops and livestock leading to chronic food shortages. Drought for example has a direct impact on agriculture [8] and is one of the key challenges arising from climate variability for ecosystems and human society [9], more than any other natural hazard [10]. Changes in rainfall patterns and amounts have also led to the loss of crops and reduced livestock production accelerating poverty and threatening food security. The loss of livelihoods and reduced agricultural production have resulted in human encroachment into wildlife habitats especially wetland and forest ecosystems leading to the draining of wetlands, deforestation, and human-wildlife conflicts. Besides, climate change could be responsible for habitat loss and impacts human livelihoods pushing humans to unsustainable utilization of natural resources.

Adaptation is one of the key approaches to addressing climate change impacts. The impacts can also be addressed by implementing flexible measures that result in benefits even in the absence of climate change through short-term investments and the adoption of low-cost safety margins that account for uncertainty [11]. Adaptation measures reduce the climate risks to lives and livelihoods and increase the resilience of communities to all hazards. Adaptation to climate change and development strategies needs to account for possible climate change impacts, even in regions with high uncertainties [3]. This calls for flexibility in methods of agricultural production, market integration, and diversification of income. There is a need to also identify and execute climate-smart initiatives that may reduce vulnerability to the risks associated with climate change, enhance low carbon growth and promote sectoral development.

Managing climate risks requires an understanding of historical interactions between society and climate hazards. These include awareness of the local coping strategies, community level of vulnerabilities, local attitudes to innovations, and developing community capacity to adopt them. It is also important to clearly understand what is happening at the community level because adaptation is largely site-specific while local livelihoods have been rendered most climate vulnerable. The goal of this study was to administer the C3A2 toolkit to collect sufficient evidence from local communities to inform climate change planning and identification of adaptation options for village-level implementation in the Yala wetlands. In this study, we used the C3A2 tools to answer the following set of questions: How are climate variability and change perceived by wetland-dependent communities, which events are felt most strongly, and who are the most exposed entities? Which adaptation options are perceived by communities as most viable and how can communities use the participatory tools to plan for adaptation actions?

2. Methodology

2.1. Study Area

Yala Wetlands (00˚02'N, 00˚02'S and 34˚1É, 34˚7'S) situated at an altitude of 1150 m above sea level is a designated Important Biodiversity Area (IBA) and a Biodiversity Significant Area (BSA) in the Lake Victoria Basin, Kenya [12]. It is the largest papyrus-dominated swamp and freshwater wetland in Kenya covering an area of 175 km^2 forming a delta of rivers Yala and Nzoia. It contains three freshwater lakes, Kanyaboli, Sare, and Nambonyo. These lakes contain some endemic haplochromine fish species, some of which are no longer found in Lake Victoria and are highly threatened with the danger of extinction. The wetland also provides critical habitats for various species of birds, mammals, reptiles, and fish. The area has two rain seasons that is between March-May and October-November. The area experiences an annual mean average temperature of 21.85˚C with a mean minimum temperature of 15.8˚C and a mean maximum temperature of 27.9˚C. The site experiences long sun hours of a mean average of 9.42 with an average wind speed of 7 km/day. The Lake Victoria basin has a highly dense population estimated at approximately 1200 persons per km^2, arguably comprising the densest rural population globally [3]. Communities inhabiting the wetland are generally poor and highly dependent on the wetland resources where they derive their livelihoods from subsistence farming, fishing activities, papyrus harvesting, and small-scale trading.

2.2. Data Collection

The descriptive research design was used for the study and purposive sampling was used to select three communities (Barolengo, Hawinga/Kaugagi, and Nyadorera) within Yala wetlands, which were assumed to be the most exposed to climate risks within the wetland. Data were collected using Community Climate Change Adaptation Assessment (C3A2) toolkit. The toolkit was applied at two levels, meso, and micro scale. The meso level involved data collection from government administration and civil society players at the county level (Siaya County) while the micro level entailed data collection at the community scale. Eight tools were used to collect data in each community while caution was taken not to mention the word "climate" in order not to pre-empt the findings. Out of these, two instruments (County Story Telling and Adaptation Attributes) were administered at the meso-level. At the community level, the following instruments were used: community protocol, risk mapping, techno transect, resilience ranking, community calendars, community storytelling, community adaptation attributes, and giving back.

Prior to actual data collection, three researchers were trained on the use and application of the C3A2 toolkit. The toolkit was administered through a series of qualitative and descriptive data collection methods at both levels. Each researcher was assigned responsibility by the lead researcher to ensure the maximum acquisition of data and efficient time usage, although their responsibilities were rotational between facilitation and note-taking or observation. Teamwork was encouraged among the team members. Those not engaged in direct facilitation were advised to be very attentive in order to capture additional information and make observations on what might be missed out. Captured evidence (data/information) was recorded in predesigned data sheets and notebooks during the administration of the instruments. A total of five days excluding the day of travel to the study area was used to administer the C3A2 tools in each study community, while the sixth day was dedicated to the compilation of C3A2 information and results by the researchers. Focus group discussions (FGD) were used to capture evidence for five of the instruments. Other methods included interviews for techno transect and storytelling while community protocol and give back was administered through plenary sessions with the community.

The data collection tools summarized in **Table 1** below were modified from the protocols of [13] based on the local community settings as follows:

Table 1. Summary of instruments used in C3A2 methodology and the results/outputs.

C3A2 Instrument	Data Collection Methods/tools	Results/Outputs
County Story Telling	Interviews	• At least 20 stories entered into the database • Data comparable across communities in MRB
County Adaptation Attributes	Two FGDs: Government, Civil Society	• Quantitative data captured and recorded • Notes on examples and exceptions recorded
Community Protocol	Plenary discussions, all-inclusive	• General history about the community outlined and recorded
Risk Mapping	Two FGD: Hazard, Risk & Vulnerability mapping	• 2 Maps (Hazard and Vulnerability Maps) • 1 Risk Map
Techno Transect	Mobile interviews Photography	• Annotated photos depicting community hazards, vulnerability, and adaptation capacity
Resilience Ranking	FGD	• Household welfare characteristics, names, notes on community mobility, wealth rankings, etc.
Community calendars	Two FGDs	• 2 calendars (Activity and Events calendars) • Important risks ranked, Notes on respective risks
Community Story Telling	Interviews	• At least 48 stories entered into the database • Data comparable across communities in MRB
Community Adaptation Attributes	FGD	• Data-entry forms filled on Adaptation Attributes • Notes for exceptions recorded • List of proposed interventions
Give Back	Plenary discussions, all-inclusive	• Preliminary results of C3A2 surveys • Proposed interventions shared
Compilation of C3A2 results	Data cleaning, data compilation, debates on results, overall triangulation, summaries, and conclusions	• Initial draft results of C3A2 assessments per survey community • Summaries, conclusions on recommendations on various aspects of C3A2 • Focus on the next hotspot community
Community-based adaptation action plans (CBAPs)	Plenary discussions, all-inclusive	• Hazards identified and prioritized • Adaptation options identified per hazard • At least one actionable community project identified for implementation by the donor or development partner

1) *Community protocol* lasted about one hour and involved the general participation of all (women, men, youth, community leaders and the elderly, and all researchers/facilitators) in a community meeting setup. The researchers provided the foundation (introduction, objectives, and process) of the study and engaged the community to answer general questions related to the local history, health, environmental, social, food security, and infrastructure profiles. Anecdotic observations were also made during the discussion sessions and comments were recorded.

2) *Risk mapping* involved focus group discussion and mapping. Twenty community participants and six researchers were involved, ten community members and three researchers each for the hazard map and vulnerability map, which were produced simultaneously. In this tool, we defined hazard as a threat or an event that originates from outside the community but has the capacity to negatively affect the local livelihoods or inflict pain that is detrimental to individual lives. The vulnerability was defined as the community condition that defines their capacity to move back to their initial status after a shock. The hazard map portrayed the relationships among settlement patterns, land/resource use, the available infrastructure, natural resources inventory, and the features associated with major environmental changes. The priority hazards were also ranked based on the community perceptions on the hazard map. The vulnerability map detailed the general vulnerability and capacity of the local community to protect their livelihoods and lives from the threats, and how this had changed over time. The variables considered included socio-economic profile, local leadership institutions, accessibility to services, water, and land access, access to energy, access to communication services, and availability and usage of educational, health, and administrative institutions. The participants in each group presented their work to each other that elicited corrections, additions, and comments on each of the maps. Finally, the two maps were compared and overlaid, and the final risk map was produced with information from both maps. The mapping information was crucial as the foundation for ranking hazards, households' vulnerability, and community capacities.

3) *Techno transect* involved a combination of participatory photography with traditional transect walks. Two researchers and two talkative but respected individuals within the community were identified among the ten community members to guide the techno transect team. Outdoor observations and problem areas on the outcome of the introductory community protocol and mapping activities were made in the field. The researchers made observations and necessary inquiries on the areas of exploration, provided assistance with photographic technology, which was preferably taken by one community guide, and noted the contents and meaning of the photos. Field observations were made on differences in various livelihoods, hazards and vulnerabilities, access to resources, resource use patterns and conflicts, and climate change interventions or mitigation strategies. A transect map was drawn detailing the observations along the transect lines.

4) *Resilience ranking* was used to explore the power relationships within the community and help them define resilience in their own local understanding

and perception. It provided a framework for sampling participants who would be engaged in the storytelling tool. We defined resilience as the capability of individuals or the community at large to bounce back into strength, shape, and elasticity; and the ability to quickly recover from challenges related to climatic variability and change. With the help of community leaders, we carefully identified 12 participants including both men and women who had a wide knowledge of the community and were neutral. We explored the word resilience and asked the participants to mention word(s) that would be used to describe it in the local language without referring to the word wealth. Differential resource's impact was also defined and described to show how different households respond to different shocks and what the different households own that may or may not make them resilient. To allocate the different households within their respective resilience groups, piling using beans (representing the household numbers within the community) was conducted whereby the participants identified 3 to 4 resilient groups within the community and piled beans by putting all households with similar resilience levels in one pile. The characteristics of each group or what made them different from other groups were discussed including housing types, education levels, access to health services, transportation, etc.

5) *Community calendars* were used to fit within an annual flow the knowledge of activities and events/hazards and to explore systematically strategies, constraints, and perceptions of the local community. The tool was divided into two; activities calendar detailing livelihood activities, adaptation, and coping strategies, and an events calendar outlining main hazards like famine, drought, floods, fire, etc. The two calendars were prepared by two groups composed of 12 diverse members representing different resilience groups, gender, and livelihoods, and two researchers each. The results were shared in plenary where the underlying logic was discussed in a multi-sectorial setting. While administering the tool, various guiding questions were asked to get community perspectives including how the activities and hazards have changed over time (past and present), the most important hazards that are related to climate change, the relationship between activities and hazards, need for diversification of community livelihoods, the activities which should be enhanced or discouraged and opinion on future perspectives by the community.

6) *Storytelling* was used to capture stories related to change within the community and interpret them to understand the relationship between the stories and climatic changes. Forty-eight individuals living within the community were carefully sampled based on gender, age, resilience group, type of livelihood activity, etc. The story-telling interviews (eight per researcher) lasting about 30 minutes, were independently organized by each researcher within the research period and at the convenience or availability of the respondents. Following the recommendation by USAID [13], the participants were asked the question, "*Tell a story about any change you have noticed recently in your community* (*good or bad*) *and especially how you*, *or anyone you know about*, *have adapted to that change*." The story details were uploaded on the global giving storytelling project

(https://goto.gg/s/550).

7) *Adaptation attributes* were used to explore the enabling or foundational resilience factors that determine the capability of communities for climate change resilience. We defined resilience as the capacity of the community to adjust to or cope with and transform to uncertainty and change. The tool was used to identify interventions and coping mechanisms with high potential to lead to sustainable change and the ability of the community to bounce back. Twelve mix-group participants consisting of both genders, local leaders, and elders with a wide knowledge of the community were carefully selected. The process was guided by all six researchers who dug in for evidence in relation to the information provided in the previous tools administered. The seven resilience attributes were discussed, and the participants were asked to gain consensus and decide whether the community would categorize each of the attributes as strong, medium, or weak with specific examples providing the evidence.

8) *Give back* was the final tool that aimed at giving thank you a message to the local community members for participating in the process. Like the community protocol, all community members who participated in the research, those willing to attend the final session, and all the researchers participated. All researchers presented to the community a summary of what they had learned and how the information collected would be used for research purposes.

3. Data Analysis

Four levels of analysis were performed on the C3A2 data: pre-analysis in situ, daily team triangulation, team conclusions per community, and cross-community reporting. *Pre-analysis in situ* involved leading the research participants of an activity to make insightful conclusions themselves, based on their own reviews in comparison to what was recorded. Daily *team triangulation* was facilitated by the lead researcher every evening, which elicited debates on the most important stories of the day. One extra day was spent by the research team within the community to compile the results and make conclusions before starting on the next community. Validation meetings were conducted at the meso level and one each at the study communities. The validation meetings were meant to share and authenticate the information collected from the community during C3A2 surveys through a participatory process, fill in the identified gaps in the previously collected data, improve local ownership of the C3A2 results, and act as a precursor for the development of community-based adaptation action plans (CBAP) for priority hazards. The CBAPs were used for participatory identification of one community-level adaptation project funded by the donor (PREPARED Project) in the study communities.

4. Results and Discussion

4.1. Identification of Climatic Hazards

Climatic hazards identified by the community included drought, floods, soil erosion, and human-wildlife conflict (HWC) (Table 2). The HWC was classified as a climatic hazard since its increase in the study area is linked to climatic changes. Other hazards mentioned such as strong winds, hailstones were insignificant.

Table 3 indicates that the results from storytelling sessions from micro and meso levels followed a similar trend.

4.2. Hazards Ranking and Local Perceptions

Drought

Drought was ranked the number one hazard across the three villages. The community defined drought in different ways by describing the manifestations associated with drought. For example, changes in weather patterns necessitated long waits for rainfall before the commencement of crop planting. Other definitions of descriptions of drought conditions included increased intensity of sunshine, increased atmospheric and lake water temperature, and increased incidence of prolonged dry spells. Results from community calendars indicated that the community also experienced frequent droughts characterized by longer dry seasons as compared to the past when it used to occur once after several years. Drought is now experienced almost yearly, and it is more severe from December to March indicating changing climatic patterns. This has resulted in changes in planting seasons calling for seasonal adjustments by local small-holder farmers. Other negative impacts of drought included food shortages hence malnutrition and hunger, crop destruction, human diseases e.g., whooping coughs, water shortages, and the disappearance of some fish species among others. The findings are supported by [10] whose studies on drought perceptions among smallholder farmers in semi-arid Kenya indicated that drought decreased agricultural productivity,

Table 2. Frequency of main hazards reported by three villages in Yala wetlands.

Hazard	Barolengo	Hawinga/ Kaugagi	Nyadorera	Total	Percentage
Drought	29	36	15	80	45
Flood	20	14	36	70	39
Human-wildlife conflict	6	8	3	17	9
Soil Erosion	5	2	6	13	7

Table 3. Frequency of stories told by respondents at micro and meso levels.

Story category	Micro/community level			Meso/county level	Total	Percentage
	Barolengo	Hawinga/ Kaugagi	Nyadorera	Siaya county		
Drought	31	29	10	11	81	41
Flood	5	10	39	6	60	30
HWC	14	18	7	2	41	21
Soil Erosion	10	3	4	1	18	9

increased hunger for humans and livestock, caused human and livestock deaths and relocation, drying of rivers, diseases for crops, livestock and humans, and conflicts. However, the respondents observed that drought contributed to an increased abundance of haplochromine (locally known as *fulu*) fish species since most of their larger predator fish species like African sharp-tooth catfish (*Clarius gariepinus*) and Nile Perch (*Lates niloticus*) go into hiding during drought.

Although the drought was recognized as a natural phenomenon, the majority (87%) of respondents believed the phenomenon is accelerated by human activities particularly cutting down vegetation. This vice is commonly witnessed nowadays while in the past vegetation cover was adequate to control some of the drought impacts. Many authors [14] [15] [16] have found that there is evidence that anthropogenic activities increase the intensity, duration, and frequency of drought although the impacts of climate change have been thought to be attributed to extremes of temperature and precipitation. Drought conditions were also accelerated by inadequate access to varied sources of water despite the growing human population leading to overuse and pollution of water sources by agricultural activities like livestock and crop cultivation within the wetland areas. This observation is consistent with [8] who concluded that the effects of drought vary in developing countries significantly and are dependent on the economic and political ability of the communities, groups, or individuals affected to respond to the drought impacts. Comparatively, the local population cultivated indigenous crops e.g., millet, cassava, sweet potatoes, and indigenous vegetables, which tended to be drought tolerant. This change in agricultural practices is consistent with the findings of [10] who concluded that smallholder farmers in semi-arid Kenya cope with drought effects by diversifying their livelihoods for short-term and long-term responses. [17] also observed that in response to drought, smallholder farmers would prefer the adoption of shorter-term coping strategies than sustainable longer-term strategies due to their resource and capacity challenges resulting in maladaptation.

Floods

The community defined flooding as a phenomenon characterized by a period of long rains lasting two months (mid-April to mid-June). The flood effects were manifested by changing seasons characterized by unpredictable rainfall and poor weather forecasts. The presence of rivers Yala and Nzoia which drain significant quantities of water into Lake Victoria and Huiro stream within the vicinity of the community would be attributed to the hydrological regimes within the wetlands. The impacts of floods included the destruction of crops resulting in hunger and malnutrition, destruction of property including homesteads, loss of pastureland for livestock, destruction of infrastructure including roads, and canals, and clogging of irrigation pipes. These effects have a direct impact on food security. In their assessment of the effect of flooding on food security, [18] observed that among those who experienced food security in Africa, approx. 12% of them were affected by flooding, simultaneously degrading food security at the local scale. The effect of floods on infrastructure is supported by the findings of [19] who pointed out that the occurrence of floods exposes infrastructure to further risks of deterioration consequently increasing the costs of their maintenance. Other effects of flooding included the destruction of sanitary structures leading to the sinking of pit latrines, and the spread of water-borne diseases such as cholera, typhoid, and bilharzia. The filling of quarry holes by flood waters has led to the danger of drowning and providing potential habitats for mosquito breeding that spread malaria. These findings are consistent with those of [20] who observed that floods cause direct effects on human health and well-being due to the vulnerability of poor households in flood-prone areas. [21] also observed that there is a potential relationship between floods and the spread of infectious diseases. Floods also affected local trade and businesses due to the lack of accessibility in many areas which leads to an increase in commodity prices.

Flooding was enhanced by two main factors. Natural factors included topography mainly low-lying and flat landscapes, nearness to water bodies like rivers, streams, and lakes, high intensity, and long rainfall hours. This finding was consistent with those of [22] who in their analysis of causes of flooding and vulnerability in Nigeria discovered that the key factors influencing flooding included rainfall, elevation, drainage density, and distance from the drainage network. Secondly, human activities accelerated flooding effects in the community. This resulted from high population densities which increased anthropogenic activities such as encroachment into and clearance of riparian vegetation along water bodies for settlement and farming. The findings of [23] confirm that the key drivers of flooding risks include anthropogenic, natural, and institutional factors, which increase human vulnerability to floods. Our findings indicate that in the past, the human population was low in these localities indicating that encroachment into the wetlands could be a critical factor accelerating flooding effects. This is because people have since cleared vegetation to engage in livelihood activities and settlement hence destroying the flood-buffering capacity of riparian vegetation. This finding supports the observations of [24] who reiterated that the biggest threat to wetlands emanates from dimensionless anthropogenic and increasing human activities, which lead to the transformation of wetland ecosystems by harvesting wetland goods to support human livelihoods. This potentially alters the hydrological regimes of catchments and wetland ecosystems leading to increased flooding that enhances the vulnerability of wetland-dependent communities.

Human-wildlife conflict

Human-wildlife conflict (HWC) (9%) was the third most common hazard. Its increase in the study area was linked to climatic changes and hence classified as a climatic hazard. Results of adaptation attributes at the meso level revealed that approx. 80% of wildlife mortalities and local species extinction resulted from direct kills emanating from HWC and habitat destruction while 20% were attributed to natural causes. As observed by [25], HWC emanates from the occupation of humans and wildlife who seek to obtain limited resources on the shared landscapes resulting in injuries, property (crop and livestock) damage, loss of lives, etc. hence contributing to the loss of biodiversity. This position is also supported by [26] who argue that climate change leads to the alteration of wildlife habitats hence wildlife tends to migrate to new areas, some of which are occupied by humans, as an adaptation measure. Many stories (**Table 2**) on HWC originated from Hawinga/Kaugagi and Barolengo where massive encroachment of wetland habitats had been witnessed. Wild animals in constant conflict with humans included wild pigs, hippos, monkeys, squirrels, and snakes. Wild pigs (41%) were the most problematic and destructive animals to crops followed by monkeys (27%), squirrels (16%), hippos (10%), and crocodiles (7%). Snakes and wild pigs mainly caused injuries to humans during drought while hippos mainly attacked human beings during floods. The findings are supported by the study of [27] who categorized the most common HWC types to include crop raiding, attack on human beings, and livestock depredation. The community believed that the population of the rare semi-aquatic antelope (*Tragelaphus spekii*), locally known as sitatunga, had reduced drastically by 85% in the wetlands mostly because of poaching (59%) and papyrus habitat destruction (41%). The finding is consistent with those of [28] who reported that Sitatunga is a highly endangered tropical semi-aquatic antelope due to wetland habitat loss and poaching.

Soil erosion

Results of techno transects revealed that soil erosion was extremely rampant with increased intensity of rainfall and during flooding events. The community reported that current prolonged rainfall lasting four months from March to June had been received in the last couple of years. However, the past trend as reported in the events calendar indicated three months (March to May) of normal, predictable, and less intense rainfall. As observed by [29] in their climate projections, soil erosion will continue to be accelerated in East Africa by rainfall intensity that exposes many areas to erosion risks. Soil erosion was accelerated by the nature of the land adjudication process in the study area. During community protocol, it was pointed out that land subdivision and demarcation were done from uplands stretching downstream to wetland areas by the then Ministry of Lands through the Provincial Administration in 1972. This created long land stretches that have led to soil erosion since it promotes longitudinal ploughing from uplands to wetlands accelerating soil erosion, contrary to contour ploughing which promotes soil conservation. The results from the resilience ranking indicated that land adjudication also promoted social divisions within the community. The poor sold their fertile land in the downstream wetland areas to the rich who established permanent homes that are climate resilient. However, the fallow lands in or adjacent to wetland areas are encroached on by the poor for farming and settlement using less resilient temporary or semi-permanent houses. The other poor occupy and cultivate the dry upland areas with poor soil conservation methods further exposing them to the negative effects of climatic hazards like drought and soil erosion accelerating food insecurity and the poverty cycle. According to [30], soil erosion is expected to increase in many areas across the world particularly in semi-arid environments, with a direct effect on human well-being and ecosystem services.

Although 9% (n = 18) of the respondents reported stories about soil erosion, some of such stories were critical in revealing the origins of the hazard. For example, one of the respondents in Barolengo reiterated during the storytelling sessions that "*Long ago during the colonial period there was a mandate for all people in the community to plant Sisal, Aloe, and Euphorbia. The locals believed the plants prevented the impact of soil erosion on our lands. However, due to settlements and changes in lifestyles, people uprooted all these plants leading to the topsoil being washed down to the swamp. This has led to reduced soil fertility hence less farm productivity that we are now experiencing*". As observed during techno transect walks, the above plants were hardly seen while gulleys and hard sub-soil layers were clearly evident indicating that fertile top-layer soils had been eroded rendering the land infertile especially in Barolengo and Hawinga/ Kaugagi villages. Interviews during the walks revealed that soil erosion has increased in the area due to the increased intensity of rainfall that has become more common in the recent past than before. The above story and observations from techno transect walks indicate that soil conservation measures that would lead to agricultural productivity have since been abandoned while extension services that would enhance land productivity are weak further impacting local communities' livelihoods and resources. Soil erosion resulted in the destruction of crops and pasture, loss of fertile topsoil, hence reduced soil fertility, and destruction of infrastructure e.g., roads and siltation of water bodies like rivers hence reducing water depth and leading to flooding. The findings are consistent with those of [31] who reported that soil erosion causes loss of soil nutrients and ultimately causes a worldwide reduction of agricultural productivity and the deterioration of water quality.

4.3. Exposure and Vulnerability to Climatic Hazards

Levels of exposure varied in relation to gender, resource availability/ownership, or wealth which influenced access to water sources and other services. Children (48%) and women (43%) were more exposed than men (9%). Children were more exposed to malnutrition due to limited food security in their households and the potential to catch diseases commonly found during drought such as whooping cough. The children would inconsistently attend schools and failed to attend classes as they provided support to their parents in search of water, or they engaged in odd jobs to support their families. Women were more exposed since they traveled long distances in search of water for domestic use. They also spent time attending to any sick members of their families further exposing them to diseases in case of contagious diseases. Besides, results from the resilience ranking indicated that the poor (61%) were more exposed than the middle-class (32%) and the wealthy (7%). The poor were more exposed to the impact of drought since they do not have the resource capacity to buy balanced diet food indicating that they were more prone to malnutrition compared to the wealthy. They also have inadequate capacity to diversify their livelihoods with poor access to health services. Individuals and households with only one source of livelihood are more exposed e.g. crop farmers or livestock farmers because when drought strikes they are likely to lose their livelihoods. Since over 60% of members were poor, this indicates that most members depended on one type of livelihood activity with limited diversification.

Women (68%) were more exposed to floods than men (32%). Women are always at home, so they get first-hand bad experiences in managing the crisis of floods such as ensuring food availability and nutrition to households and taking care of vulnerable family members like children and the sick at home. However, men were more concerned with damage to property. The poor (71%) were more exposed to flooding effects since most (63%) of them settled near riparian areas where they undertake small-scale farming activities. The poor also built traditional or semi-permanent houses that are less resilient and are more exposed to flooding effects. This indicates that vulnerable members of the community including women and poor households have a low capacity to respond to the impact of floods and that resilience to climatic hazards like floods requires adequate resources to respond to the effects.

Fishermen (64%), women (32%), and children (4%) were more exposed to crocodile and hippo attacks. Fishermen were exposed due to the nature of fishing livelihoods mainly during fishing expeditions. The tendency of women and children to draw water directly from the lakes and riverbanks exposed them to a high potential for crocodile and hippo attacks, especially during the drought when water bodies dry up or water levels drastically reduce. Poor families were further exposed to HWC compared to rich households since most of their livelihoods such as fishing, hunting, and sustainable farming were conducted in or near wildlife habitats like water and papyrus vegetation increasing their proximity to wild animals.

The results could be attributed to the increase in human population in the area which has led to the increasing need for more land for farming, grazing, and settlement. This has resulted in exploitation and wanton encroachment into areas that initially were habitats and hiding areas for wild animals. The intensity of climatic events especially drought has also led to encroachment into more fertile wetland areas that provide crucial resources such as alluvial soils, papyrus reeds, and freshwater that support local livelihoods further degrading natural wildlife habitats. Also during the drought, there is not enough food for some wild animals in the wilderness hence they tend to search for food beyond their natural habitats thereby easily gaining access to farmlands and homesteads resulting in conflicts. On the other hand, during flooding, wild animals such as hippos are drifted by the plenty waters near human settlement areas and community lands leading to presumed "trespass" that culminates into human-wildlife conflict.

Efforts to seek compensation for injuries from wildlife, damage to crops and loss of lives have been hampered by the slow response by the Kenya Wildlife Service (KWS) and the lack of funds to implement the government compensation policy further compounding the vulnerabilities of local communities living adjacent to wildlife habitats. There is a need to quantify the damages caused by wildlife and enhance the capacity of local communities to petition the government through appropriate channels for compensation. Although the loss of land productivity would result in food insecurity and loss of livelihoods in the long run, women were the most exposed and negatively affected by soil erosion because they are mostly engaged in crop production and livestock keeping, activities which are directly affected by soil fertility at the local scale.

The high level of exposure by various respondents could mean that it contributed more to vulnerability than other factors particularly sensitivity and adaptive capacity. This is consistent with the findings of [32] who reported that exposure contributed more than adaptive capacity and sensitivity to the cumulative vulnerability among smallholder farmers in Tana River, a county where smallholder farmers are dependent on wetland and related resources for their livelihoods. Elsewhere, high levels of exposure could have been attributed to various climate risks and factors as reported by many authors. These include unpredictable weather patterns, financial constraints, limited agricultural training [33], excessive rainfall, increased crop disease and pest incidence [34], and high cost of farm inputs, limited access to credit and market uncertainties [35].

4.4. Adaptation Options for Climatic Hazards

Results of focus group discussions (FGDs) conducted during community adaptation attributes revealed that the community perceived four main strategies in response to drought, flood, soil erosion, and HWC (**Table 4**). Farm/agro-forestry was the most preferred adaptation option for drought, flood, and soil erosion while alternative livelihood particularly ecotourism was proposed by the respondents as the most ideal adaptation option for HWC. Although water harvesting and tree planting were the overall best-perceived strategies, the respective villages ranked the adaptation strategies differently. The respondents had different opinions on the best adaptation options for climate hazards based on their locality and prior experience with the hazards. The respondents opined that farm/agro-forestry and water harvesting were more appropriate since their soils are no longer fertile and would use the stored water for watering the plants, domestic purposes, and small-scale irrigation. Farm/agro-forestry was also recommended since it has multiple uses such as promoting crop farming, provision of fruits, shade, soil conservation, firewood, and timber either for domestic use or sale of surplus products hence contributing to household income. In addition, the respondents indicated that tree planting was ideal since trees "attract" rains and would readily utilize their farms to plant trees alongside the cultivated crops. Water harvesting included activities such as roof water harvesting, the construction of canals to channel water into farms, and the use of underground tanks.

Table 4. Key adaptation options identified by the local community against climatic hazards.

Hazard	Adaptation options	Community responses (%)		
		Barolengo	Hawinga/ Kaugagi	Nyadorera
Drought	Farm/agro-forestry	48	39	32
	Water harvesting	31	28	25
	Planting drought-tolerant crops	14	20	14
	Rehabilitation of wells	7	13	29
Flood	Farm/agro-forestry	33	36	41
	Alternative livelihoods	24	29	18
	Health/Veterinary services	17	11	31
	Relocation to higher grounds	26	24	10
Soil erosion	Farm/agro-forestry	37	32	39
	Building terraces/gabions	28	18	22
	Organic manure	12	26	28
	Cover crops	23	24	11
HWC	Farm/agro-forestry	13	14	26
	Alternative livelihoods e.g., ecotourism	36	40	38
	Fencing	28	21	19
	Guarding	23	25	17

Discussions with community members revealed that tree planting and water harvesting was already being undertaken by community members hence it would be more prudent to enhance their capacity for adaptation by supporting such activities. Rehabilitation of dilapidated wells would contribute to the provision of water for farming activities including small-scale horticulture farming and watering of livestock further contributing as an adaptation strategy, particularly during drought. Growing drought-tolerant crops mainly cassava, sweet potatoes, finger millet, and sorghum would be appropriate but very few people are currently practicing it. However, the respondents revealed that with changing climatic patterns there was a willingness by the community to cultivate such crops. Other adaptation options that were mentioned included efficient water use that minimizes wastage through the promotion of small-scale drip irrigation, re-use, and recycling of wastewater, and sack gardening. Underground water harvesting through the sinking of boreholes and shallow wells was also mentioned.

Similar results have been reported by other authors. For example, [35] reported that improving crop varieties, crop diversification, and enhanced livestock regimes are key desired adaptation options for agropastoral communities.

[34] found that farmer training on alternative farming methods, exploring non-farm employment, enhanced institutional support, and providing older farmers with social security are key adaptation options for farming communities. Farming communities adopted the planting of drought-tolerant crops, charcoal burning, and rainwater harvesting in response to drought [36]. The choice of desirable adaptation options could be affected by various factors including male or female-headed households [34] age, level of education, and knowledge of climate change [36]. Other factors include the education of the household head, access to credit on inputs, perception of climate change, access to information, and the size of the farm cultivated [33].

4.5. Community Adaptation Action Plans (CBAPs) and Identification of Community Projects

Three CBAPs were developed one each for the three study villages. As a give back to the community in appreciation of the information provided and their willingness to use their time to chat about their own development, the PREPARED Project funded the implementation of one project in each of the three villages, which were identified and ranked top in order of importance by the CBAPs through community participation as follows: Barolengo, 3000 liters water tank for water harvesting in Barolengo Secondary School; Hawinga/Kaugagi, agroforestry demonstration farm located adjacent to Lake Kanyaboli; and rehabilitation of three shallow wells to promote horticulture and livestock production in Nyadorera. The CBAPs would be used as reference documents for future village-level climate adaptation development initiatives upon approval by the county-level administration. This according to [37] would address the underlying causes of the climate and specific responses, activities, barriers, and opportunities for climate adaptation action. The development of CBAPs is supported by the findings of [38] who reported that the partnership between local communities, local governments, the private sector, and civil society organizations should develop adaptation strategies at local and community levels that would stimulate actions to collectively address climate risks, including planning that would empower the poor and vulnerable peoples.

5. Conclusion

Community climate change adaptation assessment (C3A2) provides a set of participatory tools that can be applied in communities adjacent to water resources including wetlands, lakes, and river basins. The toolkit also has the potential for application in other ecosystems to guide the development of community-based adaptation plans and resilient community-based adaptation projects with wider local acceptance. The tools are applicable to the identification of projects particularly those geared toward designing programs for climate-smart livelihoods. However, despite the potential wider applicability of the C3A2 participatory tools, their application may be site-specific, and the tools can be administered based on local scenarios and the availability of resources.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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