



Household resilience and adaptation strategies for enhancing access to energy, water, and food during droughts and floods: A qualitative study

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ARTICLE INFO

Keywords:

Floods
Droughts
Resilience
Climate change

ABSTRACT

Background: Climate change driven disruptions, like droughts and floods, disrupt access to water, food, and energy systems, and disproportionately affect vulnerable populations in low- and middle-income countries. Understanding local impacts and adaptation gaps can inform strategies to enhance household and community resilience.

Objectives: This qualitative study explored household resilience to droughts and floods among arid and semi-arid lands (ASAL) and non-ASAL regions across five counties in Kenya, examined local resilience practices, determined impact on gender, and identified opportunities for evidence-based interventions.

Methods: We conducted 44 key informant interviews and 60 focus group discussions with men and women in Bungoma, Homa Bay, Isiolo, Samburu, and Siaya counties. We used a thematic analysis approach, and coded data using MAXQDA 2024.

Results: Droughts and floods disrupted access to energy, water, healthcare, sanitation, and food markets; reduced agricultural productivity; and worsened food insecurity and health, especially for women and children. Planning, coping and recovery strategies were limited, for energy, safe water, and nutritious food. Barriers included a lack of early warning systems, restrictive gender norms, infrastructure challenges, and limited awareness.

Discussion: This study highlighted the impact of droughts and floods on essential services, and the disproportionate burden on women and children. Limited preparedness, coping and recovery strategies existed for energy, water, and food systems. Barriers included resource constraints, limited awareness, and restrictive gender norms. Addressing these challenges requires strengthening early warning systems, expanding access to noisy energy and water, promoting adaptive food practices, and integrating gender equity and water-energy-food nexus thinking into community-driven, policy-supported interventions.

1. Introduction

Climate change and extreme weather events are some of the most significant challenges to human health and development in the 21st century, and exacerbate existing access issues to crucial resources related to energy, water, and nutritious food (Howard et al., 2016; Misra, 2014). The World Health Organization predicts an additional 250,000 annual climate-related deaths between 2030 and 2050, predominantly in low- and middle-income countries (LMICs), stemming from malnutrition, malaria, diarrhea, and heat stress (WHO, 2023).

There is an urgent need to understand how to plan for and adapt to climate change in energy, water, and food services to reduce these impacts and mitigate adverse health outcomes (Howard et al., 2016).

Consequential changes in precipitation patterns that lead to droughts and floods result in the breakdown of food systems including crops, livestock, and fisheries (Mirzabaev et al., 2023). Moreover, droughts and floods have diminished the quality and quantity of food harvest, disrupted supply chains through harvest failures and infrastructure damage, and created competition across food production systems and pose extreme threat to populations who are already food insecure (Mirzabaev

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<https://doi.org/10.1016/j.ijheh.2025.114705>

Received 28 July 2025; Received in revised form 23 October 2025; Accepted 30 October 2025

Available online 4 November 2025

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et al., 2023). The impact of climate change on food security and nutrition is projected to intensify from 2050 to 2080, underscoring a need for adaptive measures (Mirzabaev et al., 2023; Change, 2001). Vulnerable populations, including women, girls, and children are disproportionately affected by droughts and floods, with people living with disabilities experiencing a compounded burden of these impacts (Nations U; Unicef, 2016; UN Women, 2024).

Low- and middle-income countries (LMICs) face significant challenges in preparing for, coping with, and recovering droughts and floods in relation to WASH and nutrition, highlighting the need for resilient practices. A systematic review of 147 articles on pre-disaster planning and preparedness for droughts and floods in developing countries indicated that planning for droughts is less common than floods (Raikes et al., 2019). Moreover, a reactive approach to drought remains prevalent in many developing countries due to the lack of preparedness before, during and after events of droughts and floods (Njogu, 2021a). Implementing monitoring and early warning systems, assessment of vulnerable regions, and investing in risk mitigation measures are the critical initial steps in addressing drought related challenges (Pulwarty R and Sivakumar, 2014). Inadequate preparedness and recovery mechanisms have resulted to negative consequences like extreme water scarcity and intermittent supply, compromised water safety, increased costs for maintenance and supply, diminished hygiene and sanitation practices, environmental pollution, and damage to infrastructure, thus impacting wellbeing (Howard et al., 2016; Njogu, 2021a; Mekonnen and Hoekstra, 2016; Noelke et al., 2016; Okesanya et al., 2024). Disruption of livestock and crop production, including crop failures, has led to food supply chain disruption, and nutrition deficiencies due to inaccessibility and unavailability of diverse and nutritious food (Menne et al., 2002). Evidence on the impact of droughts on malnutrition in children and adults revealed that droughts conditions were significantly associated with both wasting (Odds Ratio [OR] 1.46, 95 % Confidence Interval [CI] 1.05–2.04) and underweight prevalence (OR 1.46, 95 % CI 1.01–2.11) (Lieber et al., 2022). Severe and recurrent floods had greatest impact on stunting and childhood mortality among children under five years in LMICs, although the causal pathway on the effect of floods on micronutrient deficiencies lacked (Agabiirwe et al., 2022). Understanding communities' preparedness and recovery practices and behaviors for access to water, energy and nutritious food in the events of droughts and floods is crucial. This can further highlight gaps and challenges to address future impacts of extreme droughts and floods events.

We conducted a study to 1) identify relevant domains and sub domains of household resilience, adapted to arid and semi-arid lands (ASAL) and non-ASAL contexts, and explore resultant impacts of relevant disturbances; 2) identify positive, negative, and anti-resilient practices and behaviors, and their barriers and drivers; and identify determinants of implementation and effectiveness of positive resilient behaviors and practices, 3) assess the impact of gender sensitive/transformative programming on specific interventions, and 4) explore opportunities for enhancing household resilience through existing evidence-based interventions.

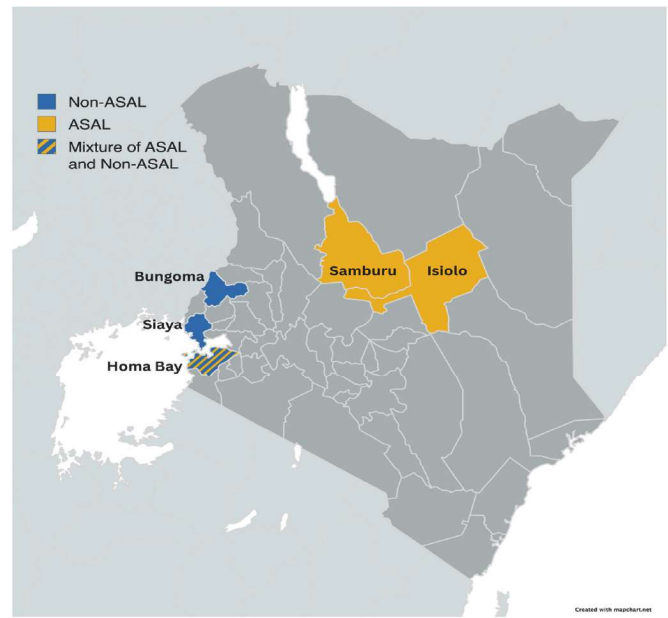
2. Methods

2.1. Study design and research partners

This study was conducted as part of the Resilient Household Investment Feasibility Assessment (RHIFA), a collaboration between Emory University, Uzima University, the Global Alliance for Improved Nutrition (GAIN), and SNV Neverlands Development Organization in partnership with Children's Investment Fund Foundation (CIFF). The purpose of the study was to design integrated evidence-based interventions that build household resilience, improve nutrition, access to reliable and clean energy, and access to clean water at household level. The project was conducted in six Kenyan counties - Bungoma, Homa Bay, Siaya, Isiolo, and Samburu - representing both ASAL, defined as dry

ecosystems characterized by low, unpredictable rainfall, high year-round temperatures, and high evaporation rates that exceed annual precipitation (Njoka et al., 2016) and non-ASAL regions. We aimed to identify 1) how households planned for, coped with, and recovered from droughts and floods related to maintaining access to clean energy, safe water, and enough nutritious food, 2) what resilient practices could be leveraged for an intervention to improve household resilience, and 3) if those behaviors and potential coping strategies differed between ASAL and non-ASAL areas.

A map of ASAL and non-ASAL counties.



2.2. Study design and setting

We conducted a qualitative research study, employing focus group discussions (FGDs) and key informant interviews (KIIs). Three wards (subdivisions within a county) were selected from each county, apart from Isiolo County where 2 wards were selected for this research. The ward and village selection process were participatory, with representatives from various ministries within the county governance structure participating in the selection process. Communities were selected based on their experiences with drought or prolonged dry spells and flooding; communities whose access to safe water and access to enough nutritious food were impacted by droughts and floods. Other considerations included ongoing conflicts and insecurity, and terrain accessibility. Fifteen communities were selected to participate in research across the five counties. Prior to participant selection, Emory University team members engaged community leaders to inform them about the study, share eligibility criteria for participants, and seek approval to engage with community members. We purposively selected participants to participate in qualitative research. Participants were selected by the assistance of the community gate keepers including chiefs, assistant chiefs or ward administrators who then engaged the village elders to support the mobilization of participants. We engaged gatekeepers due to their recognized authority and their deeper understanding of cultural norms, practices, and social dynamics of the communities. Gatekeepers provided formal permission into the community, helped build trust, and ensured that research was conducted in a culturally appropriate and respectful manner. Involvement of these gatekeepers may have influenced participant selection, potentially favoring individuals who were more active in community affairs or had closer ties with them. We emphasized on the need for broader representation of perspectives of all categories of people in the community including women, youths, and

marginalized groups.

2.3. Data collection

Qualitative data were collected from March 2024 to April 2024 across the five counties in Kenya.

FGDs. FGDs with women and men, conducted separately, sought to understand women and men's experiences and perspectives on how households plan for, cope with, and recover from droughts and floods related to maintaining access to clean energy, safe water, and enough nutritious food; perceived barriers and drivers to planning, coping, and recovery strategies; resilient practices that can be leveraged for an intervention to improve households resilience; and if behaviors and potential coping strategies differ between ASAL and non-ASAL areas.

In each county we planned to conduct at least two FGDs per community with women (youth 18–35 years, and adults over 35 years) and two FGDs with men in the same age groups, resulting in at least 12 per county, sample sizes considered adequate to achieve saturation (Hennink and Kaiser, 2022; Hennink et al., 2019). In all the counties, we conducted separate FGDs for each age group to ensure that participants felt comfortable and confident in sharing their views freely and openly in groups. In all, we conducted 60 FGDs (30 with women; 30 with men; See Table 1 for a breakdown by county). FGDs had 6–12 participants, took 60–120 min, and were conducted in local languages in each county; Kiswahili and Bukusu in Bungoma, Luo in Homa Bay and Siaya; and Samburu in Isiolo and Samburu.

KIIs. KIIs were conducted with local leaders, both men and women, to better understand community leaders' experiences and perspectives related to WASH and climate resilience. The interview guide sought to answer questions on water, energy and nutrition infrastructure and services in the community, common disturbances that disrupt normal conditions of environment, facilitators and barriers to practicing certain behaviors before, during and after droughts and floods, successful community lead initiatives to promote water, energy and food, most effective interventions for future preparedness and the role of governance, policies and frameworks to support effort to prepare for droughts and floods. We conducted 44 KIIs (11 with women; 33 with men). (See Table 1 for a breakdown by county). KIIs were conducted in the participant's preferred language and lasted 60–90 min.

Research Assistants. Four research assistants were trained for four days on qualitative research methods, research ethics, and data management prior to data collection. Qualifications of research assistants were: 1) Fluent Luo or Samburu, Kiswahili, and English speakers; 2) experience in qualitative data collection; 3) previous training on qualitative research methods, and 4) understanding of the study area. Training topics covered included the overall purpose of the study, current background on WASH and climate resilience, qualitative research methods, ethical conduct of research, transcription and translation, debriefing, and data management. Qualitative tools were translated into local languages and validated by the research assistants to ensure accuracy of translation and cultural appropriateness. Before data collection, the tools were piloted and adapted based on input from those who collected the data.

2.4. Data management

FGDs and KIIs were audio recorded, and the audio files uploaded on a secure file storage service certified for secure storage of sensitive data. Audio recordings in Luo, Samburu, and Kiswahili were simultaneously transcribed and translated into English by trained team members. Transcripts were reviewed against corresponding audios by a different member of the data collection team to ensure accuracy of data.

2.5. Data analysis

A thematic analysis approach was used for data analysis (Clarke and Braun, 2017). The field team debriefed frequently during data collection, discussed emerging themes, and identified areas for more probing. The translated and reviewed English transcripts were used for content analysis. A codebook was developed deductively using data collection instruments and inductively from the themes generated from debrief sessions and memos from transcripts. Coding of data was done using MAXQDA 2024 (VERBI Software, 2024). To ensure all coding had the same understanding of the codes, 3 team members independently coded the same transcript and met weekly to discuss how codes were used and applied throughout the transcript to reach consensus. Through this process, the coding team critically examined their own biases and perspectives, with weekly meetings aimed at reducing subjectivity in coding and analysis.

2.6. Ethics

The study was approved by the Institutional Review Board committee of Emory University, Atlanta, Georgia, USA (IRB00007567), and was approved by the Great Lakes University of Kisumu – GLUK Scientific and Ethical Review Committee (GLUSERC/002/2024), the National Commission for Science, Technology, and Innovation (NACOSTI/P/24/33917) in Kenya. All participants provided informed consent.

3. Results

Participants from all counties-Samburu, Isiolo (ASAL) and Bungoma, Homa Bay, and Siaya (non-ASAL), discussed the negative consequences of droughts and floods on access to clean energy, safe water, and enough nutritious food, and how droughts and floods affected transportation, health, sanitation, and financial wellbeing. Droughts and floods 1) reduced availability of water, food, and energy for cooking and lighting, 2) impaired accessibility through destruction of roads and supply chains, and 3) minimized functionality of different energy, water and food sources. Droughts and floods further influenced socio-economic factors, environmental conditions, and gender dynamics. Participants discussed how they planned for, coped with, and recovered from droughts and floods, and their resilience behaviors. Participants relied on traditional ways of predicting droughts and floods including inspecting animal intestines for specific patterns which informed occurrence of drought, rain, disease outbreaks, assessing the direction of wind, and reliance on elderly people who had the capability to predict such events, and occasional advertisement from the government meteorological department. We discuss details in the next sections.

Table 1
Data collection activities and participants.

County	Isiolo	Samburu	Siaya	Bungoma	Homa Bay	Total Activities	Total Participants
KIIs with women	3	2	2	2	2	11	11
KIIs with Men	5	8	5	8	7	33	33
FGDs with women	6	6	6	6	6	30	224
Women participants	43	47	47	45	42		
FGDs with men	6	6	6	6	6	30	231
Men participants	47	46	48	46	44		

3.1. Negative consequences of droughts and floods on access to energy, safe water and nutritious food

Participants reported that drought led to a reduction in water level and drying up of water sources which reduced hydropower generation. Floods destroyed electricity connections, leading to power outages and diminished availability of firewood. In Isiolo and Samburu (ASAL) counties, participants relied on livestock production as their source of livelihood, and in Bungoma, Homa Bay and Siaya (non-ASAL) counties, participants primarily practiced agriculture as smallholder farmers, engaged in small businesses, and some kept few livestock, and all these were constrained by droughts and floods. Participants reported that fluctuations of water and pasture resulted in declined agricultural and livestock productivity.

Economic losses from droughts and floods through the destruction of livelihood sources contributed to food insecurity and health challenges. Participants indicated that livestock and agriculture productivity were minimized by pests and diseases. In all communities, zoonotic diseases such as anaplasmosis, foot and mouth disease, enterotoxemia, and sheep and goat pox affected animals and humans during droughts and floods. Pregnant women and children were disproportionately affected. Participants noted that the diminished livestock and agricultural productivity led to food shortages, noting the lack of diverse food options and the high cost of nutritious foods which contributed to undernutrition, dehydration, and weakened immunity, particularly among pregnant women and children. Participants said that families resorted to skipping and rationing meals and relied on support from neighbors and government assistance programs to cope with food shortages.

In ASAL communities, men reported that to avoid losses from death of livestock, they sold them at reduced prices, limiting their financial ability to afford energy, food, and safe water. Men reported that migration with livestock often led to family separation. Men and older boys migrate for extended periods while women and children remain behind, with limited access to food, schools, and healthcare facilities adding to emotional and social strain on families. Further, floods disrupted transportation routes and market access and resulted in household displacement and property damage, leaving families homeless and with no means of earning a living.

Droughts and floods affected health and wellbeing of women, men, and children in all counties. Participants reported that reliance on traditional fuels like firewood exposed them to health risks from smoke, as one man indicated that “the smoke that it [firewood] emits suffocates the children and affects the house in many ways because it blinds the children and also make adults and children cough, and it also transmits a disease like asthma”. Women indicated that when out looking for firewood, small children would be left unattended exposing them to other risks.

Water scarcity led to the use of alternative water sources which were far, and this forced women to ration water and prioritize its use. In all counties, participants indicated that women were primarily responsible for water collection, and sometimes children helped. Women indicated that the water sources were far and time consuming due to bad terrain, queuing and water related work at the source. Most participants indicated that they did not know where to get the water treatment products (ASAL), water treatment products being expensive, or had different taste preferences (ASAL, non-ASAL). In addition, participants indicated that wells and boreholes produced saline water which made them suffer from urinary infections.

In all counties, participants reported that droughts and floods influenced communities’ sanitation. In ASAL communities, participants reported that most people in the community did not have latrines and practiced open defecation. In non-ASAL communities, men and women indicated that latrines were washed out during floods, leaving people to practice open defecation. In all counties, participants reported that floods destroyed roads and bridges, making them impassable, which hindered access to healthcare facilities especially for pregnant women in

emergencies like childbirth, increased the risk of accidents and fatalities, disrupted children’s school attendance, and broke food supply chain leading to food shortages.

3.2. Planning for energy, water and food in anticipation of droughts and floods

3.2.1. Energy

In all communities, women and men did not plan for energy in anticipation of droughts as they indicated that firewood was abundant and affordable. During floods, women planned by stockpiling firewood, charcoal, used improved cook stove which utilized few firewood or saw dust, dried and stored maize cobs after harvest, and refilled cooking gas cylinders for those who could afford. Traditional gender roles dictated responsibilities related to firewood collection, with women primarily tasked with collecting firewood, often at the expense of their own safety and the well-being of children. Women explained that the physical burden of firewood collection fell on them and girls. Women reported that they walked long distances to the forests to collect firewood and carried heavy loads on their backs causing physical harms and pains, as they also risked being raped.

“We do not plan on collecting firewood before drought I have not heard anything like that before.” FGD (YW): Baawa ward, County.

During floods, participants from ASAL and non-ASAL communities used solar lamps for lighting, and this was minimized by lack of enough sunlight to charge them, prompting them to use alternative energy sources. Firewood remained the main source of energy for cooking in ASAL communities, even during floods. Men mentioned that women were responsible for planning for firewood. In both communities, participants planned for energy by stockpiling firewood and burning and storing charcoal. Men and women mentioned that while preparing firewood and charcoal, they risked animal attacks like snake bites, accidents like cuts, and lung infections from inhaling smoke. Women and men in non-ASAL communities indicated that people planted trees which could be later cut for firewood, stockpiled maize cobs, dry cow dung, and those with financial capability bought cooking gas. In all counties, participants mentioned that some people did not plan due to lack of financial resources, disability, and sickness.

“You know the environment is dry during drought and people can collect and pile firewood with the hopes of using them when it is raining which we all know that it is usually rainy during the month of April when it is always easy to access firewood. Secondly you may find where one of you in the village has prepared charcoal, you can pick the remaining charcoal pieces which are kept being used for cooking when it is raining.” FGD (OW): Southeast Alego ward, Siaya County.

3.2.2. Safe water

Participants in ASAL and non-ASAL counties seldom planned for access to safe water, due to, in part, the lack of awareness about impending droughts and floods, insufficient capacity of households to plan for drought at scale, and lack of knowledge on the importance of planning. For women and men who reported preparing for droughts and floods, they indicated that they prepared by storing water, however, lack of water storage containers hindered the process. Moreover, participants said that they would sometimes work jointly as a community to dig wells and fence water sources. In ASAL communities, the distance to the water source hindered women to collect additional water to store. Women indicated that they would take almost the whole day collecting a single 20 L jerrican of water, which could not serve the entire family, and had to prioritize water use on drinking and cooking. In non-ASAL counties, some women indicated that they bought storage tanks, jerricans, drums and stored water during rainy season which was reserved for use during drought. In all communities, women and men indicated that they collaborated and pulled resources to repair and maintain communal

water sources to ensure continuous access to water even during drought. Women indicated that they collected water at night to avoid queues and had to travel far distance to the water source.

“You plan by going to the river to collect water. Sometimes even you go at night to fetch water because the water there is limited, and people will be many to collect water during the day. So, after the collection of water that early, you can also go to attend to other activities.” FGD(OW): Maralal ward, Samburu County.

3.2.3. *Enough nutritious food*

Participants from the ASAL communities depended on livestock as their main source of food, that is meat and milk. In most of the communities, participants indicated that it was the responsibility of the women to look for food for the family. Men and women mentioned that they planned by selling their livestock and used the money to stock up essential foods like dry maize, beans, cooking oil, and rice to sustain them during lean periods, although livestock were held as cultural heritage, and a source of pride. In addition, women in non-agropastoral communities in ASAL counties mentioned that it was difficult for them to plan for food because they were not agricultural farmers and did not have stores for food, and therefore only stored food which could sustain them from one market day to the next. Furthermore, cultural norms around agency influenced access to nutritious food as women mentioned that men are the main decision makers, making it difficult for them and young men to engage in activities which can help with addressing challenges around access to nutritious food. Participants indicated that old age, sickness, lack of knowledge on weather prediction, poor socioeconomic status, and poor soil conditions hindered them from planning for food.

“Us we have somethings we put as savings like someone may decide to put aside one of his goats to be for the savings such that during drought you can sell it with a profit because it is very healthy even though during drought the prices reduces but at least it will save children because when you sell it children can use the money for food. ...” FGD(OM): Oldonyiro ward, Isiolo County.

In non-ASAL communities, participants relied heavily on agriculture for food and sale; few people relied on livestock, and a few did menial jobs for food. In some communities in Bungoma, women said that “farms belonged to men and children belonged to women” and so women were unable to plant drought resistant crops even when the farms laid bare. Participants mentioned that the unpredictability of droughts and floods and poor prioritization hindered their capacity to plan for food. Men and women planned for food by prioritizing purchasing food over other non-essential items like clothes and shoes, stocked up food items like maize, beans, rice, stored food reserves after harvesting, and grew drought resistant crops like cassava, potatoes and cow peas. However, women indicated that even with stocks of grain, it was still a challenge to get vegetables, as some women had to collect water from far to irrigate their kitchen gardens. Men indicated that they would grow vegetables along the rivers, redirect flood water into small dams and use that water for irrigating vegetables farms during drought.

“This hunger even the men are not bothered with it. It is us women who are bothered. All the many challenges don't affect the men. He will want to eat as well, as children. The garden stays bare waiting for the next planting seasons, as farms are for the men and children for women.” FGD(OW): Chesikaki ward, Bungoma County.

In ASAL communities, participants reported that floods were not a common occurrence as they had a prolonged drought. Men and women indicated that they did not often plan for food in anticipation of floods. If they planned, women and men mentioned that they sold their livestock and used money to buy food, they slaughtered goats and dried meat for future use and planted crops (agropastoral communities) which were often destroyed by elephants.

Participants from non-ASAL communities planned by making trenches to redirect flood water from farms, grew crops on high areas where they could not be swept by flood water, and in cases where they produced their food from swampy land, during floods, men mentioned that they could not do anything to plan. Men and women reported that they prepared land early and planted so that crops would be stronger when floods come and could not be washed away. Additionally, participants mentioned using compost and commercial fertilizers to improve soil fertility and planted napier grass to control soil erosion. Men mentioned that limited land hindered them to prepare well, and participants without land resorted to other ways like burning charcoal for sale and using that money to buy food, although they indicated that charcoal burning is prohibited by the government.

“There is nothing we can say we plan for us to have enough nutritious food we just use whatever we have for food [the availability] and we still grow. If it is the rainy season, we now see the differences because we receive food from outside for us to buy and eat.” FGD(OW): Oldonyiro ward, Isiolo County.

3.3. *Coping mechanisms for access to energy, water and food during droughts and floods*

3.3.1. *Energy*

In ASAL communities, participants mentioned different ways that they used to cope with accessing energy during drought. Women mentioned that they continued with firewood collection and would pile firewood and charcoal for use when there was scarcity. Women reported that firewood collection work was difficult, as they had to carry heavy firewood under scorching sun, which left them tired. To minimize overreliance on firewood, women noted that those who had access to alternative sources like improved cookstove would use them. During floods, women continued with collection of firewood which they indicated was from far forests and risked being attacked by elephants and being carried away by flood water. Women also borrowed firewood from neighbors, used alternatives like plastics, rubber, and changed their cooking and lighting depending on the availability of firewood. Participants mentioned that some community members engaged in menial jobs to earn money to pay the daily charges for solar lamps. Women and men indicated that community members cooperated to preserve trees during drought, allowing animals to feed on the fruits from acacia trees while using dried trees for fuel.

“When you go and collect firewood you use energy, the hot sun burns you, while carrying the firewood it is very heavy, when reaching home and putting down the firewood you feel very tired, which is also a challenge. Again, sometimes you will get attacked by wildlife and they will chase you and you must come back home without firewood” FGD(YW): Garbatulla ward, Isiolo County.

In non-ASAL communities, participants used solar lamps and electricity for those who had connections. When solar energy was not paid for, people resorted to using kerosene lamps, candles, phone torches, or moonlight for lighting. Participants mentioned that some individuals engage in menial activities to generate income, part of which they used to pay for solar or electricity charges. To cope with uncharged solar lights, women prepared food early in the day. Women ensured that there were no stock outs of firewood by continuously collecting it and used charcoal if firewood stock was depleted. Some women who reported using gas economized it by using it only when preparing light meals, and for cooking during supper, while other meals were cooked using firewood or charcoal. Participants also mentioned using alternative materials like sawdust, dry leaves, plastics, or rubbers for cooking. During floods, participants indicated they used stored firewood, rationed usage of firewood to avoid wastage, and used alternative sources of fuel like cooking gas, kerosene, and energy-saving cooking methods like improved cookstove. Women mentioned that wet firewood was dried

above the cooking fire and charcoal stored on raised and dry places to avoid getting wet. Women indicated that they resorted to cooking food which takes a short time to cook to conserve fuel, shared firewood with neighbors, and had children assist with firewood collection.

3.3.2. Water

Participants depended on boreholes, unprotected wells, springs, lakes, and dry sand rivers to get water for drinking and other household purposes during drought. Women mentioned that water collection from the rivers consumed their time and energy due to water related work at the source. Women mentioned that they dug out sand from the riverbed, then waited for water to fill the hole and settle before collecting and carrying home. In ASAL communities, the water sources were sometimes far up to 20–30 km distances, dried up or had low levels, and participants linked the water quality to disease outbreaks. Participants utilized different water treatment methods based on their knowledge of water treatment, financial capability, and access to water treatment products including boiling, use of chemicals or use of traditional methods like using certain plants and ash to make water cleaner, although participants reported that not everyone made water safe for use. In addition, men and women mentioned that people would collect water in shifts, and men and boys migrated with livestock to other places to relieve stress from the diminished water sources. During floods, participants worked collectively to protect water sources from contamination by volunteering labor or materials to protect the sources. Participants placed sacks filled with sand around them, covered boreholes, and used gabions to redirect water flow. Few women collected rainwater from roof catchment through improvised methods like tying polythene around houses to collect rainwater in tanks and drums for storage and later use. Men and women mentioned that they would dig wells along the river path which served humans, livestock and wildlife.

“... during drought all the animals both domestic and wild animals like elephant, hyena wants to take that water that people use for consumption and people will even get infections as well as human-wildlife conflict as they share same source.” KII(CHV): Oldonyiro ward, Isiolo County.

In non-ASAL communities, women and men mentioned that the cost of water increased from five shillings to 15–20 shillings per jerrican, in addition to increased transportation cost by water vendors or motorbike riders. Participants used various water-saving measures such as limiting bathing frequencies, economizing water usage for laundry and bathing, and using stored rainwater only for drinking and cooking, and used alternative sources like rivers or lakes for other needs. Women indicated that they changed their daily routines, such as waking up early to fetch water before the sun got hot, to ensure continuous access to water in the household. During floods, participants mentioned that they collected rainwater, which they used for various purposes. Some participants boiled water or used water treatment chemicals like chlorine to make water safe for use. Men indicated that they dug trenches around water sources to prevent floodwater contamination and covered wells for safety.

“During drought I will depend on my legs and my head. So, I will go for three trips to fetch water and at one I will only use it for drinking and cooking. When I want to do my laundry, I will carry my clothes to the lake and wash them there. So, I don’t do my laundry at home.” FGD(YW): East Asembo ward, Siaya County.

3.3.3. Enough nutritious food

Participants in ASAL communities used different ways to cope with drought impacted access to enough nutritious food. Women mentioned that they shared food resources with neighbors like borrowing cooking flour and sent children to eat at the neighbor, rationed food for family members e.g., served small portions, skipped meals e.g., ate once a day, gathered wild fruits, and prioritizing essential food items (e.g., maize

meal, cooking oil, medicine) over balanced diets due to budget constraints. Men and women diversified their livelihood through selling livestock, charcoal burning, and engaging in menial jobs to generate income for buying food. During floods, participants relied on remittances from neighbors and family, while some women mentioned that some community members restricted sharing food with neighbors to ensure that they had enough for their families. Men sold livestock and used the money for food, and women took loans from merry-go-round groups (a group where members contribute money regularly, and the pooled money is given to one person every cycle) to purchase food. Participants bought food that could last until the next market day, anticipating transport issues during bad weather. Women mentioned that they established kitchen gardens for vegetables, but these were short lived due to lack of water.

“When they slaughter a goat and eat the meat the bones are preserved such that when githeri [mixture of maize and beans] is cooked they put one or two bones inside that pot that cooks githeri to act as cooking oil and given to children to eat so we continue like that using bones as cooking oil every time you cook githeri.” FGD(OM): Maralal ward, Samburu County.

In non-ASAL communities, participants mentioned that they changed their diet, reduced the quantity of food prepared, consumed fewer meals per day, prioritized children over adults, used stored food sparingly, and engaged in activities like fishing or casual labor to generate income to purchase food. Women said that they prepared alternative dishes like “*ndugu and ndugu*” (a type of porridge), prepared soupy foods or dishes like “*githeri*” to extend food supplies, used cassava, sweet potatoes as substitutes for maize, dried vegetables and resorted to locally available foods like sardines. Men and women indicated that people in business brought food supplies from neighboring countries or towns, which they then sold in their communities at a higher price. Further, some women indicated that they made kitchen gardens, grew and irrigated vegetables for consumption, and sold excess stored foods to buy other food items.

“We can skip meals, when you take breakfast in the morning then you can only take porridge during lunch time and then you eat ugali in the evening. Most people don’t do ugali during drought because you may have flour, but you don’t have vegetables. We cook maize mixed with beans or rice and beans because vegetables are very rare.” FGD(YW): Kibiri ward, Homa Bay County.

3.4. Recovery from the effect of droughts and floods on access to energy, water and food

3.4.1. Energy

Participants from ASAL and non-ASAL communities indicated that they went back to their normal lives after droughts and floods. For droughts, women from both counties indicated that they continued with collecting firewood. Participants indicated that the sun was available for charging solar, so they did not do anything different for lighting. However, participants indicated that they recovered from floods by mending solar, repaid loans, and continued with firewood collection.

“If firewood was the only option, even getting firewood you have to walk for some distance, and it wastes time, so a woman plans herself on collection of firewood as well as the collection of water before market day she knows the amount of both firewood and water to collect” KII(CHV): Oldonyiro ward, Isiolo County.

3.4.2. Safe water

Participants in ASAL and non-ASAL communities said that they continued with their normal ways of accessing water from their normal sources after disruptions by droughts and floods. One participant in Siaya mentioned that “*the big problem we have is how we can tap this [rain]*

water because this [rain] water goes for a waste". In Bungoma, participants mentioned that they surrounded springs with stones to prevent soil contamination and ensure access to clean water. In Siaya and Homa Bay, participants mentioned that they continued using river or lake water for bathing and washing. After floods, some participants mentioned that people would buy drinking water from others with larger water tanks or utilize rainwater collected during floods for various household activities. Participants used stored rainwater for cooking, drinking, and other tasks while preserving additional reserves for drought periods. Men and women mentioned that they planted more trees to attract rainfall and improve water availability right after floods and end of rain season.

In ASAL communities, participants indicated that they went back to their normal lives and collected water from the main sources. Participants indicated that they continued using the rainwater they had collected and stored, while some borrowed water from neighbors, and when depleted, went back to collect water from the normal sources. Participants mentioned that they protected water sources by fencing, covering the wells with sand after collecting water, and putting stones around the well to protect it from animals. After floods, participants mentioned that they never had water problems, and that livestock accessed water from other sources and boreholes were left for humans.

"Normally after the drought, we never have water problems, there is plenty of water. There are no regulations like these for people to collect water today ... When there is no drought we feel good because even if you see that machine to be having problems but as long as you can get 2 jerricans of drinking water, besides that you are able to get water from the shallow wells where the goats drink water from, the water from the shallow wells can then be used for bathing, or washing clothes. So, I think after drought we hardly have challenges in accessing water." FGD (OW): Garbatulla ward, Isiolo County.

3.4.3. Enough nutritious food

In ASAL communities, men and women mentioned that the end of drought marked the beginning of rain. Men and women said that they had access to milk since animals had pasture and water. They sold milk, collected firewood, and burned charcoal for sale, and used proceeds to buy other kinds of food. In addition, men indicated that they slaughtered animals for meat and sometimes sold livestock to get money to buy other foods. Women engaged in businesses like selling khat, potatoes, vegetables, tomatoes, and used proceeds to get nutritious foods. In agro-pastoralist communities, men and women mentioned that they ploughed land and planted vegetables, burnt charcoal, collect firewood and sold. In non-ASAL communities, participants mentioned that most people did farming and business to access food after drought. Women and men mentioned that they had no food options after droughts and floods and ate whatever kind of food they came across without minding the nutritional value. The flood washed away farms, and participants indicated that they had to start again with farm work even if they had poor harvest. With the anticipation of rain after drought, participants reported that individuals began preparing for planting by tilling land, purchasing necessary inputs like seeds and fertilizer. Some individuals engaged in menial jobs or other sources of income generation to obtain money for purchasing food. Women indicated that they relied on naturally growing indigenous vegetables like pigweeds for sustenance while awaiting to harvest the grown food. Participants also mentioned that with floods replenishing water bodies, such as lakes, individuals engaged in fishing activities to supplement their food supply. After the floods, participants said that they monitored the level of stored food and restocked when necessary, and women continued with working on their kitchen gardens to supplement food sources. See Table 2 for illustrative quotes.

"Once whatever you plant is already washed away by the floods, most of us normally start it all over again and let's not pretend here that some people will wait to sleep hungry and buy maize from the

Table 2

Illustrative quotes for planning, coping with, and recovery for energy, water, and food in the event of droughts and floods.

	PLANNING	COPING	RECOVERY
Energy	"We have no plans during drought because you are 100 % sure the sun will light and so the solar will charge to the fullest and firewood is available but the only problem which is there is how you will have access to water." FGD (YM): Southeast Alego ward, Siaya County. "It is just the same as we said earlier. If you see the signs of rain, you will check on your wife's situation there at home and the wife too starts to plan for herself with her girls or her alone. They collect more firewood and store it in the store. Mostly it is just firewood that people plan for because that is what most of them use this thing called gas, and a few of them have it." FGD (OM): Garbatulla ward, Isiolo County.	"When there is flooding, the firewood absorbs water, the solar has no energy so people face challenges during that time. So, it will force you to use plastics or unused shoes [rubber stones] to light the fire because of the wetness of the firewood" KII (CHV): Oldonyiro ward, Isiolo County. "You know the environment is dry during drought and people can collect and pile firewood with the hopes of using them when it is raining which we all know that it is usually rainy during the month of April when it is never easy to access firewood. Secondly you may find where one of you in the village has prepared charcoal, you can pick the remaining charcoal pieces which are kept for cooking when it is raining." FGD (OW): Southeast Alego ward, Siaya County.	"On that, they use solar from various companies that help in lending such as M-Kopa where they take jiko okoa which is used for cooking. These companies give loans, and they start paying in installments. There are various companies where they loan from such as Sun king, D-light and use this solar for lighting." KII Garbatulla ward, Isiolo County.
Water	"I make sure I buy a lot of 20-L jerrycan, and I can use some as chairs (laughter). So, when there is a lot of rain then I can store water in the jerrycans." FGD (YW): Gwasi ward, Homa Bay County. "We do not plan anything for water even if there is a drought that is coming because we usually dig well for water daily. What we do in this area during droughts for water is just dig wells. Sometimes we come as a community and choose at least ten men and dig wells to find water and we get water after digging very dip into the sand in rivers." FGD (YM): Oldonyiro ward, Isiolo County.	"Now, what we do is to manage that water, if the water level is gone low, we make sure that people use the water in different time intervals, if one group drinks water in the morning, the other group will then use the borehole in the afternoon and that is how we regulate how people use the borehole." FGD (OW): Garbatulla ward, Isiolo County.	"As a community around here, the dams that we dug for us here are the ones that we take care of by fencing and not allowing it to be stepped on by animals and even human beings. Little water is used as the Samburu's say "nkutukie ee malasin ake" (meaning that the water is used in small quantities. And there are underground springs below the rocks that act as water sources they are guarded from being stepped on by animals and people." FGD (YM): Oldonyiro ward, Isiolo County. "Even for you who stored your water, for the people who do not have water tanks they have to come and borrow water from you so when the water gets finished, we just all must access water from the source/

(continued on next page)

Table 2 (continued)

	PLANNING	COPING	RECOVERY
			river." FGD (OW): Baawa ward, Samburu County.
Food	<p>"For anything to do with planning, it is not possible in our area because us we are not farmers but for someone who has farm, he/she is the one who can preserve food but for us we are livestock keepers you can only go and sell goat one of the market days and buy food that will sustain you for about two weeks and again the next market day you go and sell goat again ..." FGD (OW): Oldonyiro ward, Isiolo County.</p> <p>"During drought, we really suffer. You can decide to have the kitchen garden behind the house and then you may get vegetables twice or thrice there. The next time you go there to get vegetable, it will have dried up during the drought. So, we suffer during drought" FGD (YW): East Asembo ward, Siaya County.</p>	<p>"During drought considering the issue of nutrition there are people who cook some vegetables called <i>mianzi</i> which are left to dry up and stored in the roof of the house and they can stay for a year. So, during drought you just remove two and there is a way they prepare it." FGD (OM): Chesikaki ward, Bungoma County.</p> <p>"When there is drought, I will have different types of vegetables in my small shamba near my house and I will make effort to go and collect water from the stagnated points in the village which I use for watering them and when ready, I can pluck and eat but also take some to the market and get money to buy other foods for the family." FGD (YW): Malakisi ward, Bungoma County.</p>	<p>"For us being the people living along the Lake, when the drought is ended and so the rains have started, normally there are a lot of fish and so we go back to the lake, catch a lot of fish which we sell and after selling we then invest what we get into other businesses and that is why you will find that the people doing fishing own a lot of businesses around here." FGD (YM): West Yimbo ward, Siaya County.</p> <p>"During drought there are some places along the rivers here where people normally plant some vegetables and that is why as much as it is dry in this community but still, we can have access to vegetables from these places which are sold in the markets." FGD (OW): Gwasi South ward, Homa Bay County.</p>

market. Once whatever you have planted is washed away you never give up and most people start all over again so even if the second floods come, it will just affect you, but the thing is that you have started all over again. It is not easy to be hungry." FGD(YM): Southeast Alego ward, Siaya County.

3.5. Resilience behaviors practiced by households and communities

Men and women from all counties practiced various resilience behaviors to address adverse effects of droughts and floods. Participants incorporated innovative practices to access energy for lighting and cooking. Women reported storing firewood, using improved cookstoves with reduced smoke production and utilized few firewood, and few participants, mostly from non-ASAL communities used liquefied petroleum gas. Men and women reported planting trees which they later cut and dried for firewood. Participants reported that they used solar lamps for household lighting, which they acquired through loans or paid off in installments.

Participants mentioned different rainwater harvesting techniques that they used which provided water during prolonged dry spells. Households used jerricans, storage tanks, or large drums to store rainwater during the rainy season. Participants mentioned that they treated or boiled their drinking water to prevent them from becoming sick. In addition, participants dug wells, ponds, and protected water sources by fencing to avoid being accessed by wild and domestic animals.

Women ensured access to enough and nutritious food by storing food

to be used during drought or floods, practiced food preservation techniques like sun drying vegetables, meat and cereals, storing animal bones as a source of cooking oil, relying on natural growing traditional vegetables, maintaining kitchen gardens by watering them, all enhancing food security. Participants mentioned that they planted drought-resistant crops such as millet and sorghum, cassava, and sweet potatoes, to provide stable food sources during drought.

In response to climate-driven shocks, some participants engaged in coping mechanisms that, while providing short-term relief, would have detrimental long-term consequences. Participants depended on unsafe water sources which exposed them to water borne diseases like cholera, bilharzia, and other diarrheal diseases. To access enough nutritious food, participants from ASAL areas sold livestock at low prices to prevent losses, which reduced their stock. Women and men from ASAL and non-ASAL communities mentioned that they reduced the number of meals per day, relied on minimal sustenance such as porridge or tea to stretch their food supplies, ate one kind of food, or missed meals all together.

On the other hand, participants engaged in certain practices which hindered resilience and exacerbated their vulnerability. In ASAL and non-ASAL communities, participants reported practicing open defecation, which contributed to water and environmental contamination. In ASAL communities, participants indicated that they depended on external aid, evacuated, and went back to the same areas once floods subsided, and this led to recurrent displacement and losses. See Table 3 for illustrative quotes.

4. Discussion

We found that droughts and floods significantly disrupt access to basic services, livelihoods, health, sanitation, and food security, with disproportionate impacts on women and children. Results demonstrated a lack of planning for energy, inadequate planning for water, and access to nutritious food in anticipation of drought. Moreover, these results highlighted minimal coping strategies for access to energy, safe water, and nutritious food, and reduced recovery strategies from droughts and floods in all counties. Challenges to planning, coping with, and recovery from droughts and floods at the household and community level stem from a lack of motivation to act due to infrastructural challenges, lack of resources (finances, land), unawareness, inadequate knowledge about early warning systems, and gender norms around roles and responsibilities which isolated women and youths from undertaking collective resilience efforts. We have synthesized our findings and highlighted practices which could be adapted by policy makers and organizations to inform targeted interventions and strategic planning for droughts and floods in relation to access to clean and reliable energy, safe water, and enough nutritious food. We found that:

- Droughts and floods disrupt access to clean energy, safe water, and nutritious food, and affect health, sanitation, transportation, and financial wellbeing.
- Women and children face the greatest burden due to gendered roles in firewood and water collection, food preparation, and limited decision-making power.
- Households engage in planning, coping, and recovery strategies to maintain access to essential services. These include stockpiling resources, using alternative energy and water sources, and diversifying food options.
- Resource constraints, infrastructure challenges, knowledge gaps, and restrictive gender norms hinder effective resilience practices.
- Traditional knowledge, community networks, and innovative practices such as improved cookstoves and rainwater harvesting can support resilience.
- Innovations are needed that strengthen early warning systems, expand access to clean technologies, promote adaptive food

Table 3
Illustrative quotes for Household resilience behaviors and practices.

ASAL communities			
	Positive resilience behaviors	Negative resilience behaviors	Anti resilience behaviors
Energy	<p>“Charcoal is not considered because I myself as the conservancy board, we discourage people strongly against charcoal burning because we want to do conservation and charcoal burning is not conservation friendly so we advise people not to use charcoal a lot but they do, you know we have a lot of wild animals moving around and they can do destruction to trees so when you see the trees being destroyed by an animal, then you can use it but don't cut it to use so we are trying to discourage people against the charcoal burning.” KII (Chief): Lodokejek ward, Samburu County.</p> <p>P2: What I can say is that, during floods not everyone use electricity, some use solar and as you know the solar lamps are charged, the batteries are charged too and so you simply put it on at night since it was already charged in the day. For those using firewood, they put it in the houses so that they are not rained on or get soaked in water. FGD (YM): Garbatulla ward, Isiolo County.</p> <p>“We plant trees to avoid deforestation, or we do replacement when you cut one tree at least you plant two to attract rains also to ensure that when drought comes, we have trees for firewood which we cut down for firewood and we plant others”. FGD (YW): Maralal ward, Samburu County.</p>	<p>“Yes, we have no plans on firewood as well as things we use for lighting, we cannot just wake up to go and collect more firewood to store just because we are expecting drought.” FGD (YW): Baawa ward, Samburu County.</p> <p>“When it comes to drought, we do not know when it is coming. So, anything to do with planning, we do not plan it just find us not planned. Not everybody will plan for himself because not everybody knows when the drought is coming. Just knowing alone about drought how will know? And what will you plan yourself with?” FGD (OM): Garbatulla ward, Isiolo County.</p>	<p>“People here we are livestock keepers we are afraid of using gas because we usually hear of the story that when you mess while lighting the gas it explodes so people are afraid of using it.” KII (CBO leader): Garbatulla ward, Isiolo County.</p> <p>“And firewood also has a lot of disadvantages because this smoke that it emits suffocates the children and this smoke affects the house in many ways because it blinds the children and also makes them cough and also makes adults to cough and it also transmits a disease like asthma.” FGD (OM): Maralal ward, Samburu County.</p>
Water	<p>“.... So, people who have drums they collect more water and store with their jerrycans but for people who do not have drums, they have to collect with their jerrycans and when the water get finished, they continue going to the source to collect water.” FGD (OW): Lodokejek ward, Samburu County.</p> <p>“According to me, everyone should have their own toilets so that when it rains the waste is not carried to our water sources causing water contamination. They should also get used to boiling of the water before use.” KII: Baawa ward, Samburu County.</p> <p>“You know when the heavy rains fall it helps because we harvest water from the roof top so that when the dirty one that is flowing comes, we still have the rainwater.” FGD (YW): Oldonyiro ward.</p> <p>“You buy a big polythene bag and cover your house with it. You tie jerry cans at the end of the four corners of the house because we do not have permanent houses to harvest water from. After tying the jerry cans to the ends, you fold the polythene bag a little so as to direct the water into the jerry cans. ... And that is how we get clean water. FGD (YM): Oldonyiro ward, Isiolo County.</p> <p>“For those of us living next to eroded places, we normally fill up those trenches with sand so that water flows far away from you. FGD (OW): Garbatulla ward, Isiolo County.</p>	<p>“Another thing is on drinking water- there is no drinking water during drought, okay there was a time we had water being pumped from the lake but not anymore. Therefore, people are straining to access clean drinking water and therefore what people use is that water from the water pan which is decanted and used for drinking, but it is very dangerous for our health.” FGD (YM): Lodokejek ward, Samburu County.</p> <p>“Our water is clean because it is from the borehole. When you talk of people boiling water maybe some of them but not everybody because when you go telling people ways of treating water, they will start asking you questions if you are the doctor to tell them so.” FGD (OM): Garbatulla ward, Isiolo County.</p> <p>“We just take dirty water because people who do not have toilets, they use bushes and also girls change their pads there in the bush and when there are rains the flowing water carries away the wastes into the river and people go and collect water there, so, it affects the sources that people collect water from.” FGD (OW): Baawa ward, Samburu County.</p>	<p>“When there are floods for people who use rivers as toilet their feces is being carried by the water to the river where people usually collect water from and when people collect water there, they will be affected with diseases like cholera.” FGD (YM): Maralal ward, Samburu County.</p>
Food	<p>“During drought there are plants which are drought resistance so people should plant such plants so that when drought come, they have food.” FGD (YW): Maralal ward, Samburu County.</p> <p>“There an organization called Narik which came and helped in constructions of dams hence helping in the supply of water used for farming which in turn helps in growth of nutritious food.” KII (Health promotor): Baawa ward, Samburu County.</p> <p>“Last year when we had floods in this region, I heard so many different things over the radio like a heavy downpour is likely to take place, the roads will become impassable, I just heard so many things over the radio and during that time most people planned for that including me, I also planned for that, people stocked food in their houses depending on one's financial ability, for me I bought food in advance and stored in the house ... FGD (OM): Garbatulla ward, Isiolo County.</p> <p>“If you have any vegetables in your possession, there</p>	<p>“People have started practicing farming but during drought season we depend on the government to bring us food and also the non-governmental organization or the well-wishers because during that season we don't plant anything.” KII (Village Administrator): Baawa ward, Samburu County.</p> <p>“For food, people only get food from the market, there is not any other way of getting food because it is only on Friday and people are not conversant with carrying cash all the time. They only get the money by the moment they sell livestock and get cash for food, and the food is for one week until the next Friday which is the market day.” KII: Oldonyiro ward, Isiolo County.</p> <p>“There is nothing we do during this time, if it comes, we just struggle the same way we do for the livestock but again if we could have that ability then at times, we can sell these livestock and get money which we use to buy food from the places which have food. Therefore, for us we never have such like plans in the community but again what I can say is that it will be</p>	<p>“We are sometimes forced to move out from our own homes and go live in different area and maybe I had planted a farm this will make one go through a loss.” KII (Village Administrator): Baawa ward, Samburu County.</p> <p>“We usually leave our houses and migrate with livestock to other places where we can access pasture [grass] for the livestock. We go to far places like Wamba, Meru, Maralal, Somali as long as our livestock gets what to eat, we believe even us we will get what to eat. We do not even plan for our own sake. FGD (OW): Garbatulla ward, Isiolo County.</p> <p>“We do not have plans on food unless when we go to the market and buy food for about 2–3 days because we do not even have money to buy food in bulk, so, money also becomes a challenge.” FGD (OW): Baawa ward, Samburu County.</p>

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Table 3 (continued)

ASAL communities			
	Positive resilience behaviors	Negative resilience behaviors	Anti resilience behaviors
	is a way we usually dry them up if you know that there is a drought that is coming. You first boil the vegetables until it is almost cooked and then you remove it and put it in the sun to dry and when dry, you store them in boxes for use during droughts." FGD (YM): Oldonyiro ward, Isiolo County.	good if we can get training from the people like you who can show or tell us how to prepare in case of a suspected drought or floods." FGD (OM): Garbatulla ward, Isiolo County.	
Non-ASAL communities			
	Positive resilience	Negative resilience	Anti resilience
Energy	<p>"When we harvest the maize, we put the "Masogoro" which is the maize cob; the stems also are used because when you cut trees we are asked by our men. We also make "nungo" which is where we dry our firewood from the heat and smoke from the cooking area."- FGD (YW): West Bukusu ward, Bungoma County.</p> <p>"There are women who make these cooking <i>jikos</i> that you can even cook with one firewood and there is no smoke, we have women here in our village that have been taught on how to make <i>jikos</i> that can either use firewood or less charcoal, meaning there will be no loss and you will not use much money, you can even buy for 20Ksh and cook <i>githeri</i> until it gets ready for consumption." FGD (YW): Kibiri ward, Homa Bay County.</p> <p>"I think we are really trying in the sense that we have solar lights like D-lights and Sun-kings in our houses which even when there is no strong sunlight to charge but still will never fail to even charge slightly with the available sun shine heat and so we are able to have light and of course the introduction of the solar lights has saved us from the initial use of the olden tin lamps which involved use of paraffin." FGD (YW): Gwasi South ward, Homa Bay County.</p>	<p>"I can say that my community has an attitude that the trees don't do well in this place. Women also have an attitude that it is the men who are supposed to plant trees. So, they have left that responsibility to the men to plant the trees. The men are also busy working in the lake, and they don't have time to plant trees. So that has made this place where we stay to have less trees." FGD (OW): Wang' Chieng ward, Homa Bay County.</p> <p>"I saw with my open eyes when a woman takes rubber slippers and even plastic shoes. She gathers old or used plastic shoes and uses firewood for cooking. She uses plastic shoes to cook so that her children can even get porridge to drink." FGD (OW): Wang Chieng ward, Homa Bay County.</p>	"What some people do is to cut down trees and place somewhere to dry so as to use when it is raining." FGD (OM): Gwasi South ward, Homa Bay County.
Water	<p>"So, after fetching water, you don't come directly and put the water guard inside because it can't help. You must first keep the water in a jerrican and allow it to settle such that the mud layer goes down then you filter out the clean water and treat it because you cannot treat the water while it is dirty." FGD (YM): Chesikaki ward, Bungoma County.</p> <p>"We normally boil drinking water, and this is one of the ways in which we purify water. We also buy water guard which we put in water and by doing that, there are some bacteria which are killed by water guard." FGD (YM): Southeast Alego ward, Siaya County.</p> <p>"What I do during the rainy season is that after collecting the rainwater, I sieve and then add the chemical which is water guard to make it safe. Once treated I therefore cover it and use it for drinking." FGD (YW): West Yimbo ward, Siaya County.</p>	<p>"Another thing is on drinking water- there is no drinking water during drought, okay there was a time we had water being pumped from the lake but not anymore therefore people are straining to access clean drinking water and therefore what people use is that water from the water pan which is decanted and used for drinking, but it is very dangerous for our health." FGD (YM): Kibiri ward, Homa Bay County.</p> <p>"I think 1 % of the villagers only treat water, there was a time that dispensers were placed at the water source, and people used to say that chlorine will kill them. So, people were not treating water even if the chlorine was at the source." FGD (YM): Southeast Alego ward, Siaya County.</p>	"During this time water enters the house but they don't move out to new place they only shift places" FGD (OW): West Bukusu ward, Bungoma County.
Food	<p>"I am still on the cultural method of preserving which was the backbone of the community. For example, my mother was using Ash in the farm to kill pests which attacks vegetables. That ash also preserves food like maize and after that we will buy medicine. The price of good food will then be sieved to remove the soda ash and at the end of the day you will just eat good food." FGD (OM): Chesikaki ward, Bungoma County.</p> <p>"What we normally do is early planting, this enables crops to grow in a short period of time hence they can sustain floods and is normally done by people from lowlands." FGD (YM): West Bukusu ward, Bungoma County.</p> <p>"We have food like wheat, sweet potatoes, they actually help in those days of drought because the moment they grew up even without rain they mature, and they can even stay in a span of two years." FGD (OW): Malakisi ward, Bungoma County.</p> <p>"People plan by having cassava, people plant these in the farms with the intention of using it as food during drought. We also have sweet potatoes planted and used for food during drought. We have vegetables such as cowpeas which can withstand drought and so these are</p>	<p>"We minimize the food we take that is if we were taking 2 meals a day, we start taking 1 a day." FGD (OW): Malakisi ward, Bungoma County.</p> <p>"During drought you will find that the number of meals reduces. That is when we say that "we only wash our hands once" (a phrase that is commonly used during famine to mean that people only eat once in a day) we will only eat at night. During the day people can just walk around going to talk to the neighbors just to pass time. So, when night comes that is when people cook and eat." FGD (OW): Wang Chieng ward, Homa Bay County.</p> <p>"Sometimes we find other means like taking porridge the whole day or we survive on tea to ensure that not all we cook at least for the food to last for more time." FGD (OW): Malakisi ward.</p> <p>"This is because we survive with ugali that we take as supper and maybe for our kids we try and provide porridge for lunch that is made from the same flour used to make ugali." FGD (OM): Malakisi ward, Bungoma County.</p> <p>"During drought you will find that the number of meals reduces. That is when we say that "we only</p>	<p>"Many people in our community use to sell food in order to get extra money to purchase other basic needs so the best way is that they should be advised not to sell food but to save for later use." FGD (OW): West Bukusu ward, Bungoma County.</p> <p>"Like right now people are being told to migrate from that place, but they are not moving out anyway. And another thing is that some people use this thing as a trading tool because they are able to receive some goodies when there are floods, and mark you some can move from there to some of the lands which are not flooded and so some take it as something normal, that which we call "serikali saidia" Swahili word loosely translated as "Government please help" FGD (YM): Kibiri ward, Homa Bay County.</p> <p>"In fact, since time in memorial, I haven't seen people preparing, just a few individuals. Even the preservation methods of vegetables I don't think this generation is aware about. So, it is hard." FGD (YM): Wang' Chieng ward, Homa Bay County.</p>

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Table 3 (continued)

Non-ASAL communities		
Positive resilience	Negative resilience	Anti resilience
<p>the things we plant to use for food during drought.” FGD (YM): Southeast Alego ward, Siaya County.</p> <p>“During the rainy season and when there are a lot of vegetables, you get the vegetables and then you soak the vegetables in the hot water. So, after doing that you put the vegetables then take something we call ‘<i>teng’a</i>’ (Something open made of reeds that can be used to drain water from the vegetables) So you put your vegetable there to drain water from it then later store the vegetables on a mat or a sack and it stays there for as long as it can last. So, when the drought strikes you, then that is what you cook and eat. FGD (YW): East Asembo ward, Siaya County.</p>	<p>wash our hands once” (a phrase that is commonly used during famine to mean that people only eat once in a day) we will only eat at night. During the day people can just walk around going to talk to the neighbors just to pass time. So, when night comes that is when people cook and eat.” FGD (OW): Wang Chieng ward, Homa Bay County.</p>	

practices, address gender inequities, and integrate water-energy-food nexus thinking into interventions implementation.

4.1. Impact of droughts and floods

These findings, consistent with other studies (Haile et al., 2019; Njogu, 2021b; Gichere et al., 2013; Quandt and Kimathi, 2017), highlight the severe impacts of droughts and floods, including increased human and livestock morbidities and mortalities, diminished agricultural productivity, and environmental degradation. Additionally, water scarcity, infrastructure damage and disruption of essential services, for example, supply chains, education, and healthcare, have contributed to poor health outcomes including physical pain, psychological stress and emotional distress and economic instability within affected communities (Ho et al., 2021). Poor crop and livestock production practices can perpetuate the community’s vulnerability to environmental changes, exacerbating hardships such as hunger and financial instability, thus elevating poverty (Scott, 2006; Ogwu et al., 2024). Like in other studies (Ho et al., 2021; Cutter, 2017; Njenga et al., 2021; Asaba et al., 2013; Graham et al., 2016; Stevenson et al., 2012; Venkataramanan et al., 2020) women and children are disproportionately impacted by firewood and water collection, and food planning and preparation without necessary means or decision-making power. These burdens can pose significant health risks such as long-term physical damage, stress, and reduced time for women to pursue productive activities, and time that children could otherwise invest in schoolwork or leisure.

4.2. Planning for access to energy, water and food in anticipation of drought and floods

Planning for access to energy, water, and food during times of disruption is critical for enhancing households’ ability to cope with and recover from droughts and floods. Most communities did not plan for energy and food shortage in drought and had limited planning for floods. Planning for access to energy and food in anticipation of floods was more common than for droughts, which aligns with evidence from other studies (Raikes et al., 2019). Inadequate planning was driven by abundant firewood, lack of time, resource constraints, lack of awareness, and cultural norms around decision making. At the policy level, Kiptum and others reported a lack of national flood risk management framework in Kenya (Odhiambo, 2013a; Kiptum et al., 2025). These barriers point to the importance of targeted interventions that strengthens and enhances local knowledge and adoption of positive resilience practices already practiced in the communities which can enhance access to energy, water, and food, and integrate participatory planning into household and community resilience strategies.

Despite Kenya’s progress in communicating early warning signs including community-based monitoring systems and monthly updates

(King-Okumu et al., 2019), most communities in our context were rarely reached with information due to limited access to communication infrastructure, prompting reliance on traditional strategies. Traditional knowledge, practices and experiences like weather forecasting have played a fundamental role in informing communities’ readiness to anticipated climate-related shocks and disturbances (Mekonnen et al., 2021). Results from this study pointed to overreliance on traditional methods of early warning signs, which were deemed unreliable, and were unable to predict the duration of shocks. Integrating such practices into national planning for disaster preparedness can help streamline the issues with predictability and the extent to which the shock may last. Early warning signs communication through community meetings, community radios, and social media like mobile phone notifications can expand the information reach, as 93 % of Kenyans are mobile phone users (Demombynes and Thegeya, 2012). Strengthening community awareness and increased integration of scientific and traditional knowledge may foster more effective anticipatory actions.

4.3. Coping and recovery strategies to maintain access to energy, water and food during and after droughts and floods

Households across all counties reported using clean energy sources for lighting, which was primarily solar, reflecting the progress in adopting sustainable clean energy. However, challenges were reported with the availability and accessibility of back-up lighting system during floods due to minimal sunlight to charge solar panels, and financial capacity to procure available alternative lighting sources, especially for low-income households. Integrating energy resilience strategies, including supporting hybrid energy systems and back up lighting technologies through private sector financing, can alleviate some of these challenges. Hybrid energy systems like wind-diesel-battery configuration and a photovoltaic-biogas hybrid system can provide options for distributing power to rural communities (Lukuyu and Cardell, 2014; Kimutai et al., 2025). Although renewable energy innovations offer promising solutions for clean energy access in rural areas, high installation costs remain a barrier, due to limited income and purchasing power. The Kenya’s ASAL Policy emphasizes the importance of expanding access to renewable energy and climate-proofing infrastructure in vulnerable regions, although its implementation has faced numerous challenges (Odhiambo, 2013a, 2013b). Addressing these gaps may contribute to equitable access to reliable energy, especially for the most remote populations in droughts and floods-prone areas.

Firewood and charcoal, unclean sources of energy (Stoner et al., 2021), are still the main sources of energy for cooking, similar to other countries (Nzengya et al., 2021; Ndegwa et al., 2011). Despite the widespread knowledge and experiences of health risks associated with exposure to smoke from firewood and charcoal (Shilenje et al., 2022), many households in both ASAL and non-ASAL counties continue to use firewood and charcoal for cooking citing their affordability and

accessibility. However, strategies like the use of improved cookstoves, which use less firewood and charcoal, are the first positive steps already being embraced to address such challenges. Such innovations can be advanced to reduce exposure to household air pollution and health risks related to smoke.

Coping strategies for water access commonly practiced in both ASAL and non-ASAL counties included rainwater catchment like dams and roof catchment, and household water storage practices such as the use of jerricans, small tanks, and water trucking, which was unsustainable. While Kimani (2015) reported that rainwater harvesting has a potential to improve livelihood (Kimani et al., 2015), we found that such strategies were hindered by resource constraints such as costly water storage containers and water trucking, cultural practices due to the nature of housing especially for roof catchment, and compromised water quality due to household water handling practices. With the existing social networks, communities can pull funds and labor to address the financial constraints and ensure operations and maintenance, including rehabilitation of existing community water systems such as dams, protecting springs, and other community water systems. Capacity building on water treatment, utilizing existing funding models like microfinance, and increased planning for sustainable community water systems can accelerate community access to safe water and improve livelihoods.

Droughts and floods undermined agriculture and livestock productivity, reducing both food availability for household consumption, and income derived from livestock and agricultural sales. These impacts result in households adopting reactive coping strategies like off farm employment to generate income to cover the gap between household crops and food needs; purchase of food at increased prices because of inaccessibility due to destructions on infrastructure, and food relief (Devereux, 2007; Lolig et al., 2014). Such approaches are costly and unsustainable and could exacerbate the ripple effect of poor productivity. These shocks also lead to negative dietary coping mechanisms, including households skipping meals, consuming inadequate food, and eating one type of food, practices which can increase the risks of undernutrition (Olagunju et al., 2024). Proactive strategies such as food stock piling; cultivation of drought resistance crops (e.g., cassava, sweet potatoes, millet); investing in livestock and crop insurance and preserving meat and vegetables through drying (Huhu, 2020; Okoye and Oni, 2017) demonstrated the potential to enhance food security in the event of droughts and floods. Strategies which target capacity building on how best to produce, store and preserve foods while retaining nutritional values and ensuring hygiene can improve the effectiveness of these practices.

4.4. Resilience behaviors practiced by households and communities

Households across all counties practiced resilience behaviors to adapt, cope with, and recover from the effects of droughts and floods. Resilience is the capacity to absorb, cope with, or adapt to a changing environment, while maintaining the principal factors or structure, function, and identity (Cinner and Barnes, 2019). Our findings revealed a complex interplay of behaviors and practices which promoted and undermined communities resilience. These practices either sustainably promoted the households ability to overcome and adapt to disturbances in a healthy manner, were not sustainable or healthy for those within the system or hindered the system's ability to overcome and adapt to disturbances (Zabaniotou, 2020). Like in other studies (Teel, 2019; Alvar-Beltrán et al., 2021; Lombe et al., 2024), households employed adaptive strategies such as storing firewood, harvesting rainwater, cultivating drought resistant crops in non-ASAL counties, food preservation (drying vegetables and meat in non-ASAL and ASAL communities respectively), planting of trees, construction of trenches and gabions to reduce erosion, and construction of community dams, all which reflected their resourcefulness in the face of shocks and stressors. Such strategies can contribute to strengthening policies and programs in areas of food security (community gardens, promoting drought-resistant crops

and food preservation techniques through agricultural extension services), community led water preservation and treatment initiatives and early warning signs systems strengthening (Alvar-Beltrán et al., 2021). However, practices such as open defecation led to water source contamination resulting in health risks, affecting pregnant women and children (Saleem et al., 2019); and the smoke from firewood exposed participants to respiratory illnesses (Bede-Ojimadu and Orisakwe, 2020). Furthermore, the lack of water treatment exacerbated health vulnerabilities. These anti-resilience behaviors highlight the need for targeted interventions that address both infrastructure and behaviors. Programs such as community led total sanitation (CLTS) which have worked elsewhere, and interventions such as climate resilient sanitation solutions like elevation of latrines, so that they are situated beyond the reach of the floodwaters and can function properly, health education on water treatment and latrine use, and promotion of outdoor cooking especially when using firewood can help address such behaviors (Haque et al., 2022; Langbein, 2017; Borges Pedro et al., 2020; Okolimong et al., 2020; Wasonga et al., 2023). Communities in ASAL areas also reported selling livestock, migrating to areas with pasture and water, and reliance of government relief, practices which could be unsustainable. Economic strategies such as livestock insurance, food and seed banks can protect communities from these impacts as they offer buffer against assets losses and support long term resilience.

4.5. Strengths and limitations

This study has several strengths. Using qualitative data collection methods to understand the planning, coping, and recovery mechanisms for households during droughts and floods was crucial in capturing diverse voices, experiences, and perspectives. Participants were able to explain how droughts and floods affect households' access to energy, water services and nutritious food, providing a comprehensive understanding of how these factors interplay across different contexts. Participation of diverse groups in FGDs and KIIs allowed for the exploration of how gender norms are operationalized and provided validation of women's and men's experiences, considering that male involvement can contribute to reinforcing positive masculinity. Engaging local enumerators enabled building trust with participants as they knew the language and culture and shared lived experiences with the participants. Some limitations exist. Audio records were translated from local languages to English and during this process the meanings of some topics could have been lost or misconstrued. Furthermore, using community gatekeepers to recruit participants and selecting a convenience sample are limitations, as we may have missed key perspectives from diverse individuals who were not contacted. The season in which data was collected led to the replacement of one community, due to inaccessibility and displacement of communities. Moreover, the five counties included in the study represent a wide range of ecological, cultural and socioeconomic contexts influencing communities' experiences and response to climatic events. Significant variation within counties, across sub-counties, and villages affected coping mechanisms, access to resources, and communities' priorities. Moreover, insecurity in some ASAL areas impeded data collection, leading to potential underreporting of the most vulnerable groups. Additionally, we could not quantify the extent of the impact or the effectiveness of the strategies. Future studies could use methodologies for quantification of strategies' to better understand their effectiveness.

5. Conclusion

Droughts and floods significantly disrupt access to energy, water and food in our study area. As these extreme weather events become more frequent, it is critical to develop strategies for planning, coping with, and recovering from these events, which are essential for both the short- and long-term resilience of communities and their future development (Raikes et al., 2019). Scientific knowledge and insights combined with

traditional practices and institutional support can enhance household resilience to droughts and floods. Community driven solutions such as empowering communities to build clean energy stoves (improved cook stoves), rainwater harvesting, water conservation-protection of water sources, climate proofing of water systems, improving soil health, afforestation, or kitchen gardens could significantly enhance resilience. Moreover, strengthening communication of early warning systems, expanding access to clean energy and water technologies, promoting adaptive food practices like promoting drought resistant crops, food storage and preservation, and addressing gender inequities can contribute to sustainable resilience building efforts. These strategies can provide a foundation for policy recommendations for strengthening climate adaptations frameworks in Kenya. Integrating water-energy-food nexus (Awandu et al., 2024) thinking into interventions and supporting community-driven solutions will be key to sustaining WASH and nutrition outcomes amid increasing climate variability.

CRedit authorship contribution statement

Emily A. Ogutu: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Hemali H. Oza:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Monique Beun:** Writing – review & editing, Methodology, Conceptualization. **Reinilde Eppinga:** Writing – review & editing, Resources, Project administration, Methodology, Conceptualization. **Richard Muga:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Matthew C. Freeman:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Conceptualization.

Acknowledgements

We are grateful to the participants in this study for their valued time and for sharing their experiences. We also acknowledge the contributions of the research assistants: Azeez Olanike, Jackline Okumu, Rosebella Ouda, and Parker Haslam, who supported data collection and analysis. We extend our appreciation to the county governments of Bungoma, Homa Bay, Siaya, Isiolo, and Samburu as well as to SNV in Kenya, for their collaboration and support throughout the study duration. We appreciate the Children's Investment Fund Foundation (CIFF) for funding this work (Award number 2023 R-2201-07311). Hemali Oza was supported by a grant from the National Institute of General Medical Sciences, USA (K12 GM000680/GM/NIGMS NIH HHS/United States).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijheh.2025.114705>.

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