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Behavioural communication change for empowering small-scale farmers in addressing climate change: Perceptions, mitigation and adaptation strategies

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Climate change poses a serious threat to Kenya's food security, necessitating immediate and steadfast attention to the development and implementation of comprehensive climate risk management and adaptation strategies at both the national and sub-national levels. This study is a crucial undertaking that utilizes the direct knowledge and experiences of farmers in Kisumu, Kenya, to tackle important problems necessary for the effective implementation of strong climate change frameworks in the country. Its focus is to encourage small-scale farmers to adapt and mitigate and to undertake proactive measures to avoid maladaptation food insecurity scenarios. This study highlights major insights by utilizing a combination of content analysis, focus group discussions, and a thorough comparison of results with vast secondary data covering weather patterns from 1988 to 2017. The findings reveal a clear truth, although farmers are aware of the long-term changes in climatic factors, such as temperature variations and shifts in rainfall patterns, they find it difficult to accurately connect these changes with the broader idea of climate change. Notwithstanding this consciousness, farmers struggle with the hazards presented by climate variability and catastrophic weather occurrences without strong measures in response. While some farmers occasionally modify their farming operations both on and off the pitch, these adjustments are mainly reactive rather than proactive responses to climate change. These measures include adjusted planting and harvesting timetables, the cultivation of resilient crops, the adoption of agroforestry practices, occasional migrations to urban areas, and the dependence on remittances from external sources. These strategies are implemented as temporary alternatives to cope with the negative effects of climate change. This study emphasizes the necessity for proactive policy actions to address climate change, urging strong frameworks to manage and adapt to risks within the African context. Kenya's food security situation underscores the urgent need for practical, proactive initiatives.

Key words: Perception, climate risk management, vulnerability, passive adaptation, small-scale farmers.

INTRODUCTION

In the past few decades, incidences of climate variability and seasonal uncertainty have been on the rise globally

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(Wiebe et al., 2019). According to Muiruri et al. (2022), climate incidents including increased temperature, erratic rainfall, frequent floods, and prolonged droughts have undermined efforts for food production in sub-Saharan countries including Kenya. Projections indicate that approximately 50% of the agricultural production will be lost in developing countries if temperatures rise by 1 to 2°C (Change IPCC, 2014). Kenya has experienced a rise in annual temperature by 1.0°C since 1960, at an average rate of 0.21°C each decade. In Kisumu County, there was a decline in annual precipitation between 1960 and 2009 as well as an average increase in temperature according to meteorological data observations (Gioto et al., 2016). Targeted transformation within the food production value chain is therefore an important requirement for effective management of anticipated climate risks. This therefore calls for a detailed examination of factors that influence how farmers perceive climate change and associated risk management strategies. However, this is a complex task that involves the physiological interpretation of factors such as knowledge, beliefs, attitudes, and practices that are associated with changes in local climate patterns (Whitmarsh and Capstick, 2018). The perception of farmers about climate variability is defined by household characteristics, historical experiences of how seasonal climate patterns have undermined or enhanced productivity, accessibility of climate knowledge, and socio-cultural and geographic contexts of food production practices (Whitmarsh and Capstick, 2018). According to Singh et al. (2017), for effective achievement of long-term adaptation goals, technical knowledge must reside within the communities. It is important to note that since the level of technical knowledge is somehow influenced by the experience and/or educational background of an individual, perception can holistically be viewed as a cognitive process that entails receiving and decoding sensory information (Kabir et al., 2016).

In this study, the seven climatic characteristics and several consequences that farmers have experienced because of climate change were used to describe their perspective on variability in climate patterns. Temperature variations, rainfall levels, beginning and ending dates, farming season duration, frequency of flooding and drought, and other indicators were all considered. Climate variability affected soil fertility and erosion hazards, agricultural production, and natural and managed forest cover, all of which influenced how farmers in Katuk Odeyo experienced it. Temperature increases and rainfall decreases contribute to soil moisture stress and poor crop performance patterns, which affect crop growth, food crop production patterns, and livelihood strategies in sub-Saharan Africa. According to prior research, most smallholder farmers in sub-Saharan African countries see climate change as a key factor that underpins their food security (Tesfahunegn et al., 2016). Farmers in most parts of sub-Saharan Africa have either noticed and/or reported a drop in precipitation and an increase in air temperatures as indicators of climate variability, according to Ochieng et al. (2017). Meteorological observations appear to support farmers' views of climate variability (Mkonda et al., 2018). Climate change has shifted cropping calendars, resulting in shorter cropping seasons as well as changes in rainfall amount, distribution, and timing (e.g., late-onset and early cessation), all of which have a significant impact on agricultural production (Mubiru et al., 2018) and make households more vulnerable to climatic risks. As a result, findings from surveys of farmers' perspectives on climate variability could be useful in identifying possible areas for climate policy, adaptation, and mitigation, and could further guide sustainable agricultural activities that benefit farmers (Masud et al., 2017). Despite the importance of farmers' climate views, Western Kenya, like many other developing country regions, lacks documentation of local indicators and implications of climate change (Recha, 2017). To offset the effects of climate change, Africa's agricultural industry must undergo fundamental transformation through individual farmer initiatives as well as the introduction of new regulations. Kenya's small-scale farming sector can be stabilized and increased productivity in the face of climate unpredictability and uncertain rainfall by implementing climate-smart agriculture practices. Because Kenyan smallholder farmers are less educated, have weaker adaptive capacities, and rely on rain-fed agriculture, reorienting agricultural output for them is a difficult challenge.

Among the coping methods investigated in this study were cropping and soil management practices such as intercropping, terraces, tied-ridging, fertilizer application, planting strips, crop rotation, and contour farming. A study conducted by Kibue et al. (2016), for example, found that knowledge about agriculture has a significant impact on how people perceive and respond to climate change. Mango et al. (2017) discovered that characteristics such as group participation, education level, land ownership, and access to affordable financing were major predictors of the adoption of soil and water conservation strategies in the Katuk Odeyo in the Lake Victoria basin (Kenya) and the Chinyanja Triangle of the Zambezi River basin (Zambia, Malawi, and Mozambique). According to Macharia et al. (2014), livestock manure is used by most smallholder farmers in Kenya's central highlands to boost soil fertility. This strategy boosts agricultural productivity while decreasing greenhouse gas emissions (Macharia et al., 2020; Musafiri et al., 2020a). Few African studies have attempted to link farmers' perceptions of climatic variability and field-based adoption of adaptation and mitigation measures to socioeconomic, institutional, and environmental variables. While much research on the subject has concentrated on institutional and socioeconomic issues, very few have examined how national officials have considered local views and/or perspectives when making choices.

According to Reimer et al. (2012), approaches that adopt regression models are inadequate in elaborating strategies that are directly dependent on farmers' behavior and/or perspectives. Without delving far enough into institutional, regulatory, and environmental aspects, Asare-Nuamah and Botchway (2019) investigated the association between socioeconomic variables and climate perception predictions in northern Ghana. Without investigating environmental and policy factors, Marie et al. (2020) calculated the impacts of socio-economic and institutional variables on farmers' adoption of climate adaptation practices in northwestern Ethiopia. These practices included using improved crop varieties, planting at different times of the year, conserving soil and water, mixed cropping, irrigation, and diversifying income sources. In their study of Kenya, Ethiopia, Uganda, and Tanzania, Shikuku et al. (2017) focused on socio-economic and institutional variables, while Asayehegn et al. (2017) looked at the effects of socio-economic variables in Central Kenya, along with a small set of institutional factors (access to extension services and affordable credit), and environmental factors (agro-ecological zones) that underpin food production. As a result, the study set out to determine how farmers' view climate variability, their tactics for adapting to and mitigating the effects of climate change, policy implications, and the complexities and dynamics surrounding these factors. Three important contributions were made by the study. Given the multi-faceted nature of farmer adoption processes, the study first established a connection between farmers' views on climate variability, indicators, and repercussions and a more comprehensive set of farms' socio-economic, institutional, and policy frameworks (Reimer et al., 2012). Secondly, the research elaborated on the intensity and quantity of the adaptation techniques that were being adopted by the farmers. Thirdly, the study assessed the historical factors that motivate small-scale farmers to employ adaptive measures. This research is significant because it will add to the body of knowledge aimed at enhancing policy frameworks through the incorporation of experiences and perspectives of small-scale farmers in sub-Saharan Africa.

This study investigated the perspectives of smallholder farmers towards climate impacts, using Katuk Odeyo, a hamlet in Kisumu County, Kenya, as a representative sample. The findings are presented in Table 3. The relevant secondary data (Opande et al., 2019b) contained climate data from three weather stations in Kisumu, Ahero, and Katito, along with information on local adaptation drivers and responses. The study area is characterized by a semi-arid climate and experiences food insecurity due to a combination of socio-economic and environmental factors (Raburu et al., 2012). Additionally, the area faces issues related to low productivity in farm work (Recha, 2017). In addition, the process of land degradation and fragmentation has resulted in the loss of land that could have been utilized for agricultural purposes (Opande et al., 2019a). Consequently, the farmers are facing a significant and intimidating gulley that stretches for several kilometers. Efforts to enhance productivity in the current conditions have resulted in excessive cultivation, depletion of soil nutrients, and more erosion (Onyango et al., 2012). Opande et al. (2019a) identified several challenges that hinder effective adaptation and food production. These challenges can be categorized as poverty, weak social networks, insufficient technical capacity, and limited access to essential resources such as land, climate information, innovative solutions, viable and affordable financial instruments, and extension services.

The relationship between climate change and agriculture

The linkage between climate change and agriculture is intertwined. Agricultural discourse has evolved from an earlier thinking of just increasing the production of staple foods to a means of looking at food security in all its facets including availability, nutrition, the health and well-being of producers and consumers, and the sustainability of the production landscape (Sambasivan et al., 2013). This holistic approach has led to an increase in land cover changes and intensive food production systems that are known to emit large volumes of greenhouse gases (GHGs) (Solomon et al., 2007). A deep dive into GHG emissions indicates that collectively agriculture and deforestation contributed an estimated two-thirds of emissions in Kenya (GoK, 2016) and one-fifth (21%) globally between 2000 and 2010 (approximately 44 billion tonnes) according to the Food and Agriculture Organization (FAO, 2020). In 2018, emissions from agriculture and related land use and land use processes accounted for 17% of global GHG from all sectors, down from the 2000s. The reduction was due to increasing emissions from other economic sectors that are equally growing at relatively faster rates. In particular, N^2O emissions from livestock manure left on pastures by grazing animals and the application of manure to cropland contributed an additional 1Gt CO^2 eq in 2018 (Tubiello, 2019). At the global level, N^2O emissions from synthetic fertilizers contributed 13% to the total (0.7GtCO^2eq) while CH^4 emissions from rice cultivation contributed a further 10% (0.5GtCO^2eq) according to FAO (2020). High emissions from the agricultural sector are mainly due to an increased allocation of land space and the use of chemical fertilizers to provide for the high demand for meat and its products.

The link between agriculture and climate change is intricate and has gradually hindered endeavors for food production, especially in intense monoculture systems. Specifically, farm animals, primarily bovines, consume over 95% of the soy produced worldwide. Cederberg et al. (2009) reported that the production processes of one kilogram of bovine meat result in the emission of approximately 200 kg of carbon dioxide. This indicates that in the case of a country such as China, which has approximately 700 million pigs, a total of 80 million tonnes of soy must be either domestically produced or imported only to satisfy the need for pig feed.

The variations in climate can negatively affect agriculture by disrupting temperatures, precipitation, and other weather patterns. These disruptions can lead to reduced water availability, soil fertility, increased pests and weed infestation, and unintended physiological changes in food crops. The severity of climate effects on food production can vary from low to high and can have either positive or negative outcomes depending on various factors such as the specific region or geography (Mendelsohn et al., 2006), socioeconomic status of the community (Tripathi, 2017), access to climate information, early warning systems, and institutional support (Opande et al., 2019b). Tol et al. (2004) discovered that an increase of 1°C in temperature and a rise of 0.2 m in sea level had a beneficial impact on certain countries in the Middle East region. In contrast, similar shifts resulted in adverse effects in certain underdeveloped countries particularly those that are situated in regions with low latitudes and lack sufficient infrastructure for disaster prevention and management (Hertel and Lobell, 2014).

Agriculture can on the other hand offer opportunities for mitigating carbon emissions through sequestration, sustainable soil and land use management, and biomass production (FAO, 2020). For instance, 105 out of the 189 countries that committed in 2016 to limit their national carbon emissions to 2°C - if possible, to 1.5°C - mentioned agriculture as a key mitigation sector. However, to achieve the 2°C target, an estimated 1 $GtCO^2eq$ must be reduced annually from agriculture alone by 2030. This is a significant challenge given the increasing demand for food from an increasing global population.

Key climate change frameworks in Kenya

The Government of Kenya has shown commitment to fighting climate change by ratifying the Kyoto Protocol in 2005 and contributing to various continental, regional, and national frameworks. At the national level, summaries of selected legal frameworks that are relevant to food security and climate change have been highlighted in the following.

Constitution of Kenya (2010)

Some articles in this document provide grounds for the formulation of adaptation and mitigation legislations, policies, and strategies. For instance, in Article 11 under Culture, the roles of science and indigenous technologies in national development are recognized. Further, it emphasizes that legislation will be enacted to recognize and protect ownership of indigenous seeds and plant varieties for community use. It goes further (Chapter 4, Article 42) to guarantee the right to a clean and healthy environment under the Bill of Rights. Article 43 on Economic and Social rights states that “every person has a right to be free from hunger and should have adequate food of acceptable quality”. In Chapter 5 on Land and Environment, Article 69 provides for obligations in respect of the environment while Article 72 requires Parliament to pass legislation relating to sustainable management of the environment.

The Kenya Vision 2030 (2008)

This document is the country’s development blueprint and aims to transform Kenya into a “newly industrializing, middle-income country by 2030 in a clean and sustainable environment”. This document recognizes the role that agriculture should play towards the achievement of a sustained annual GDP growth rate of 10%. This document, which is based on three pillars: economic, social, and political, recognizes climate change as a risk that could slow the country’s development.

Kenya Climate Smart Agriculture Strategy (2017-2026)

This strategy aims to promote efforts for climate adaptation and resilience building of agricultural systems while minimizing GHG emissions. It targets three main objectives:

(a) sustainably increase agricultural productivity and incomes,
(b) adapt and build resilience to climate change, and
(c) reduce and/or remove greenhouse gas emissions.

National Climate Change Action Plan (2018-2022)

This plan provides mechanisms for realizing low-carbon climate-resilient development pathways. The plan emphasizes sustainability and in parallel prioritizes adaptation and enhanced climate resilience for vulnerable groups.

The Climate Risk Management Framework (2017)

This framework integrates disaster risk reduction, climate change adaptation, and sustainable development so that they are pursued as mutually supportive rather than stand-alone goals. The framework thus promotes an integrated climate risk management approach as a central link for policy and planning at the national and county levels.

National Climate Change Framework Policy (2018)

This policy aims to integrate climate change considerations into planning, budgeting, implementation, and decision-making. The policy targets key sectors that are relevant for fast-tracking economic development and the social well-being of the citizens. The key sectors targeted include environment, water, and forestry; agriculture, livestock and fisheries, trade, extractive industries, energy, physical infrastructure, tourism; and health. This policy specifically, aims to enhance the adaptive capacities, and resilience of communities as precursors for low-carbon development.

LITERATURE REVIEW

Climate variability and its associated impacts have emerged as significant challenges for agricultural systems worldwide, particularly in sub-Saharan Africa (SSA). In this literature review, we examine the perspectives of smallholder farmers in SSA, focusing on Katuk Odeyo, a representative sample in Kisumu County, Kenya. We draw upon a range of studies to explore farmers' perceptions of climate change, the adaptation strategies they employ, and the socio-economic, institutional, and environmental factors that shape their responses.

Perception of climate variability

Smallholder farmers in SSA, including those in Katuk Odeyo, have experienced firsthand the adverse effects of climate variability on agricultural productivity. Studies by Muiruri et al. (2022) and Gioto et al. (2016) highlight how increased temperatures, erratic rainfall patterns, floods, and droughts have undermined food production efforts in Kenya. IPCC projections (2014) indicate that even a modest temperature rise of 1 to 2°C could lead to significant agricultural losses in developing countries. In Kisumu County, the observed increase in temperature and decline in precipitation further exacerbates soil moisture stress, affecting crop growth and livelihood strategies (Gioto et al., 2016). Farmers perceive climate change through a combination of historical experiences, access to climate knowledge, and socio-cultural contexts (Whitmarsh and Capstick, 2018). Ochieng et al. (2017) found that farmers across SSA have noticed decreases in precipitation and increases in temperatures, aligning with meteorological observations.

Adaptation strategies

To cope with climate variability, smallholder farmers in Katuk Odeyo and similar regions employ a variety of adaptation strategies. Cropping and soil management practices such as intercropping, terracing, and crop rotation are commonly used (Kibue et al., 2016). Mango et al. (2017) identified factors such as education level, group participation, and access to financing as predictors of the adoption of soil and water conservation strategies. Livestock manure application, as observed by Macharia et al. (2014), not only enhances soil fertility but also mitigates greenhouse gas emissions. However, challenges such as poverty, limited access to resources, and weak social networks hinder effective adaptation efforts (Opande et al., 2019a).

Factors influencing adaptation

The adoption of climate adaptation measures among smallholder farmers is influenced by a multitude of socio-economic, institutional, and environmental factors. Knowledge about agriculture plays a crucial role in shaping farmers' perceptions and responses to climate change (Kibue et al., 2016). Access to resources such as land, climate information, and financial instruments also affects farmers' ability to adapt (Opande et al., 2019a). Furthermore, socio-cultural factors, including group participation and land ownership, influence the adoption of adaptation strategies (Mango et al., 2017). Institutional support, including extension services and affordable credit, is vital for facilitating adaptation at the grassroots level (Asayehegn et al., 2017).

Research gaps and policy implications

Despite the growing body of literature on farmers' perceptions and adaptation strategies, several research gaps persist. Reimer et al. (2012) argue that regression models alone may not adequately capture the complexity of farmers' behavior and perspectives. Moreover, studies often overlook environmental and policy factors that influence adaptation decisions (Asare-Nuamah and Botchway, 2019; Marie et al., 2020). There is a need for interdisciplinary research that considers the interplay between socio-economic, institutional, and environmental variables in shaping farmers' adaptation practices.

Summary

Understanding smallholder farmers' perspectives on climate variability and adaptation strategies is crucial for informing policy interventions in SSA. Farmers in Katuk Odeyo and similar regions face numerous challenges due to climate change, including food insecurity and loss of agricultural productivity. Effective adaptation requires addressing socio-economic, institutional, and environmental barriers while leveraging farmers' local knowledge and experiences. Future research should adopt interdisciplinary approaches to capture the multifaceted nature of farmer adaptation and inform evidence-based policy frameworks that promote climate resilience in agricultural systems.

METHODOLOGY

The study area is locally known as Katuk Odeyo and is in the Nyakach area of Kisumu County, Kenya. The area is semi-arid and has long experienced food insecurity, complex socio-economic and environmental challenges (Raburu et al., 2012), low farm labour productivity, and population pressure (Onyango et al., 2012). Further, the subdivision of cultivation land into smaller plots and, land degradation due to gulley formation and deforestation among other factors, has collectively undermined food production systems (Recha, 2017; Opande et al., 2019a).

An in-depth analysis of the region being examined uncovers little economic progress and insufficient catastrophe readiness mechanisms (Recha, 2017). Moreover, the community's vulnerability to climate impacts like as flooding, soil erosion, and land degradation has been exacerbated by insufficient access to climate information (Opande et al., 2019b). Nevertheless, to gain a clearer understanding of how climate impacts have negatively affected the well-being of communities, it is crucial to comprehend how the accessibility and affordability of food, the availability of clean and portable water, and the provision of health and education services have collectively weakened the ability of households to adapt (Opande et al., 2019a). Thousands of marginalised and impoverished families, who are facing difficulties in producing sufficient food for their sustenance, suffer from the consequences of insufficient incorporation of farmer perspectives into climate planning initiatives. While there have been efforts by various players and NGOs to improve the ability of farmers to withstand challenges in the study area (Recha*,* 2017), there is a lack of research on how shaping farmers' perceptions can increase the adoption of climate-smart innovations to boost food security.

The research methodology used a careful stratified random selection approach to guarantee a well-balanced representation of 315 homes from five different clans within a particular village setting. The initial data-gathering process consisted of transect walks and participatory mapping, guided by the village population register. This register provided a critical model for comprehending the complex socio-economic, environmental, and climate factors present in the research area. The initial preparation was crucial in establishing the foundation for the following stages of data gathering. The main data was collected by intentionally utilizing Focus Group Methods (FGMs), a purposeful decision made to enable a thorough examination of participant viewpoints, interpretations, and community dynamics. Focus Group Meetings, chosen over individual interviews for their capacity to provide inclusive perspectives and accelerate the understanding of community perceptions and lifestyles, facilitated extensive group discussions involving participants from diverse clans, aged between 30 and 60 years, and representing different genders.

In addition, this method allowed for the formation of smaller subcategories within the larger groupings, which made it easier to analyze the different perspectives of farmers with marginal, small, and medium-sized farms, and tenant farmers. The segmentation, which was conducted based on landholding sizes, sought to reveal a wide range of perspectives and experiences within the agricultural community. In addition to community interaction, the study integrated climatic data obtained from three Kenya meteorological stations located near Kisumu. This data served as crucial external references for temperature and rainfall trends. This methodology combines quantitative and qualitative methodologies to analyze the research region. It incorporates population statistics, weather information, and community interaction to gain a thorough picture of the complex dynamics in the area. The analysis involved exploring themes and making comparisons to identify common patterns and connections between the investigated town and its surrounding areas.

FINDINGS AND DISCUSSION

Farmers' perception of how local climate impacts affect food security

Certainly, the initial stage of cultivating a favorable attitude among farmers is imperative for promoting successful adaptation techniques within the agricultural domain. Gaining insight into farmers' perceptions of climate change is a crucial foundation. This entails assessing not only their knowledge of climate change but also exploring the extent of their comprehension of its presence and prospective effects on their farming methods. The perspectives of farmers serve as a guide for directing the theory of change and implementation of solutions that can effectively address the socio-economic challenges associated with managing climate risks and producing food. The strategy suggested by Frank et al. (2011), highlights the importance of integrating feedback spheres and a thorough grasp of farmers' perspectives into adaptation processes. This technique emphasizes two primary goals. Firstly, it aims to determine if farmers recognize the existence of climate change and its expressions within their specific local environment. This acknowledgment acts as a fundamental component for later stages in adaptation planning. Additionally, the objective is to comprehend the farmers' impression of climate change, as this perception greatly impacts their inclination to participate in mitigation and adaptation endeavors and more importantly in identifying and harnessing any opportunities that come along with climate change.

It is thus crucial to prioritize risk management methods by for instance encouraging farmers to adopt investigative approaches and climate-resilient technologies to recognize and manage climate hazards. This however entails increasing efforts to reduce any anthropogenic-induced hazards as well as actively adjusting agricultural methods to manage the evolving climate conditions. By aligning adaptation measures with the perceived risks and requirements of a farming community, the probability of effective adoption of sustainable and beneficial techniques is increased. Essentially, this method highlights the significance of incorporating farmers' perspectives on climate change into the planning and execution of adaptation measures. By doing this, it not only recognizes the influence of perception on behavioral reactions but also establishes a basis for cooperation and enforcement of efficient risk management measures that

Table 1. Basic demographic, socio-economic, and cultural profiles of the study area.

Attribute	Group 1	Group 2	Group 3	Group 4	Group 5
Clan name	Obinju	Kamango	Kamwana	Kobiero	Warieya
Farmer religion	Christians	Christians	Christians	Christians	Christians
Farm size	Small holders	Small holders	Small holders	Small holders	Small holders
Age	40-50	50-60	50-60	40-50	50-60
Farming experience	< 25 years	> 25 years	> 25 years	> 25 years	> 25 years
Level of education	Primary/ Secondary	Primary/ Secondary	Primary/ Secondary	Primary/ secondary	Primary/ Secondary
Primary occupation	Farming	Farming	Farming	Farming	Farming
Secondary occupation	Retired/small scale business	Retired/small scale business	Retired/small scale business	Retired/small scale business	Retired/small scale business

are customized to the requirements and comprehension of local farmers.

During the focus group discussions (FGDs), farmers affirmed facing challenges linked to global warming and/or less frequent and undependable precipitation, escalating soil degradation as well as incidences of flooding and or surface water runoff, delayed onset of rains, and increasing frequencies and intensity of floods over the past two decades. The farmers further elaborated on how a large gulley, several kilometers long, has undermined their livelihoods by eroding several hectares of farmland. The farmers jointly agreed that in the last three decades, precipitation patterns have changed, although differing opinions on increasing temperatures also came up. In-depth discussions indicated that this divergence in opinion was due to differences in the way individuals perceive interlinkages between direct sunshine and reduced tree coverage. Further, farmers who believed that warming is real argued that reducing tree coverage and subdividing land for new homesteads, is the reason behind diminishing precipitation, increasing warmth, and high speeds of surface water runoff. It is important to note that this perception complements scientific evidence (Recha, 2017). It is however important to note that 20 out of the 30 farmers could not directly link the fluctuating weather patterns with the formation and expansion of the large gulley. However, all 30 farmers came to a consensus that the fluctuation in weather patterns is compromising their efforts for food production. The attributes of the participants are presented in Table 1. The table indicates that the community is mainly made up of small-scale farmers between 40 and 60 years old who have generally not gone beyond the secondary level of education and have around 25 years of farming experience. Findings indicate that the community is unable to develop and manage effective food systems without extension services and access to climate resources such as early warning systems (Table 2; the availability of basic resources). Effective extension services and access to climate resources are vital for building positive perceptions towards climate adaptation and/or mitigation (Tripathi and Mishra, 2017). According to Bryan et al. (2013), the inability to access usable and time-bound climate information and targeted technical support can lead to a negative or no perception to climate change.

In-depth discussions revealed that those under 40 years old stood out in the community because they were relatively more educated, exposed and/or had access to newspapers, radio, TV, and smartphones. This observation confirms the relevance of digital media in awareness raising (Sampei and Aoyagi-Usui, 2009) and increasing access to information for influencing perception towards climate-smart food systems (Tripathi and Mishra, 2017). Further probing revealed that the farmers have responded by changing their planting times and/or adopting climate-smart seeds for those who can afford them. Affordability and availability of seeds was thus a key determinant for accelerating the uptake of smart agriculture. It also came out that the farmers preferred adaptation drivers: (a) social networks and collective action mainly through women groups and religious gatherings and (b) peer learning through experiments in peer farms to enable learning by doing.

These findings emphasize three important aspects: (a) encouraging farmers to attend social gatherings is important especially if opinion leaders and influencers will speak about climate-friendly solutions; (b) access to climate information services can influence the formation of positive climate perceptions, and (c) young and older farmers have different views and perceptions on climate change, food production, and climate risk management. The results from the study corroborate findings by Habtemariam et al. (2016) who established a direct correlation between access to climate information and the formation of positive perceptions for effective

Table 2. Basic resources that can be found within the sublocation/clan at Katuk Odeyo village.

Resources	Obinju	Kamango	Kamwana	Kobiero	Warieya	Nyagol
Village development office	0	0	0	0	0	0
Church	1	1	1	1	1	1
Piped drinking water	0	0	0	0	0	0
Agriculture extension office	0	0	0	0	0	0
Market	1	1	1	0	0	0
Cold storage	0	0	0	0	0	0
Agro seed sales shop	0	0	0	0	0	0
Veterinary extension office	0	0	0	0	0	0
Milk collection centre	0	0	0	0	0	0
Primary school	1	1	1	1	1	1
Secondary school	0	0	1	0	0	1
Nursery school	0	1	0	1	0	1
Primary health centre	0	0	1	0	0	0
Paved road	0	0	0	0	0	0
Cooperative saving facility	0	0	0	0	0	0
Mobile money (Mpesa) kiosk	1	1	1	1	1	1
Score	4/16	5/16	6/16	4/16	3/16	5/16

Table 3. Climate impacts that are undermining food production in Katuk Odeyo.

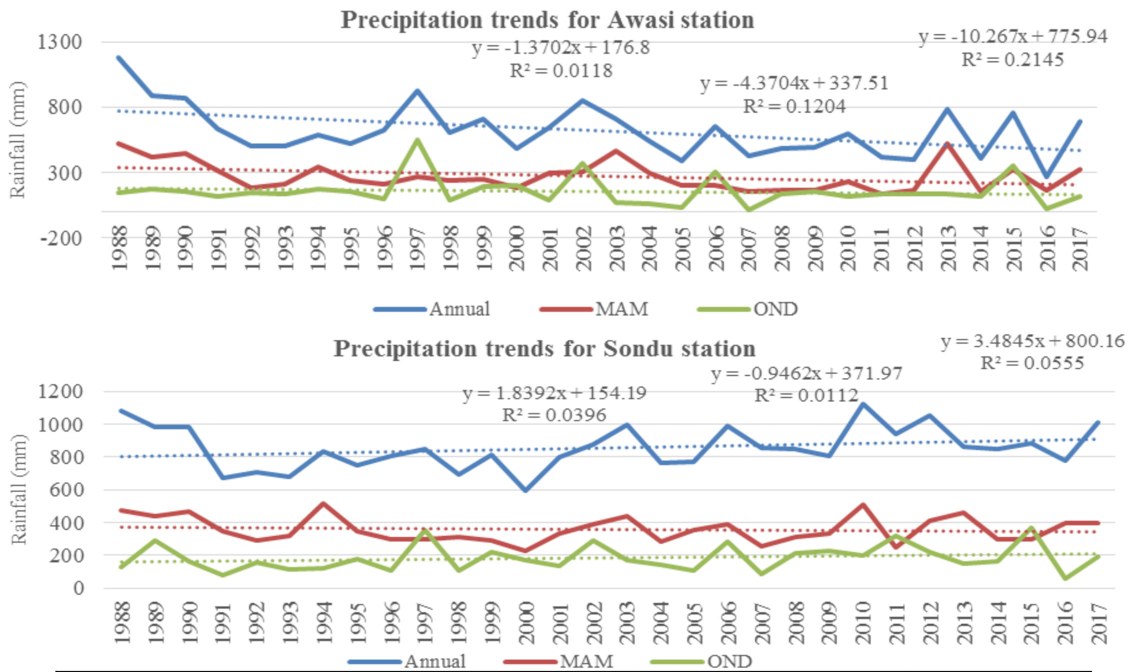
Rising temperature	Changing rainfall patterns
Drying crops and seedlings	Washing away of crops
Drought	Late and unpredictable rains
Emerging weed and pest species	Unpredictable planting patterns
High food prices	Higher food prices
Water stress	Land degradation (gulley's)
Changing ecosystem species	Soil infertility
Health problems	Increased incidences of malaria
Rural-urban labour migration	Destruction of properties and infrastructure by floods and water runoff
-	Family separated by the huge gulley

management of climate risks and food systems.

Table 3 presents the perceptions of farmers towards negative climate impacts. An analysis of findings that have been presented in the table further justifies an endless cycle of low income and food insecurity at the community level. It is important to note that perceptions in Table 3 corroborate findings from Figures 1 and 2 on climatic trends and selected adaptation drivers by Opande et al. (2019b). On the other hand, marginal farmers with small land holdings or whose farms had been washed away by floods somehow shifted their livelihoods away from on-farm work to other alternatives such as remittances from outside the community, small-scale businesses, and migrating to urban areas for off-farm paid jobs. Indeed, the findings of this study indicate that negative perceptions or lack of perception towards climate change can exacerbate climate vulnerability, and food insecurity and in the long term shift farmer focus to off-farm alternatives.

An analysis of local climate trends between 1988 and 2017

An analysis of local climate trends shows annual increasing maximum and minimum temperatures of about 0.022 and 0.034°C, respectively. The climate data further shows that the rise in minimum temperature is significant in comparison to that of maximum temperature. Similarly, an analysis of precipitation data shows variability in decreasing amounts and increasing incidences of floods. Finding from the FGDs that precipitation trends are changing, and the onset of March-May (MAM) and October-December (OND) planting seasons were delaying, somehow complements findings from the analysis of secondary climate data. A deep dive into



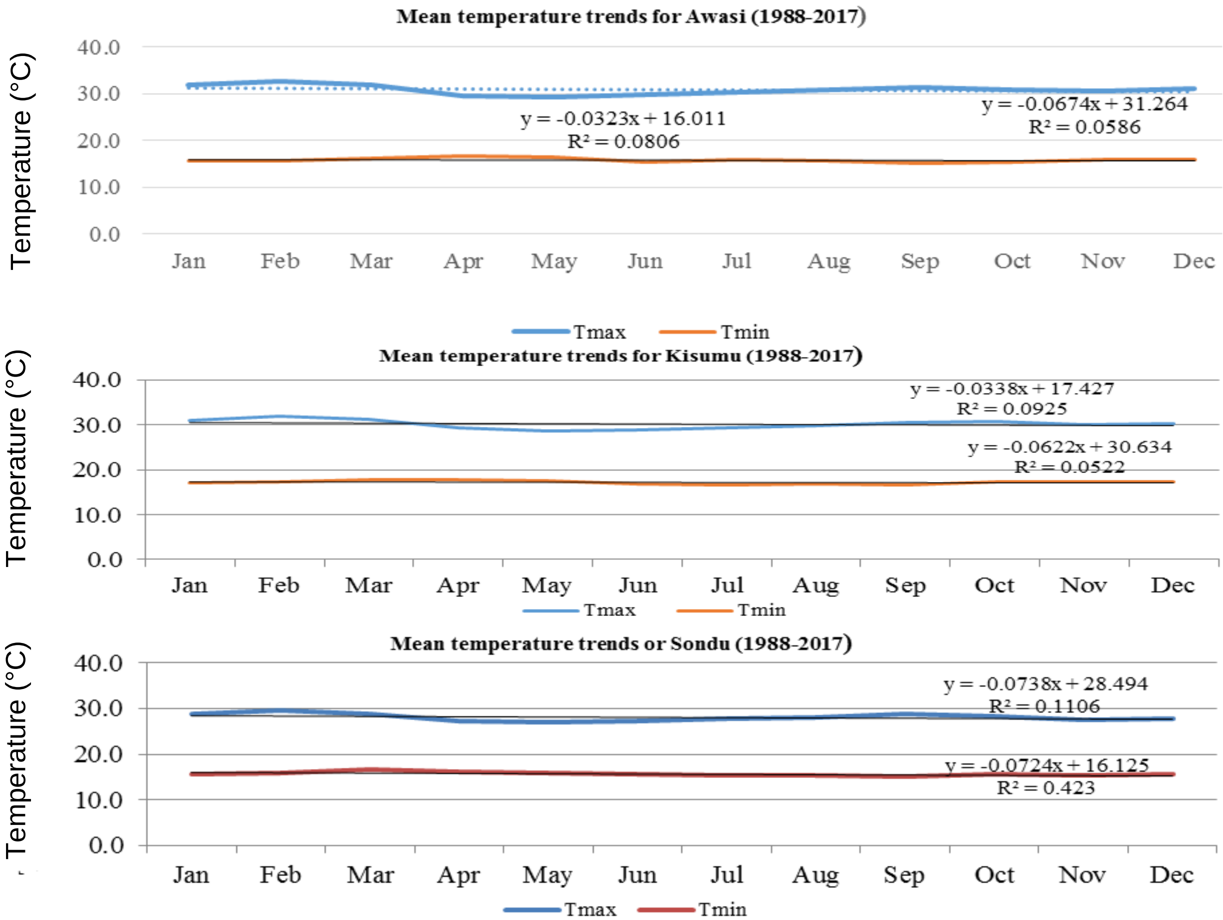
Station		Annual	MAM	OND
Awasi	Kendall's Tau	-0.2966	-0.3130	-0.1984
	P-value	**0.0216**	**0.0160**	0.1292
Kisumu	Kendall's Tau	0.0989	-0.0783	0.1172
	P-value	0.4574	0.5560	0.3760
Sondu	Kendall's Tau	0.1872	-0.0912	0.1406
	P-value	0.1613	0.4994	0.2934

Figure 1. Time series of observed precipitation trends for Awasi, Kisumu and Sondu stations between 1988 and 2017. Kendall's Tau significance tests: the –ve sign means a negative trend and the +ve sign means a positive trend. Further, a p-value less than 0.05, indicates a significant trend while a p-value greater than 0.05 means the trend is insignificant. Bold values mean significant trends for respective climate parameters.

weather patterns (Figure 1) confirms irregular annual precipitation patterns with a slight decline in the long rainy season of MAM. The analysis however revealed an increased precipitation from September to February in some years. This increase has been attributed to a tendency of the short rainfall season (OND) to extend into the normally hot and dry months of January and February (Recha et al., 2017). This variability in temperature and precipitation impacted farmers' ability to produce food given that they practiced rain-fed agriculture.

CONCLUSIONS AND POLICY IMPLICATIONS

Climate change and food security are significant concerns for most African nations. While emissions from Kenya, are not significant, the agricultural and deforestation sectors contribute the most carbon emissions. It is worth noting that food production in Kenya heavily relies on rainfall, and therefore the ongoing variations in temperature and rainfall patterns persistently affect the socioeconomic progress and food security of the community under study. Despite their limited ability to adapt, the community has responded in both beneficial and detrimental manners. Hence, it is crucial to acknowledge the necessity of endorsing cost-effective and feasible technologies to enable the farmers to enhance their food security position. Nevertheless, this necessitates a fundamental change in the way policy frameworks are formulated and food security measures are implemented. Hence, this article suggests a comprehensive reassessment of the strategies and methods now being implemented by the Kenyan government for climate adaptation. The plans should be revised to incorporate growing climatic and socio-economic concerns. This can be achieved by initially



Station		Tmax	Tmin
Awasi	Kendall's Tau	-0.0606	-0.1212
	P-value	0.8406	0.6384
Kisumu	Kendall's Tau	-0.0606	-0.1515
	P-value	0.8406	0.5452
Sondu	Kendall's Tau	-0.1212	-0.4242
	P-value	0.6384	0.0629

Figure 2. Time series of observed mean monthly temperature trends for Awasi, Kisumu and Sondu stations between 1988 and 2017. Kendall's Tau significance tests: the –ve sign means a negative trend and the +ve sign means a positive trend. Further, a p-value less than 0.05, indicates a significant trend while a p-value greater than 0.05 means the trend is insignificant. Bold values mean significant trends for respective climate parameters.

assisting communities in identifying how they might take advantage of climate-related opportunities. One way to achieve this is by facilitating their comprehension of climate dynamics within their immediate surroundings and utilizing this understanding to encourage the development of climate-friendly solutions in the areas of food production, distribution, and marketing. This will facilitate their cognitive process in perceiving climate change in a constructive rather than pessimistic approach. Furthermore, it is crucial to identify and promote suitable strategies that are tailored to the specific local context to expedite the community's response to perceived climate risks and their repercussions. This strategy should motivate individuals to take initiatives and have a future-oriented mindset, rather than relying on extension systems that are sluggish or unresponsive. This could significantly mitigate the prevalence of maladaptive responses, which are frequently executed hastily and without informed deliberation. Perceptions should be received, interpreted, and explained promptly, accurately, and with knowledge as a cognitive process.

It is important to further note that the accuracy of perception is dependent on the level of knowledge and experience of a particular individual and/or family. Based on this backdrop, this paper tried to look at two things. First, perceptions of the smallholder and marginal farmers to climate change, and climate risk management, and second, how farmer perception can influence on and off-farm adaptation responses. The findings of this paper indicate that farmers are aware of climatic trends concerning temperature and precipitation fluctuations. The paper further suggests that passive adaptation is common among farmers despite ignorance about the causes of climate change. This, therefore, makes it necessary to promote effective adaptation practices by first making the farmers knowledgeable so that they see beforehand the negative impacts of maladaptation. The findings also confirm that perception around deforestation and soil erosion is important for taming land degradation and in this context gulley formation. While perception around sustainable land management is known to be an important signal for enhancing crop yields and improving community livelihoods, this study has proved that print and digital media (newspapers, TV, radio, and smartphones) and, social networks are important catalysts for enabling positive perceptions. According to Singh et al. (2016) sharing climate information and farmer advice through mobile phones is more convenient than using traditional print media especially if farmers own smartphones. The study has further proved that farmers tend to rely on social networks when support from extension services is limited or not available. Social networks, particularly gatherings such as funerals, churches, and women and peer group meetings, are therefore important catalysts for enabling positive farmer perceptions and outreach pathways. It is therefore beneficial to set up organized social networking platforms where farmers can learn and share ideas about climate change, risk management, and food security. This study thus concludes that perceptions are somehow linked to the local knowledge and experience of the household head. This linkage should thus be taken into consideration as key in the development and implementation of policy frameworks for enhancing food security and climate risk management.

In conclusion, we recognize constraints in achieving internal validity because of inadequate controls and a limited sample size. Consequently, these discoveries may not be universally applicable to other regions. It is important to understand that focus groups are particularly suitable for conducting exploratory research and are not commonly employed for explanatory or descriptive research purposes. However, our work aimed to address these limitations by conducting a comparative analysis of our findings using secondary data obtained from earlier studies.

RECOMMENDATIONS

Based on the insights provided in the excerpt, the following four recommendations were proposed:

Promote climate literacy and knowledge sharing

Farmers' perceptions of climate change are influenced by their level of knowledge and experience. Therefore, there is a need to prioritize climate literacy programs that educate farmers about climate dynamics, its impacts on agriculture, and adaptation strategies. This could involve leveraging various communication channels such as mobile phones, social networks, and community gatherings to disseminate climate information effectively. Government agencies, NGOs, and other stakeholders should collaborate to develop and implement educational initiatives tailored to local contexts.

Facilitate community-based adaptation strategies

Community-based adaptation approaches should be encouraged to empower farmers to develop and implement context-specific adaptation strategies. By involving farmers in identifying climate-related opportunities and developing climate-friendly solutions, communities can enhance their resilience to climate risks. This could include promoting sustainable land management practices, such as afforestation and soil conservation, and supporting the adoption of climate-smart agricultural techniques.

Enhance extension services and social networking platforms

Given the limited access to formal extension services, particularly in remote areas, there is a need to strengthen extension networks and establish organized social networking platforms for farmers. These platforms can serve as valuable channels for knowledge sharing, capacity building, and peer learning. By leveraging existing social networks, such as community gatherings and peer groups, farmers can access vital information on climate change, risk management, and agricultural best practices.

Integrate local knowledge into policy frameworks

Policy frameworks for enhancing food security and climate risk management should be developed with a deep understanding of local knowledge and experiences. Policymakers should engage with local communities to incorporate their perspectives and priorities into adaptation planning and decision-making processes. This could involve establishing participatory mechanisms, such as community forums or advisory committees, to ensure that policies are contextually relevant and responsive to the needs of smallholder farmers.

By implementing these recommendations, policy-makers, stakeholders, and development practitioners can support smallholder farmers in sub-Saharan Africa, including those in Kenya, in building their resilience to climate change and improving food security outcomes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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