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Adoption of climate resilient agricultural practices among the Giriama community in South East Kenya: implications for conceptual frameworks

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While quantitative studies are robust at assessing the extent of climate change adaptation, and statistical relationships among variables involved, qualitative studies are also essential to understand the social rationales underlying relationships among variables, and to identify the roles of variables that have been overlooked or are hard to measure. This study investigates factors that influence the adoption of climate resilient agricultural practices by resource-poor Giriama farmers in southeast Kenya, with a view to understanding why some smallholders from this cultural group adopt climate resilient practices, while others do not. Data was collected through in-depth interviews with 30 farmers, 15 of whom had adopted climate resilient farming practices recommended by agricultural experts, and 15 of whom had not adopted any of those practices. The adopters were market-oriented, and tended to have individual land tenure, higher levels of experience in farming, slightly larger farm sizes, middle to high school education levels, and be younger. They had access to agricultural extension, access to farm inputs, and their off-farm activities tended to be related to agricultural supply chains. Non-adopters farmed entirely for subsistence, on communal or leased land, had less formal education, and adhered strongly to cultural beliefs and practices. Their off-farm income was unrelated to agriculture. More of the adopters were males, while many of the non-adopters were female. Particular cultural practices and taboos inhibited the adoption of several of the climate resilient practices, such as planting hybrid maize, keeping dairy goats, using improved goats such as the Kenyan Alpine for breeding purposes and the use of water conservation structures for crop production. Further, the qualitative information explains how and why factors such as land ownership, gender, culture, and access to information are interrelated, in ways that are not necessarily obvious in statistical analysis. The study thus highlights issues that need to be considered in conceptual frameworks underpinning both quantitative and qualitative studies, and particularly how they interact, in order to provide the knowledge essential to policy and programs intended to enhance smallholder farmers' adaptive capacity.

KEYWORDS

climate change, adaptation, gender, culture, vulnerability, qualitative, conceptual framework

1. Introduction

Climate change has been a major threat to the efforts to achieve food self-sufficiency and improving the livelihoods of rural communities in low-income countries (Serdeczny et al., 2017; Zakaria et al., 2020). This is due to the communities' high reliance on rain-fed agriculture, which is climate sensitive (Bryan et al., 2013; Wassie and Pauline, 2018). Africa is projected to experience an increase in the frequency and intensity of drought and flash floods (Chiang et al., 2021; Ayugi et al., 2022). This will have a direct negative impact on crop and livestock enterprises and the availability of water for agricultural production in most areas of the continent (Shrestha and Aryal, 2011; Zakaria et al., 2020). Despite Africa's vulnerability to climate change, its adaptive capacity is still low due to over-reliance on rainfed agricultural systems.

Adaptation to climate change is a complex process incorporating many factors such as economic, cultural, institutional, and biophysical environment (Bryant et al., 2000). In human systems, adaptation to actual or expected climate and its effects (Intergovernmental Panel on Climate Change, 2014) seeks to moderate or avoid harm or exploit opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (Osumba, 2011; Posas, 2011). Adaptation involves considerations of resilience, the capacity for a social-ecological system to adapt, reorganise and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts (Bryant et al., 2000), and vulnerability or susceptibility to climate change, related to system exposure, its sensitivity and adaptive capacity (Bryant et al., 2000; Osumba, 2011).

In recent years, climate change researchers and policy makers have focused on mitigation, with less emphasis on adaptation measures, especially those that promote resilience and reduce the vulnerability of the resource poor (Shaw et al., 2013). Rapid and unpredictable climatic change has forced agro-ecosystem stakeholders to develop new agricultural management practices such as early maturing crop varieties, drought resistant varieties, crop diversification, conservation agriculture, small livestock which require less feeding, bee keeping, and small-scale irrigation for high value crops (Perez et al., 2010; Bryan et al., 2013; Makate et al., 2019; Nyang'au et al., 2021; Gikunda et al., 2022). These practices could be potential interventions for ensuring food security and provide income for resource poor farmers (Yila and Resurreccion, 2013; Brown et al., 2018; Etim and Ndaeyo, 2020). However, these practices are developed with minimum or no involvement of the end users, i.e., the farmers as well as other relevant stakeholders (Wreford et al., 2010; Khatri-Chhetri et al., 2017; Mwongera et al., 2017). This has resulted in low adoption of these practices, with farmers continuing to practise unsustainable and poorly adaptive production methods, which have perpetuated food insecurity and loss of livelihoods (OECD, 2013; Brown et al., 2018).

As a prerequisite for improving farmers' adaptive capacity, there is a need for a paradigm shift from farming practices that are vulnerable to climate change to more risk-averse sustainable production approaches, as well as effective ways of engaging the communities in taking adaptive actions (Adger et al., 2013). Further, it is necessary for all stakeholders to focus on interventions that enhance resource-poor farmers' resilience to climate change for the realisation of food security and improvement of farm incomes (Nelson et al., 2009). Thus all the factors influencing the adoption of new farming approaches have to be considered in a systemic way in order to identify sustainable strategies that will manage climatic risks and also take advantage of the opportunities created (Cobon et al., 2009; Woldeyohannes et al., 2015).

Several studies have documented factors influencing farmers' decisions to adopt climate resilient agricultural practices to include access to extension services, farmer experience, access to credit, size of land, gender and education among others (Deressa et al., 2009; Bryan et al., 2013; Meijer et al., 2015; Makate et al., 2019; Antwi-Agyei et al., 2021; Nyang'au et al., 2021). Resource poor farmers have borne the greatest impact of climate change as a result of their low capacity, low levels of education, lack of access to formal and informal sources of credit, and the use of inappropriate technology (Bryan et al., 2013). Recent studies (Yila and Resurreccion, 2013; Musa et al., 2018; Nkomoki et al., 2018; Teklewold et al., 2019) have also recognised land tenure as a factor influencing adoption of climate adaptation strategies. Meanwhile, Neef et al. (2018) studied climate adaptation strategies in Fijian communities and found that adaptation strategies are influenced by culture and social norms. Awiti (2022) found that in Africa, climate change affects women more negatively than men in a number of areas, including agriculture, and that gender-responsive solutions are needed. A recent quantitative study by Gikunda et al. (2022) in Mbeere North Sub-county Kenya, found that cultural elements such as societal traditions, values and gender roles are effective predictors of climate-smart agricultural adoption. Even with this growing body of literature on the adoption of climate resilient practices, there is limited knowledge on the interrelation between gender, culture, land tenure, and adoption of these practices. With most studies using a quantitative approach (Amadu et al., 2020; Zakaria et al., 2020; Antwi-Agyei et al., 2021; Serote et al., 2021; Gikunda et al., 2022) there is a need for qualitative studies to uncover neglected factors and explore the societal rationales connecting the important factors.

Given these gaps in knowledge, this study sought to investigate the factors influencing the adoption of climate resilient practices by resource-poor Giriama farmers in southeast Kenya, and to understand why some smallholders from this cultural group adopt climate resilient practices, and others do not. The Giriama is one of the nine ethnic groups that make up the larger group called the Mijikenda that occupy the coastal belt and hinterland of Kenya. Since the Giriama people are rich in culture, the study particularly seeks to assess the role of culture and gender in the adoption of climate resilient practices. We also take advantage of the first author being Giriama. In offering a "rich picture", qualitative study, we seek to identify factors and relationships that are important in conceptual frameworks to guide future research.

2. Methodology

2.1. The case study site: Kaloleni Sub County, Kenya

This study was conducted in Kaloleni Sub County, Kenya (see Figure 1), a major centre of Giriama people. The sub county's

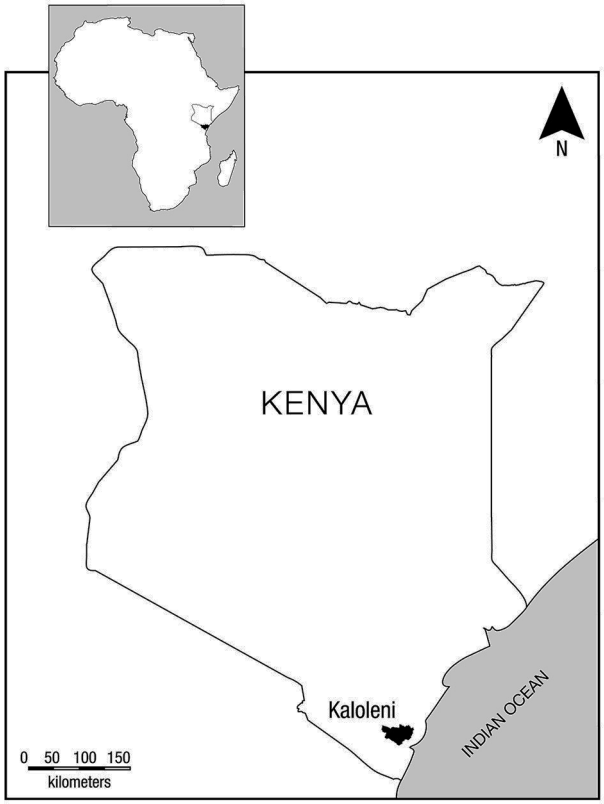

FIGURE 1
Location of the study area.

total area of 651 square kilometres is predominantly semi-arid. The total annual rainfall varies from 500 mm to 600 mm per annum in the hinterland and from 600 mm to 1,000 mm on the coastal belt. Rainfall is bi-modal, with long (and more reliable) rains between April and June and short but less predictable rains experienced between October and December. The average annual temperature ranges from 26.3–28.8 degrees Celsius. Climate change and variability are evident in the area (Figures 2, 3), affecting the livelihoods of the farming communities owing to their high reliance on rain-fed agriculture and their low capacity to adapt (Kamau and Mwaura, 2013; Sanneh et al., 2014). Since 1980 annual rainfall in the study region has fluctuated, with some reduction, while temperatures have risen (Figures 2, 3). The population is also vulnerable: among Kaloleni's total population of 193,682 (Republic of Kenya, 2019), the poverty level is 71.7%, the food insecurity rate is 67% and only 68% are literate (State Department of Crop Development and Agricultural Research, 2020).

The community practises mixed farming, having extended their pastoral practices into increasing adoption of cropping over the past century (Parkin, 1970). Most farmers are involved both in rain-fed crop and livestock production. There is no meaningful crop production between the two rainy seasons as these are dry months with low soil moisture levels. The weather patterns are no longer predictable so farmers are not able to synchronise cropping patterns with the seasons as they used to in the past. This increases their vulnerability (Shrestha and Aryal, 2011).

3. Materials and methods

Secondary data was collected from Kenya's Ministry of Agriculture reports to identify the climate resilient practices recommended by the department (Table 1). Data on rainfall, mean and maximum temperatures for the past 30 years was collected from Mtwapa Agro-Ecological weather station, and used to identify recent climate trends in Kaloleni and validate some of the climate information and trends given by the farmers interviewed.

Primary data was collected through semi structured in-depth interviews, designed to obtain direct, valid, reliable, and unique information (Hair et al., 2009). The use of semi-structured interviews allowed intensive probing to encourage the participants to express themselves freely on issues affecting their adoption decisions and avoid missing out valuable information they held (Creswell and Creswell, 2017). Thirty smallholder[1] farmers, comprising 15 adopters and 15 non-adopters of climate responsive farming strategies, were selected through purposive sampling. Purposive sampling (Morse, 2004) is commonly used in qualitative research, as it enables specific targeting of people meeting the criteria for study. The adopters were defined as farmers who were practising one or more climate responsive strategies (Table 1), and the non-adopters were defined as those who continued to use practices that were vulnerable to climate change (Stokes and Bergin, 2006) such as growing of local late maturing and non-drought tolerant seed varieties, which are low yielding. Recruitment was assisted by the area's agricultural officers from the Ministry of Agriculture.

Participation was voluntary, under ethics approval granted by the School of Agriculture and Food Sciences, The University of Queensland. Interviewees were asked background questions on themselves, their farms and farming practices, and reasons for carrying out farming. They were given a list of the practices recommended by the Ministry of Agriculture as suitable for the study area (Table 1), which they discussed. We probed the socio-cultural and technical factors that influenced their adoption or rejection of these practices, including environmental sustainability, profitability and adaptability. The participants were also asked about their use of agricultural extension services, their perceptions of climate over the previous 10–20 years and any influences on their farming practices.

Interviews were conducted at the farms by the first author, in Giriama or Swahili, in December 2014 and January 2015. To meet cultural protocols while ensuring privacy, women were interviewed outdoors within the sight, but not the hearing, of a male relative. After each interview a short tour of the farm was made with the interviewees to validate the information given especially about the size of the land and the nature of the farming enterprises. The interviews and other information were recorded in a field

1 Small scale farms are sometimes defined by their type of farming activity, sometimes distinguished from medium-scaled farms by size (Gachara et al., 2021).

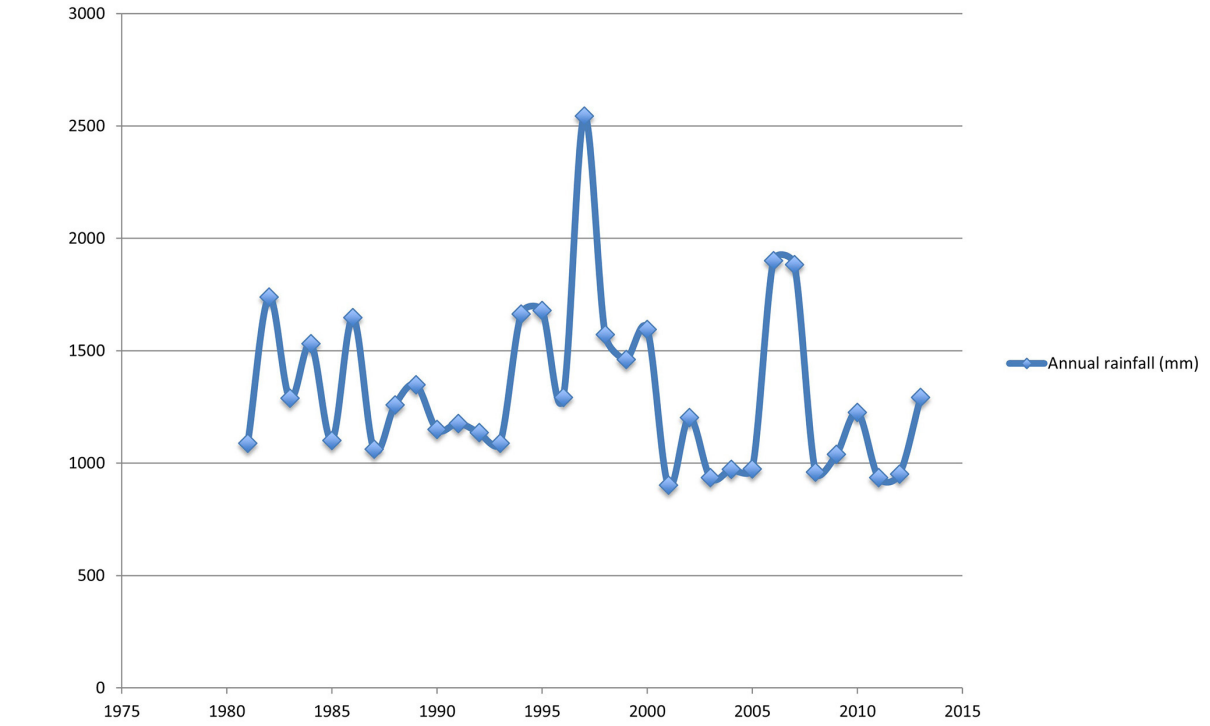

FIGURE 2
Annual rainfall over South Eastern Kenya 1981-2013.

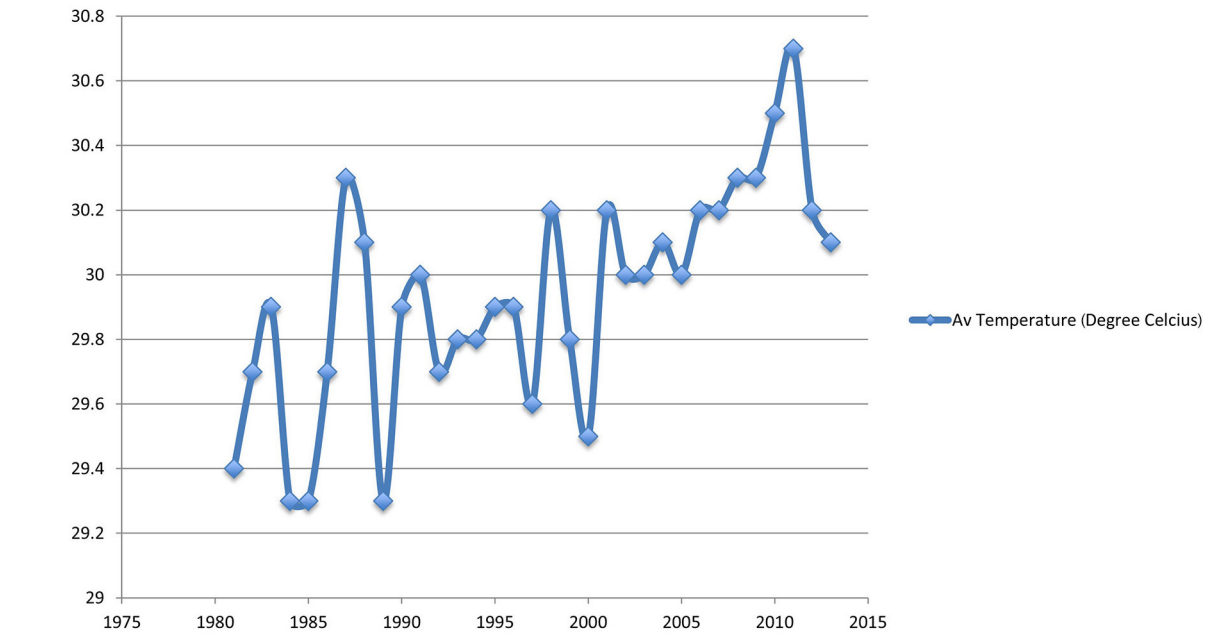

FIGURE 3
Temperature changes over South Eastern Kenya 1981-2013.

notebook, where each participant was given a code from one to thirty to ensure confidentiality.

Thematic analysis was used to analyse the interviews. Themes and sub themes were identified in relation to factors that influenced farmers' adaptation capacity towards climate change. A preference ranking of climate resilient practices was created from the frequency with which the adopter-farmers reported their use (Stokes and Bergin, 2006).

TABLE 1 Climate resilient practices recommended by the Ministry of Agriculture.

Climatic issue	Recommended practice or technology
Dwindling pasture due to unpredictable rainfall	Keeping of small livestock such as goats and poultry (Guinea fowl), bee keeping, fodder preservation
Unreliable and inadequate rainfall	Small-scale irrigation for high value horticultural production, conservation agriculture
Unpredictable weather pattern	Use of water conservation structures such as Zai-pits and retention ditches for crop production.
	Introduction of early maturing and high yielding hybrids.

Zai-pits are small planting pits, 20-30 cm deep and spaced 60-80 cm wide, designed to capture runoff and improve infiltration. Unfortunately the shape promoted in this region is grave-like.

Given that the participants were selected purposively, for a qualitative study, and the sample is small, statistical analysis was not originally intended. Given opportunity for some statistical comparison between the adopters and non-adopters, we ran correlations, least squares regression and *t*-tests on the participants' characteristics that could be represented quantitatively or in categories. This analysis was conducted after the qualitative analysis.

4. Results

4.1. Characteristics of the adopters and non-adopters

The characteristics of the adopters and non-adopters are shown in Table 2. Clear distinctions are evident in most attributes. The following results are reported from a qualitative perspective, emphasising the participants' explanations for their farming decisions and practices, but supported with statistics where variables could be measured. Where statistical results are reported, they are based on the binary distinction originally intended, between adoption and non-adoption. Analyses on the number of practices adopted had little influence on the results.

In summary, the regression shows age ($t = -2.13$, $p < 0.04$), years of experience in farming ($t = 4.49$, $p < 0.0002$), education ($t = 2.57$, $p < 0.017$), farm size ($t = 4.8$, $p < 0.0001$) and owning land communally ($t = -5.75$, $p < 0.0000$) to affect the likelihood of adopting the recommended agricultural practices. In this analysis (excluding the individual explained below and in footnote 2), adjusted R-squared is 0.782. These results suggest the more years in farming, the more likely recommended practices are adopted, yet overall older farmers are less likely to adopt. Larger farms are more likely to adopt and communal farms are less likely to adopt recommended practices. Education becomes important once accounting for a male who was highly educated but left the farming to his wife.

The form of land tenure, individual rather than communal land, was very strongly associated with the adoption of climate responsive practices ($t = 13$, $p < 0.0000$). The adopters tend to have high individual (or immediate family) control over their land, which is either individually owned (14 of the 15 adopters) or individually leased (1 instance). In Kenya, leasehold entails rental or use of the land for a period; leaseholders may be limited in how they can use the land. The non-adopters have varied degrees of potential control over their land use. Just over a quarter (4 of the 15) have land that is communally owned and a third have leased land, though some of them have individually-owned land (see Table 2). The implications of land tenure in the Giriama cultural context are explained further below (see Section 3.3).

The average farm size for all interviewees is 2.41 acres. While differences between the farm sizes of adopters (mean 2.47 acres, range 1 to 3.5 acres, SD = 0.85) and non-adopters (mean 2.37 acres, range 1–6 acres, SD = 1.64) appear minimal, surprisingly this variable emerged as significant ($t = 3.93$, $p < 0.0006$).

Men (11) predominated among the adopters, while women (9) predominated among the non-adopters. Although gender shows a modest level of correlation with adoption (correlation 0.34) it did not emerge as statistically significant in the regression. We explain the role of gender, and its relationship with other social factors among the Giriama, in Section 3.3 below.

As we expand in Section 3.3 below, adopters gave up some of the cultural practices of their people, or adapted recommended practices so as to avoid contravening cultural norms. Non-adopters were deeply committed to cultural practices; these prevailed over climate adaptation advice.

The adopters were wholly or partially market oriented (only one adopter was a subsistence farmer). Adopters were attracted to climate resilient practices that would increase yields in the shortest possible time. These farmers aimed at continuous supply in order to meet market demand throughout the year. Thus they adopted practices such as growing high value, early maturing hybrid varieties and practising small-scale irrigation. Some of them also grew crops using water conservation structures such as retention ditches and Zai-pits. Meanwhile, all of the non-adopters practised subsistence farming focused on local varieties of maize, cowpeas and cassava.

The adopters were also more likely to practise off-farm income generating activities that were agriculturally based, such as hiring out their ox-drawn ploughs for land preparation, a greengrocer business for selling fresh vegetables from the farms, and a grain milling factory to add value to cereals. By contrast, the non-adopters engaged in non-agricultural activities that required unskilled labour, such as working as loaders at construction sites. Some interviewees explained that their low levels of income and education were barriers to investing in agribusiness: they could not understand the market dynamics in order to trade in demand-driven agricultural products. In addition, some of the non-adopters attributed their choices to having experienced crop failure for several years due to changing weather patterns. That prompted them to engage in non-agriculture based activities in order to have a steady income to sustain their families. However, despite perpetual crop failure they continued to practise "agriculture as usual" following their old farming methods, as they believed the community would look down on them if there was no crop on the

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TABLE 2 Characteristics of the adopters and non-adopters.

Characteristics	Adopters ($n = 15$)	Non-adopters ($n = 15$)	Row totals ($n = 30$)
Land tenure* **	High personal control over land use	Mixed levels of personal control over land use	
Individual	14	6	20
Communal	0	4	4
Leasehold	1	5	6
Gender +			
Male	11	6	17
Female	4	9	13
Market orientation **	Market oriented. Meet cash income needs from agriculture.	Practising subsistence farming. Meet cash income needs from other sources.	
Commercial	2	0	2
Commercial with subsistence	11	0	11
Subsistence NB. Totals add to 13 adopters as data was missing for two.	0	15	15
Off-farm activities	Off farm activities related to agricultural supply chains such as operating a flour mill	Off farm activities were non-agricultural	
Education*	High education levels	Low education levels	
None	0	6	6
Primary	3	7	10
Secondary	9	1	10
Tertiary	3	1	4
Access to and use of agricultural extension and training	High access and use	Low access and use	
Public	8	3	11
Private (NGO or commercial)	2	0	2
None	5	12	17
Farming experience (years)* **	Majority have over a decade's experience	Majority have less than a decade's experience	
1–10	5	11	16
11–20	5	1	6
21–30	4	2	6
31 +	1	1	2
Age (years)*	Somewhat younger than the non-adopters	Somewhat older than the adopters	
30–45	7	4	11
46–60	6	8	14
61–75	1	3	4
76–90	1	0	1

*** significant at 0.001 level; ** significant at 0.01 level; * significant at 0.05 level; + marginally significant. Where no significance is indicated, that variable was only explored qualitatively.

farm in the planting seasons. One participant said, "I would rather plant the traditional maize so that my neighbours don't look down upon me for abandoning traditions, then go to town to look for manual jobs; why should I invest when I know there is no rain". Hence they were growing crops for the sake of conformity but taking other jobs to be sure of some income, as they were unsure of yields due to the unpredictable rainfall patterns associated with climate change.

Educational level was associated with the adoption of climate adaptive practices ($t = 0.57$, $p = 0.012$), with the adopters

TABLE 3 Climate resilient technologies preferred by adopters (listed from most to least frequently adopted).

Technology	Adopters ($n = 15$)
Hybrid varieties (maize, cowpeas, dwarf coconut and cassava)	15
Small livestock keeping (local poultry, dairy goats and meat goats)	14
Water conservation structures	9
Bee keeping	2
Small scale irrigation	2
Guinea fowl	1

having the higher levels of education (Table 2). One individual with tertiary education was a non-adopter: in this case the male was interviewed, but his spouse who is neo-literate was the one implementing farming activities[2]. Most of the non-adopters had primary level education or less, and as we noted earlier, nine of them were women. The female farmers aged 40 to 60 years attributed their low level of education to cultural factors. In this age cohort males were educated in their youth while females were nurtured and groomed for marriages. Adopters with high education levels reported that they were more confident to approach agricultural support agencies, particularly private and public extension staff, on issues regarding up-scaling their agricultural production. They were quick to source information and to apply it on their farms, in contrast to their poorly educated (and mainly female) counterparts. Although adopters tended to be somewhat younger than non-adopters ($t = -2.13$, $p < 0.04$), they tended to have more experience in farming ($t = 4.49$, $p < 0.0002$), Most non-adopters had 1–10 years' experience (see Table 2).

4.2. Preferences among the recommended practices

The farmers identified some past crops and farming practices that had become obsolete in this region, the loss of which they associated with the challenges of climate change. They pointed out that growing paddy rice was not possible as the rains were not adequate and so the lowlands, which were previously used as rice fields, had been converted to growing maize. Thus, the smallholder farmers are both well aware of climate change and used to making certain adaptations.

The rates of adoption of each of the climate resilient practices recommended to the smallholder farmers are shown in Table 3, in order of their frequency. All the 15 adopter farmers interviewed had introduced drought tolerant and early maturing maize varieties such as Pwani Hybrid and Dry land Hybrid. The growing of hybrid varieties especially for maize was highly acceptable as maize was already a staple food for the community, however, the non-adopters used the low yielding and uncertified local varieties of maize, namely Kanjerenjere and Dzihana. Small livestock keeping was the second most widely adopted choice, as it has greater carrying capacity than cattle. Further, those who wanted to have a sustainable supply of agricultural produce for the market preferred to use irrigation as well as water conservation structures for production. Beekeeping was perceived to require heavy initial investment due to the high cost of hives, so was the fourth most preferred for adoption. Further, the high risks associated with the aggressiveness of the African bee were also a disincentive for those with small land holdings. Small scale irrigation that required the use of drip lines was seen as too technical for the smallholder farmers hence was least adopted. Keeping Guinea fowl was not commonly adopted. The single adopter for Guinea fowl indicated that the birds were resistant to diseases and had few predators, and a market was available for their meat.

The adopters who had introduced drought tolerant and early maturing hybrid varieties of crops such as maize and cowpeas in their farms said that the hybrid varieties yielded almost eight times more than the local varieties. However, the adopters of climate resilient practices experienced many challenges. For instance, they indicated that inputs such as certified seeds (hybrids), pesticides and fertiliser were not accessible as the agro-dealer shops were located up to 70 km from their farms, requiring difficult and expensive travel. This increased the cost of production and was a disincentive for venturing into new practices especially introducing hybrid crops. Further, they could not afford the high cost of labour especially for establishment of water conservation structures, discouraging adoption. For the establishment of these structures the adopters mostly used family labour.

The adopters who were keeping dairy goats lacked a market for goat milk, since in the culture of the community it was considered as baby food. Meanwhile, oversupply affected prices for horticultural products such as amaranth and cowpea leaves, that the adopters produced due to their high dependency on rain fed agriculture. Adoption of small scale irrigation could promote off season production thus spread supply throughout the year and stabilise market prices. Non-adopters indicated that their lack of capacity to adopt small-scale irrigation was a disincentive for horticultural production.

4.3. Social and cultural rationales in adoption of climate resilient agricultural practices

We focus here on some key factors which the interviews showed to interact with others to influence adoption, or non-adoption, of the climate-friendly practices recommended by government. These deserve far greater attention and exploration in conceptual frameworks concerning climate adaptation among smallholders.

2 For this reason this case was removed from the regression analysis. The effect on other variables was unchanged.

4.3.1. Implications of land tenure

Fourteen of the 15 adopters had individual land tenure, and the other had leased land. Those who owned land individually indicated that they were highly motivated and could implement activities without depending on a long chain of others for approval, as occurs in communally-owned or leased land holdings. Some practices such as digging of water conservation structures were viewed as reducing the utility of land to the community, hence they were not easily approved in communally owned or leased land. Most adopters had title deeds, which they used as collateral to access agricultural loans. Banks do not accept communal title deeds for accessing loans. Most non-adopters had no title deeds, as their type of land holdings did not permit individual titles. Thus there is a close linkage between the type of land holding, access to agricultural loans, and adoption of climate resilient agricultural practices.

Four of the non-adopters (but none of the adopters) referred to extended family land as "communal". Three of these interviewees came from families where the fathers were polygamous. This made it difficult for land to be sub-divided, as the individual units would be uneconomical for agricultural production thus prompting them to retain the land as an extended family. One interviewee revealed that his father had seven wives; he had 65 brothers who would have to share the approximately three acre farm. Further, each of the brothers had an average of eight children. Their communal ownership was also related to the government inability to give individual title deeds over fragmented holdings. Further, bee keeping, which is one of the key practices recommended, relies on large land holdings because the African bee is known for its aggressiveness. This made it difficult to keep bees on small land holdings, as well as the communal lands, which were in most cases not well planned to accommodate this sensitive technology.

4.3.2. The role of gender

Only four of the adopters were female, whereas a majority of the non-adopters (nine of the 15) were female. In this small sample gendered influence on adoption, considered alone, approaches significance ($t = 1.89$, $p < 0.07$). The people explained that Giriama culture has empowered men and boys in decision-making while the women are relegated to the role of implementing male decisions. The female interviewees indicated that they require approval from their spouses or their sons to implement any major agricultural activity. Some said that even though they attended training it was very difficult for them to explain what they had learnt to their spouses, in order to be allowed to implement the climate resilient practices. However, they explained that if only males attended training it would slow the pace of adoption of new practices, as the men could move to do off-farm activities, leaving the women to implement activities they lack technical knowledge about.

Further, gender interacts with education ($t = 1.99$, $p < 0.057$). Five of the females had no education, and six had only primary education. They attributed their low education levels to traditions during their childhoods whereby girls were usually only allowed to attend school to grade 3. Female non-adopters were more likely to be between 46 and 60 years old. Thus qualitative information shows a close relationship between gender, culture, education level and the adoption of climate responsive practices, yet the effect of education predominates in the regression analysis (culture not measured; education $t = 3.12$, $p < 0.004$; age $t = 1.82$, $p < 0.079$; i.e., approaching significance; gender not significant with $t = 1.128$, $p < 0.27$).

4.3.3. Cultural factors

Cultural beliefs and practices play a strong role in the Giriama farming community and some of these were hindering adoption of particular practices. Participants explained that most households do not follow the recommended practice of shelling maize immediately after harvest and storing it in sisal bags to prevent destruction by pests such as the weevil. They shell it just before consumption. This is because shelling of maize is seen as an omen of death or other catastrophe that would bring many guests who would need to be served all the food that is shelled and ready for consumption. These taboos particularly affect the adoption of hybrid varieties of maize, which are soft and sweet and prone to post harvest damage unless shelled before storage. Thus farmers continue planting the local variety, which despite being low yielding has a tougher testa that is able to withstand post-harvest pest damage for longer periods.

Culture also influences the adoption of rectangular water conservation structures for growing of crops in the area, such as Zai pits and retention ditches. These are viewed as an abomination as the recommended form resembles graves. The adopters of this technology had taken an initiative to re-design the structures to either square or circular shapes, understanding the principles and recognising that other shapes could work.

Further, lack of market for products such as goat milk, which is perishable, discourages the farmers from keeping dairy goats. Goat milk is considered to be food for babies, thus the demand is only sufficient to make production worthwhile when there are many lactating mothers. This mindset prevents potential customers in the area from buying the milk for their own consumption due to the cultural stigma attached to adults consuming the milk.

The practices for breeding goats such as the Kenyan Alpine goat (a cross-breed of the east African goat with the German Alpine goat) by using improved breeds of bucks also met challenges in the study area. Those interviewed indicated that the community considered the bucks' behaviour of mounting other bucks as well as the does completely unacceptable. Thus most bucks that exhibited such behaviours were immediately slaughtered, leading to low spread of the new breed. The appropriate practice was to have the bucks restrained in isolated pens and only brought into contact with does which were on heat. The adopters interviewed suggested that if proper husbandry was adhered to, the chances of the bucks surviving would be increased and the local breed could be improved.

4.3.4. Access to information and advice

4.3.4.1. Weather forecasts

The interviewees indicated that the area has been experiencing changes in the two seasons of rainfall and in the levels of precipitation (consistent with data from Mtwapa Agro-Ecological Station). Access to accurate and timely weather information in order to carry out proper planning for crop production and other

farming activities was a challenge to all farmers. They could not access weather information owing to the high fees, which the farmers could not afford. Instead they relied on the mass media that provided general weather information for a wider region, but this was insufficiently specific for farming and was too short-term. It did not provide forecasts for a growing season, so it was not usable for planning purposes. The interviewees disclosed that lack of proper weather information influenced their low adoption of hybrid varieties which were either designed for drought tolerance or for above-average rainfall. Planting a variety that does not suit the rainfall intensity for that season risked crop failure. Thus the majority of the interviewees were not ready to invest in the new high yielding varieties in the absence of accurate and affordable weather information. All the interviewees recommended that a Short Message Service (SMS) would be an effective way to receive this weather information.

4.3.4.2. Extension advice and information

Extension is a critical element in improving smallholder farming in developing countries (Kiptot and Franzel, 2019). Farmers who accessed extension services and information through training and sensitisation programs were also more likely to adopt climate resilient practices. All adopters had attended training in water conservation structures, and 14 of the 15 had attended training in maize agronomy, local poultry, dairy goat production and fodder production. All of the non-adopters had also attended training in water conservation structures, but not on any other practices. In most cases this was long previously, and none adopted water conservation structures, for the cultural reasons explained above. Adopters utilised extension services from both the public and private sectors (involving both commercial providers and NGOs, see Muyanga and Jayne (2008), increasing their awareness of the best adaptive responses available as well as gaining the technical knowledge for implementing the methods. Those seeking crop-based extension services were obtaining information on suitable hybrid varieties to be grown and agronomical practices for maize, cowpeas and cassava. Livestock based extension was available, and used by adopters and non-adopters, but the advice sought focused on local poultry production and veterinary services.

Both adopters and non-adopters identified needs for training in hybrid agronomy (14 of the 15 adopters and non-adopters respectively) as well as for the production of small livestock (13 adopters, 14 non-adopters) especially issues on disease management. Thus non-adopters are as interested in training. However, non-adopters indicated that the high cost of inputs and improved breed management was beyond their capacity. Most adopters reported that they had attended agricultural training events on climate change adaptation that were organised by non-governmental organisations. The presence of aid agencies advocating for climate change adaptation accelerated the change process, unfortunately non-adopters did not attend sensitisation meetings, as they perceived that the practices promoted were beyond their capacity.

4.3.4.3. Cost of the technology

Most farmers consider the profitability and riskiness associated with adoption of any new technology before undertaking it (Yila and Resurreccion, 2013). Some practices, including water conservation structures, require high initial establishment cost (Bryan et al., 2013). In our study, market conditions including input and output prices, changes in consumer demand and competition played an important role in adoption of climate responsive practices. High cost of investment was a disincentive for non-adopters. However, adopters could foresee the profitability in terms of access to market, and that motivated them to venture into the practices. This is closely tied to security of land tenure, enabling agricultural loans, thus increasing the farmers' capacity to adopt the practices recommended. Some other studies have shown that the likelihood of adoption was influenced by an individual's access to market and agricultural inputs (Bryan et al., 2013).

5. Discussion

Farmers' capacity to adopt climate-responsive practices depends, in part, on their perception and understanding of the effects of climate change (Woldeyohannes et al., 2015). Most farmers in the developing world perceive the occurrence of climate change, and this is a necessary but not sufficient condition of their initiation of adaptation practices (Yila and Resurreccion, 2013). The participants in our study recognised climate change [as have other Kenyan smallholders, see Kichamu et al. (2018)]. However non-adopters still practised production systems which were vulnerable to climate change, for a complex and interacting set of reasons.

Knowledge and experience in agricultural production, and hence awareness, are gained over time (Silvestri et al., 2012). Our study corroborates that experienced farmers are more likely to perceive climate changes early and hence they are more prepared for adaption (Gebrehiwot and Van Der Veen, 2013; Zakaria et al., 2020). In our study, those who were highly educated and had practised farming longer were more likely to have adopted recommended practices.

Adoption of any technology relates to many factors, including the relative advantage of the technology proposed, the characteristics and perceptions of the population among whom it is introduced, and the ease and speed of learning about the new practice (Kuehne et al., 2017). Our study with the Giriama shows relationships among these factors: that a technology may have relative advantage to some farmers but not to others, depending on their circumstances. The high yield realised from certain crop varieties is considered an incentive for adoption (Posas, 2011). Most studies have shown that the hybrid crop varieties have higher yield compared to the local varieties when all good agricultural practices are adhered to (Cooper et al., 2008), hence these varieties should be promoted. However, the farmers in this study explained a number of individual, cultural, and risk factors that make the high yielding varieties a difficult option in their circumstances. It is therefore important for stakeholders to promote what the local communities have identified to be probably workable given their existing resource capacity, so that there can be appropriate and faster uptake of these practices. Equally, climate-friendly practices and technologies should be developed with, not for, users (Tariq et al., 2018).

Personal and collective characteristics of the population are indeed relevant (Matarira et al., 2013; Amadu et al.,

2020; Etim and Ndaeyo, 2020), but so is the relationship with the land and other farmers. The nature of land tenure, especially communal and leasehold land, and gender relations associated with farming roles, affect autonomy in decision-making. These are social-ecological, rather than purely social, relationships. While access to information, with gendered limitations, was raised as a factor affecting ease of learning about the new practices, speed of learning about the practices was not mentioned.

The study confirms several factors identified in previous studies, and the qualitative findings make useful contributions in explaining why these have the influence they do. Higher levels of education increased the likelihood of the farmer adopting new agricultural practices to cope with climate change, corroborating (Silvestri et al., 2012). Others have found gender to be associated with decision-making to adopt or not (Murage et al., 2015; Makate et al., 2018; Kumasi et al., 2019; Olaosebikan et al., 2019; Serote et al., 2021) whereas in our small-sample study this was present but eclipsed by other factors in the regression. This study expands on information from quantitative studies to show that at least for the Giriama, education and gender are related to cultural aspects of the community, which empowers men (Yila and Resurreccion, 2013). Men were privileged in all aspects of decision-making and boys were given priority in education. Male-headed households were thus more likely than their female counterparts to take the risks to venture into new practices (Asfaw and Admassie, 2004; Kumasi et al., 2019; Awiti, 2022). In the study area, women play an important role in agricultural activities, and provide family labour for most agricultural production activities. The males engaged in off-farm activities, thus there was disparity between those who had authority over activities to be implemented on the farm (the men) and the implementers of the farming and hence the climate adaptation projects (the women). Targeting women in capacity building on climate responsive technology could influence adoption, but within the constraints on capacity presented by land tenure (Kumasi et al., 2019), and female deference to males in agricultural decision-making.

Among the opportunity factors identified in this study as supporting adopters of climate resilient practices, and constraining factors limiting those who do not, certain insights stand out. First, the farmers' goals, whether commercial (predominantly or in conjunction with subsistence), or purely subsistence, align very strongly with adoption. This appears to have been neglected in previous studies. Then, land tenure, culture and gender interact in interesting ways among themselves, and with factors previously identified in the literature and in our study, such as education levels (Deressa et al., 2009; Bryan et al., 2013; Meijer et al., 2015; Makate et al., 2019). These socially meaningful associations warrant a holistic approach in addressing climate adaptation issues. For instance among the Giriama and many other societies there is a long-term need for education of female children, redressing the past empowerment of male children alone. Some of the cultural issues that have prevented girls from equal opportunities in education such as early marriage for girls have to be addressed by the government and other stakeholders in order to increase collective adaptive capacity, among many other benefits. However, education standards need to be addressed for both genders, through more government investment, in order to increase the community capacity for action on climate change.

Culture is an important factor influencing the response of a community to the need for adaptation towards climate change (Adger et al., 2013; Gikunda et al., 2022). Studies have shown how culture has shaped values and social norms (Neef et al., 2018), which have created discrepancies between adaptations that are deemed desirable by either individuals or the community at large (Adger et al., 2013; Gikunda et al., 2022), and those that are not. The Giriama in Kaloleni Sub County have a rich culture, however some of the practices recommended by the Kenyan government conflicted with Giriama cultural beliefs and practices, leading to low adoption of essential climate responsive and food security related practices. Hence there is a need to be sensitive to local cultures when developing and introducing modern climate resilient practices, and to work with local people in doing so (Tariq et al., 2018). For instance there is opportunity to work with local peoples to consider how principles such as water retention, can be applied in culturally appropriate ways. Meanwhile, as interest in commercial sales is attracting Giriama farmers to adopt new practices, that can be taken into account at the same time.

Some practices such as water conservation structures required high initial establishment cost (Bryan et al., 2013). Most farmers consider the profitability and riskiness associated with adoption of any new technology before undertaking it (Yila and Resurreccion, 2013; Makate et al., 2018). In this study, market conditions including input and output prices, changes in consumer demand and competition played an important role in adoption of climate responsive technologies. High cost of investment was a disincentive for non-adopters, who were also limited by the need for collective decision-making under communal land, and gendered roles. However, adopters could foresee the profitability in terms of access to market, and that motivated them to venture into the practices. This is closely tied to security of land tenure, enabling agricultural loans. Some studies have shown that the likelihood of adoption was influenced by an individual's access to market and agricultural inputs (Bryan et al., 2013). This was a factor in Kaloleni Sub County, where the average distance to the closest commercial centre is 21 kilometres (hence further for many). Again, more could be done to consider the local appropriateness of the practices recommended, such as affordability in a context of high rates of poverty, and land tenure arrangements which limit many farmers from making autonomous decisions, including financial decisions.

This study also confirms land tenure as a relevant factor in technology adoption especially in developing countries: the uncertainty associated with lease ownership or the continuation of the lease contract deters adoption of irreversible land improvement practices (Ramirez and Shultz, 2000; Kurgat et al., 2020; Antwi-Agyei et al., 2021). Kim et al. (2008) explained that farmers were less likely to adopt conservation practices if their land tenure was not secure, and Gebrehiwot and Van Der Veen (2013) documented that adoption of technologies is associated with land that is individually or privately owned. These issues were also found in the study area. Further, the community not only viewed land as a factor of production but also as a long-term secure investment. Land tenure security was an incentive for some farmers to invest in

strategic climate resilient measures that required high initial capital. In the study area land adjudication has not been carried out hence most farmers had no title deeds. Title deeds are mostly issued to individual land holdings; if the government would carry out more land titling in the area the community would feel more secure about investing in climate adaptation. It would also provide them with opportunities for securing agricultural loans for other purposes. This calls for strengthening policies especially those concerning land adjudication as well as agricultural credit. Nevertheless, subdivision of land to provide titles to individuals is limited by family size—in very large families the plots could be too small for viability.

Access to agricultural extension services, information exchanges, capacity building and sensitisation programs enhances adaptation strategies towards climate change among communities (Mwalukasa, 2013). Other studies have shown that farmers' interaction with extension officers influenced the adoption of technologies (Bryan et al., 2013; Yila and Resurreccion, 2013; Asfaw et al., 2018). An increase in climate adaption practices in the study area was associated with use of agricultural extension services. To bring extension services closer to the community, the Kilifi County Government allocated an extension officer to each of its four wards to increase access, however the average area of 162 km^2 per ward is still vast for effective coverage. The mode of staff transport has been motorcycles, however lack of proper servicing has contributed to ineffectiveness in terms of farmer coverage owing to a high rate of breakdown. Further, the extension officers need to be equipped with basic skills in climate change adaptation knowledge and practices in order to be effective change agents for their clientele. Setting up of Farmer Field Schools could enhance effectiveness through training courses where farmers can learn through practise and demonstration, as the population consists largely of semi-literate people (Kamau and Mwaura, 2013).

This study thus confirms a number of factors identified in quantitative studies. Importantly, it also highlights factors that are overlooked or under-emphasised in quantitative studies, and the complex relationships among the well-known and lesser-known factors. There are not merely correlations, but systemic relationships among factors such as goals, land tenure, culture, gender, education, age, and others, with their own social and cultural rationales.

5.1. Implications for conceptual frameworks and measurement

The study confirms the relevance and importance of commonly measured variables such as extension services, farmer experience, access to credit, size of land, gender, and education (Deressa et al., 2009; Bryan et al., 2013; Meijer et al., 2015; Makate et al., 2019; Antwi-Agyei et al., 2021; Nyang'au et al., 2021). It confirms land tenure, and property size (Musa et al., 2018; Nkomoki et al., 2018; Teklewold et al., 2019). It introduces the importance of a farmer's goals, whether commercial or subsistence. It highlights and expands particularly on culture and social norms (Neef et al., 2018). Culture affects adoption of climate-friendly technologies in its own right, and also influences gendered access to education, and independence of decision-making (in that those strongly committed to culture tend to have communally owned land, with constraints on individual decision-making and hence adoption of innovations). Further, it adds factors that may well be considered by scholars and practitioners with backgrounds in agricultural extension (such as access to weather information, extension advice and training, and the financial and other costs of implementing an innovation). These are not necessarily included in all types of study. Meanwhile it also confirms the relevance of most independent variables typically included in quantitative studies: age, gender (or sex), education level, and length of experience in farming.

The *interactions* among the important factors affecting adoption are crucial in conceptual frameworks (Awiti, 2022). We therefore argue that conceptual frameworks underpinning both quantitative and qualitative studies (and of course mixed methods designs) need to explore culture, and interactions between gender, culture, land tenure, and other important considerations such as goals, thoroughly and carefully. Statistical studies predominate in African studies of adoption, yet a statistical relationship may or may not be sufficient to explain the nature of the interactions that occur within a society to create the interest and capacity to adopt climate-resilient agriculture. The interactions among previously recognised, measurable, variables, and culture and goals, raise issues of autonomy in decision-making. Perceived advantages or disadvantages, and the practicalities of implementing each innovation proposed, should also be explored in each local context. Meanwhile, factors involved in access to weather forecasts, extension advice, training and information, the cost of implementing the technology, and access to credit if required, should continue to have a place in conceptual frameworks.

The need to recognise culture, and its interactions with gender and other variables, is challenging in quantitative studies. Gender, of course, is easy to record, and correlate with other basic variables. The underlying question of importance to policy makers and program developers is *why* these associations occur, and what they mean for action. Gender can influence access to land, access to resources including finance and labour, autonomy and self-esteem to make decisions, and access to extension services. Culture is more difficult to capture meaningfully, and hence explore, in quantitative studies. An exploration of culture could be approached in a number of ways. In any particular region or country, it would be possible to ask respondents whether they identify as (for Kenya) Kikuyu, Luhya, Kalenjin, Luo, Kamba, Somali, Kisii, Masai, or others (there are over 40 distinct groups in Kenya, but these can be grouped by type or region). Then, drawing on social science studies where available, it would be possible to use the format of questions about values, attitudes and beliefs typically used in the social sciences. These are commonly in the form of statements to which the respondent can agree (or disagree) according to a numerical scale such as a Likert scale (Nyang'au et al., 2021; Gikunda et al., 2022). Sets of answers to such statements can also be used to create indices, such as an index of adherence to cultural norms. Another strategy, for those with the patience to code (or the knowledge to create sets of codes for) open-ended questions, is to ask "why" the respondent has given a previous answer.

5.2. Limitations and further research

This research, like any study, has certain limitations. As a qualitative study, limited to 30 in-depth interviews among the Giriama of one Sub County, Kaloleni, it has provided "rich picture" data that might not have been uncovered through a quantitative study, given one must already know about an issue in order to include it in a survey. While we applied statistical testing to the participants' characteristics, we have approached this very cautiously given the purposive sampling, the small sample, and the limitation to easily measurable variables. Rather, the study provides a basis for possible survey research on larger, randomly selected samples to examine the extent of adoption of climate resilient agricultural practices among this and other populations, and the extent of influence of particular factors, especially if possible culture. Further qualitative research is also necessary among other peoples. While we may accept that cultural factors may be highly relevant in adoption of climate adaptation practices, or indeed other types of practice developed without sufficient farmer consultation, the particular beliefs, practices and taboos will differ among cultures.

By design, the study makes a binary differentiation between adopters and non-adopters. However, adoption of an agricultural innovation is not necessarily permanent (Setoun Sissinto-Gbenou et al., 2022). Adopters may give up a practice.

6. Conclusions

This study has shown the value of a qualitative study in identifying factors that are not necessarily included in the types of quantitative study that predominate in African research on climate adaptation, and the potential contribution of qualitative research in identifying relationships among factors that support or impede adoption of climate-friendly technologies. While quantitative studies explore relationships among variables through statistical methods, qualitative studies enable participants to explain relationships in their own ways, bringing in their local and cultural understandings and personal experiences. Further, it is essential to use critical thinking in understanding what is happening in any situation, and what that means for interventions. Reliance on quantitative studies alone could divert policy-makers' and other intervenors' attention towards variables that are not easily changed, or may not offer the best intervention points in the complex system involved in smallholder's adoption of climate-friendly agriculture.

Among the Giriama of South East Kenya, the main challenges to adoption of the climate-friendly practices recommended by experts were factors associated with farming goals, land tenure, and culture (influencing education levels of women), coupled with lack of accurate weather information in the face of increasingly unpredictable rainfall, and insufficient access to technical knowledge and advice. The climate resilient technologies preferred by the farmers in the study area provide an insight into the possible areas of intervention as a consequence of the farmers' current socio-economic, cultural, and institutional circumstances. Therefore, a holistic approach in addressing climate change is critical in addressing the gaps that exist in adoption of adaptive practices.

This presents critical policy implications for the development and promotion of technologies proposed by experts. Culture played an important role in the uptake of such technologies hence this calls for a close linkage between researchers, extension and farmers in designing technologies that are culturally acceptable and meet the needs of the end users. In doing so it is necessary for all stakeholders to understand the community cultural and gender issues, which will enable them to develop effective co-design and engagement approaches that will lead to design or customisation of more locally appropriate practices. Where there are many ethnic groups within a country such as Kenya, cultural factors can differ regionally, or even locally. The Giriama participants claimed that gender and culture were closely interrelated in influencing the uptake of technologies; differences in education, a variable typically measured in quantitative studies, are related to gender and culture. Meanwhile, recommended technologies also need to be affordable, and accessible to those who lack decision-making autonomy, and access to advice remains important.

Extension played an important role in promoting adoption, at least among those seeking opportunities and having decision-making autonomy. This calls for increase in the number of locally-based extension officers to bring extension services closer to the farmers. In Kenya, the agricultural extension staff would benefit from capacity building on climate change adaptation, including awareness of the social and cultural factors identified in this study, to make them more effective in their service delivery. Promotion of market-led production through relevant government departments could assist adoption of climate resilient technologies as the findings of this study were that adopters had commercialised their agriculture.

The main implications for conceptual frameworks are support for the types of variable so far considered in African and international studies, and a call for inclusion and stronger focus on culture, and the nuances of relationships among gender, land tenure, culture, education, and numerous other factors. The factors affecting smallholder farmers' climate adaptation (or otherwise) cannot be considered in an additive way, assuming that the presence of most factors will assure success. Rather, systemic relationships among the factors need to be understood well, in order to influence the design and promotion of appropriate interventions.

Data availability statement

The datasets presented in this article are not readily available because of ethics committee requirements and undertakings to participants not to disclose interview data. Requests to access the datasets should be directed to safariziro@yahoo.com.

Ethics statement

The studies involving human participants were reviewed and approved by School of Agriculture and Food Sciences, The University of Queensland. The participants provided their written informed consent to participate in this study.

Author contributions

The data was collected by JZ and under the guidance of HR and GP. EK-W also contributed to the conceptualisation of the study. All authors contributed to literature review, interpretation of the results and their implications, and writing the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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