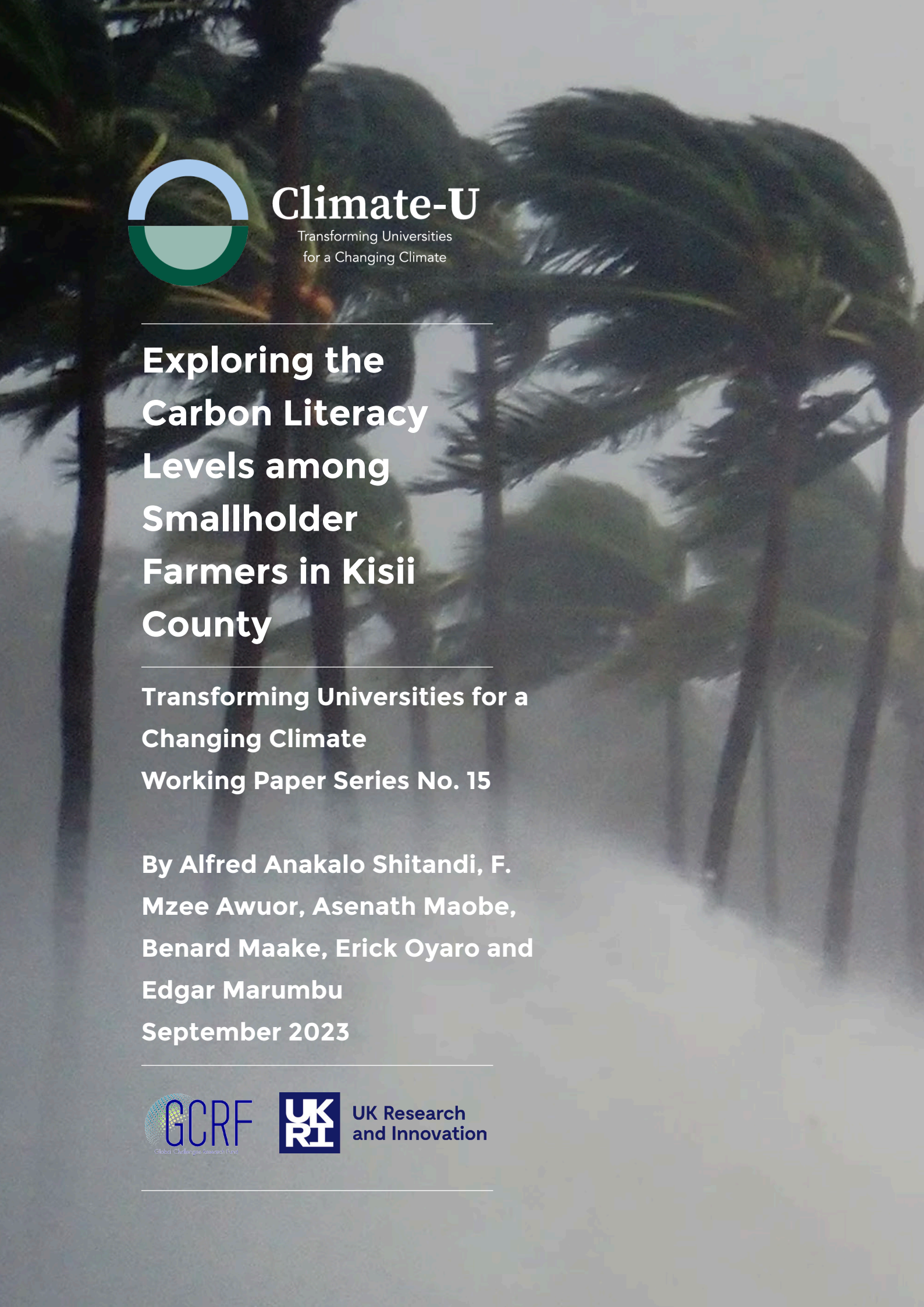

Climate-U
Transforming Universities for a Changing Climate

Exploring the Carbon Literacy Levels among Smallholder Farmers in Kisii County

Transforming Universities for a Changing Climate
Working Paper Series No. 15

By Alfred Anakalo Shitandi, F. Mzee Awuor, Asenath Maobe, Benard Maake, Erick Oyaro and Edgar Marumbu

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Abstract

In recent years, the effects of climate change have significantly degraded agricultural productivity in Africa, thus threatening food security and livelihoods. Farmers who rely entirely on rain-fed agriculture have counted massive losses as weather has become unpredictable with persistent droughts and unprecedented floods, and invasion of pests and diseases. Evidently, this threatens the achievement of Sustainable Development Goals (SDGs) 1 and 2 which focus on poverty reduction and food security respectively. Climate change thus increases the pressure on subsistence livelihoods, commercial activities, and food security. Increasing global temperatures cause water to evaporate in larger amounts, which will lead to higher levels of atmospheric water vapour and more frequent, heavy, and intense rains in the coming years. In order to survive the effects of climate change, smallholder farmers need to develop resilience and proactive mechanisms in relation to farming practices. To realize this, farmers need to understand the effects of climate change on their operations and appreciate that their traditional farming methods have been severely affected by climate change and some of these farming practices may now not be sustainable. In this project, we sought to establish smallholder farmers' carbon literacy levels in Suneka, Kisii County with a view to leveraging their understanding of developing to curb effects of climate change on their operations, and building their capacity on resilient farming practices. To this end, this report shares our findings on the information needs of smallholder farmers in relation to carbon emissions, the co-design of a digital tool for farmers' continuous learning on climate change and strategies to curb its effects in the region.

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BACKGROUND AND PROBLEM DEFINITION

Climate change adversely affects smallholder farmers' income, nutrition and even wellbeing. In recent years, the effects of climate change have significantly degraded agricultural productivity in Africa, thus threatening food security and livelihoods. For instance, farmers who rely entirely on rain-fed agriculture have counted massive losses as the weather has become unpredictable with persistent droughts and unprecedented floods, and invasion of pests and diseases. According to Pathak, Maskey, & Rijal (2021), increased temperatures worsen pests and disease infestations in crops. Evidently, this threatens the achievement of Sustainable Development Goals on food security and poverty reduction.

To survive the effects of climate change, smallholder farmers need to develop resilience and proactive mechanisms concerning farming practices. To realize this, it is becoming increasingly clear that climate change and its effects are rendering traditional farming methods unsustainable. Farmers must therefore grasp the impact of climate change on their operations and recognize that traditional practices, including agroforestry, intercropping, crop rotation, cover cropping, traditional organic composting, integrated crop-animal farming, shifting cultivation, and slash-and-burn farming, are gradually losing their effectiveness. In addition, farmers need to appreciate emerging farming techniques in view of developing resilience to the effects of climate. For instance, there is the use of climate-smart agriculture that combines traditional knowledge with modern technologies in building resilience to climate change. Other emerging farming technologies include aquaponics, precision agriculture, agroforestry and conservation agriculture that introduce new technologies alongside traditional methods. To achieve the previously mentioned goals, these farmers, who are mostly vulnerable groups such as the elderly and women, may require specific and personalized continuous learning programmes to fulfill their information needs, and guidance to apply the skills they acquire. It is against this backdrop that this project proposed a carbon literacy programme for the rural smallholder farmers. The study was carried out in Itierio - Isamwera village of Suneka Sub-County in Kisii County as discussed in the methodology section.

Specifically, this project sought to establish the information needs of smallholder farmers in relation to carbon emissions, and to design a carbon literacy training programme to meet this need in the context of improving the productivity of their farms and developing resilience to the effects of climate change.

The research questions answered in this study were as follows:

1. What is the local smallholder farmers' understanding of climate change and how has climate change affected their farming activities and productivity?
2. What are the information needs of these local smallholder farmers' in relation to climate change and farming productivity?
3. How can these information needs be met by designing a carbon literacy programme for continuous learning?
4. What digital tool might be leveraged to design and deliver this carbon literacy programme for continuous learning?

METHODOLOGY AND RESEARCH DESIGN

In answering the above research questions, this project adopted a qualitative research methodology with a participatory action research approach. To start with, Itierio village in Suneka sub-county was identified as the study area of the project. This was based on predominant effects of climate change such as unprecedented flooding, mass wasting and unpredictable drought that had been witnessed in the area in the last decade. This village is further characterized by hilly topologies that precipitate water run-offs and massive gullies. Throughout the entire project, the focus was on providing carbon awareness training on climate change preparedness and mitigation measures to a group of 100 smallholder farmers, and this number of beneficiaries remained constant. In order to ensure the participation of the farmers throughout the whole period of the project, their consent was established and collected verbally. The exercise involved an eclectic participatory method inter alia: focus group discussions, key informant interviews and observations for a period of three months. The data collection tools used were video recording, photography, audio recording, and note taking.

We conducted three focus group discussions, each consisting of roughly 20 participants. The groups were organized based on which clan they came from, activities they engaged in, gender, occupation and their literacy levels. It was easy to form these groups because the participants were already involved in other projects, and they were able to participate in the focus groups alongside those projects. Verbal consent was obtained from each participant in every focus group. We also conducted key informant interviews and asked the participants to suggest experienced and literate individuals who had good communication skills.

In this process, questions such as what the farmers know about climate change, what they lack, and information needs in relation to climate change were asked. The feedback from smallholder farmers regarding their knowledge of climate change, their perceived limitations, their information needs related to climate change, their perception of the impact of climate change on their respective activities, and whether they had access to resources and support to mitigate the effects of climate change, was used to co-design and develop a digital platform for accessing information on climate-smart agriculture. The whole interview process also took cognizance of smallholder farmers' socio-economic inequalities such as access to information, patriarchal culture, income levels, gender, and education levels in order to provide feedback that was contextualized and intersectional to the community.

STUDY FINDINGS AND ANALYSIS

The following five main socio-economic inequalities emerged as important demographic features of the farmers: access to information, patriarchal culture, income levels, gender, and education levels. Besides these socio-economic demographic features, discussed in detail below, additonal themes emerged from the findings, such as smallholder farmers' understanding of climate change and strategies to develop resilience to climate change. These inequalities were directly quoted by the participants.

A. Research Question 1: Understanding of Climate Change

What are local smallholder farmers' understanding of climate change and how has climate change affected their farming activities and productivity?

1. Level of access to climate change information

The farmers reported limited access to the local government agricultural extension office for consultation and support. This is because of a variety of reasons: the extension offices may be understaffed or underfunded; some offices may be located far away for the farmers; cultural and language barriers; and some farmers are simply not aware of the services available to them. These findings corroborate other studies in Kenya on smallholder farmers and their limited access to information and agricultural extension services support (Krell et al., 2021; Ngugi, Gitau, & Nyoro, 2007). The farmers do not possess adequate information to assist them in making decisions regarding when to plant, which crop to grow, and which season to choose, or how to cope with pest infestation problems (Maina, Ritho, Lukuyu, & Rao, 2020). As highlighted by the farmers:

"Ekero to kogenda chiobisi che serekali etokonyora chisekeire na Abaobisa ti baiyo. i go ntori konyora amang'ana igoro yo ob oremi bun akare." (Ekegusii).
"Whenever we go to visit the government offices to access information on climate change, we find them closed."(Translation)

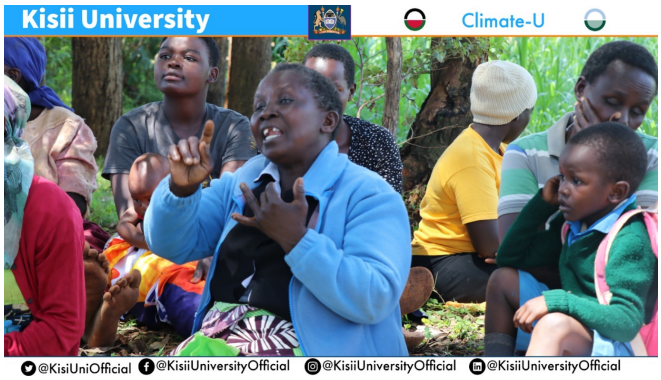

Figure 1. Small holder farmers focus discussions

The study shows that the majority of farmers have access to radios and phones, but only a small percentage have access to more advanced technology like televisions and smartphones. Radios seem to be the main source of information for farmers regarding climate change, while smartphones are primarily used for accessing social media and helping children with homework. The farmers however, reported not to have time to dedicate to listening or watching TV due to its accessibility and prefer radio programs on climate change mostly aired through weather forecasting news. They are however willing to access climate change information in any way that would grant higher farm outputs.

"Esimu eye yane onye kebwate a kareti nonya nkokora egasi, nkoigwa ochakire gokwana nabo nkotinga eki nare gokora ndategerera, ekiagera tokonyora gokora ebinto bibere rimo." (Ekegusii)
"I am able to listen to radio on phone and access information on broadcast while I am doing othertasks." (Translation)

2. Gender and patriarchal culture in decision making

Gender is a social construct and involves analyzing behaviours, characteristics, altitudes, and social norms linked to one's biological sex at birth (Lindsey, 2005). Gender as a social construct varies from society to society. This construction is also likely to change with time (WHO, 2014). In other words, gender refers to the roles, expectations, and values placed on men and women by society in what it considers to be appropriate for them. The consideration of gender inequality was key to understanding how the smallholder farmers viewed their roles in household farming. From the findings herein, it emerges that gender plays a key role in their livelihoods.

For instance, whereas our community dialogue call was for all smallholder farmers, we noted that the majority who turned up were women. It was established that smallhold farming is predominantly done by women. Despite the fact that land is owned by men, it is women who till and use it for family sustenance with the permission of their husbands.

"Ekero nkotoma abana ase tata ise ase obokonyi bonde bwensi akobairania gocha asende, bono nanarire gwetenenera" (Ekegusii)
"Whenever I send my children to their father for any assistance, he in turn sends them back to me, so I have learnt to just be the one fending for them."(Translation)

"Nigo nkoboka chinsaa inye chia botuko ekiagera omogaka are nigo araire" (Ekegusii)
"I wake up at 4 am in the morning while my husband is a still a sleep." (Translation)

"Omogaka one anga buna omonene one" (Ekegusii)
"My husband is like my supervisor." (Translation)

What was revealed was that there are complex gender dynamics and expectations within smallholder farming households in Kisii County. The responsibility for caring for children seemed to fall primarily on the women. The husbands on the other hand depicted supervisory roles over wives, indicating a power imbalance within the household. These attitudes and practices may be reflective of wider social and cultural norms that perpetuate gender inequality.

In this community group, the men make all the decisions in regard to cropping, farm management, and selling the farm produce. These findings are a contrast from Adeagbo, Ojo, & Adetoro (2021) whose findings on smallholder farmers identified women as the main decision makers on farm management. According to smallholder farmers in this study, the bigger portion of the income from the sales proceeds is kept by the man. It was apparent that women are the ones who are actively involved in the wellbeing of the family-daily subsistence and yet they do not have rights to make important family decisions on their own. It appeared that the culture disfavoured women, and traditionally, Kisii society has been patrilineal and patriarchal, with power and authority being held by men. Women have typically been expected to marry and have children, and their primary roles have been seen as being domestic in nature. Women have often been excluded from formal education and from participating in public life and decision-making processes (Osoro & Areba, 2013). Of great use to the study was the realization that for improved smallholder farming, the man of the household was key in decision making, thus the need for inclusive engagements. During these dialogues, the researchers took a chance to undertake civic education on both gender and the role of cooperation and team work in combating the effects of climate change on their farms. Participants were also taught leadership skills such as delegation, goal-setting and decision making which could ensure cooperative efforts were successful and conflicts were reduced. Finally, gender awareness was raised on how men and women can engage in cooperative efforts.

3. Average Income levels

The smallholder farmers were generating income from the sale of farm produce. Most of them reported that they make US$1 a day and that happens when there is an available demand market.

For some farmers, they reported that they make losses whenever they are not able to sell their fresh produce. The low incomes from farming would be addressed by designing agricultural investment and policies that provide for seed capital to undertake modern farming technologies and practices to improve efficiency, productivity, and sustainability (also known as smart farming) and, long term rewards for mitigation practices will help reach larger numbers of farmers than specialized mitigation interventions (Nyang'au, Mohamed, Mango, Makate, & Wangeci, 2021). These findings resonate with those of Wollenberg et al. (2012) whose study identified the potential of smallholders' abilities to increase value in their produce by improving the management and planning of their resources. This entails the identification of ready markets for their produce given that most of the farmers were losing their fresh produce from rotting before sale. Identifying and accessing markets for these smallholder farmers was challenging due to a variety of factors, including limited infrastructure and transportation, lack of market information, and limited access to finance.

"Amatuko ande amatoke aane atagoriri nkoirana naro gochia bone agunda kindigerereti" (Ekegusii)
"Some days I return home with my ripe bananas for lack of a buyer, so they just rot as I watch." (Translation)

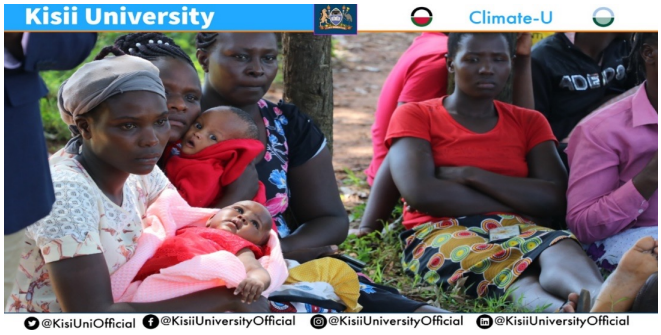

Figure 2. Engagements with smallholder farmers

4. Education Levels

The economic system and its development is essentially connected with the educational system, because knowledge is the basis of any economic system (Cimoli, Dosi, & Stiglitz, 2009). To achieve closer cooperation between these two systems, management is necessary to meaningfully connect them.

The education levels of smallholder farmers were reported as inadequate, with a majority dropping out of school either at the elementary or secondary level. This is a common trend observed among socially vulnerable groups, as they often lack general and financial literacy. Low levels of literacy, resulting from inadequate education, pose a significant challenge, especially for women. The findings revealed that only a small fraction of the smallholder farmers, had completed high school:

"Abange baito ntokoreti esukuru" (Ekegusii)
"The majority of us barely finished school." (Translation)

5. Smallholder farmers' understanding of climate change

In order to appreciate the farmers' understanding of climate change, and from data gathered, it was established that they can observe the existence of some of the climate change impacts but had little knowledge about what they can do to mitigate the effects.

The farmers have noticed a delay in the rains, and that rains are sporadic and unpredictable. The farmers have relied on birds and their flying patterns to predict the planting seasons, however, they also reported that these birds fly in low numbers and do not form the patterns they would usually look out for. Additionally, these birds do not fly anymore when rains are expected.

Interviewer: *Mlisema kuna wakati ndege wanapita ndio mnajua ni wakati wa kupanda ama ni wakati wa kulima ndio muweze kupanda. Hizo ndege bado huwa zinapita?"*
Interviewee: *Hiyo ndege, zamani ilikuwa inapita mwezi wa pili (February) nyingi, shosho wanaanza kusema sasa ni wakati wa kulima, mkilima sasa ndio mnapanda.*
Interviewer: *Lakini skuizi haziko nyingi?"*
Interviewee: *Siku hizi ni kidogo, ata ikipita ni kidogo, ha hata watoto wadogo kama hawajui, hawawezi jua ati hii ndege ni ya nini."*

Translation:
Interviewer: *"They say that there are times when birds pass by and that's when you know it's time to plant or cultivate. Do these birds still pass by?"*
Interviewee: *"Those birds used to pass by a lot in February, and the elders would say it's time to cultivate, and once you've cultivated, then you can plant. But nowadays, there are very few of them. Even if they do pass by, even small children wouldn't know what kind of bird it is."*
Interviewer: *"But there aren't many of them now?"*
Interviewee: *"Not anymore, these days they are few and far between."*

The farmers did not have access to clear information on when to plant and so they rely on inaccurate information, some of which came from their neighbours – for instance, somebody would plant when s/he notices that her neighbour is planting. This gap was clearly identified so that the information needs app can address the challenge.

The farmers who have smartphones reported using weather forecasting news to predict when to plant. Notably, they do not use weather applications to know when to plant. These farmers do not use any digital tools to determine when to plant. They have limited access to smartphones, low literacy levels, and low income.

Interviewer: *"Nonya nogocheji oko kwe rire onde oino onya gotumia esimi komanya igoro yogoonchoreri kwe rire?" (Ekegusii)*
"Who among you have used phones or digital applications to access information on when to plant and on climate change?" (Translation)
Crowd: *"Ntochibwate rende ?" (Ekegusii)*
"Do we really have phones to access such information?" (Translation)

6. Climate Change Mitigations

In order to cope, the farmers were using random methods for weather forecasting news to predict when to plant. They however had their own methods of mitigating erosions such gabion building using banana stalks, and practices of intercropping for optimal harvest. Besides, some of them were willing to cut down heavy feeder trees such as eucalyptus to help improve crop productivity.

The government has an extension office in the area which is hardly opened. There are no NGOs in the area to provide extension services except for Kisii University that has a community outreach and extension services. One example of agricultural extension services offered to smallholder farmers by Kisii University is community outreach, which included activities such as training farmers on best farming practices, soil testing and analysis, crop diversification, financial literacy and market information. This was indicative of their low access to mitigation information and use.

The farmers reported significant reduction in the farm production and experience low farm productivity:

Interviewer: *"Huwa unapanda nini?" (Swahili)*
"What do you plant?" (Translation)
Interviewee: *"Mahindi. Nilikuwa mimi napanda mahindi, lakini sai mimi naanza kupanda miwa". (Swahili)*
"Maize. I used to plant maize, but now I plant sugar cane". (Translation)
Interviewer: *"Kwa nini umewacha kupanda mahindi?"*
"Why did you stop planting maize?"
Interviewee: *"Mimi naona ni hasara, nanunua mbolea kilo mia moja,na mahindi paketi sita lakini wakati wa kuvuna unavuna tu kidogo kama gunia mbili tatu hivi. Nikaona ni hasara wacha niende niweke miwa."*
"I think it is just a loss, I buy 100kg of fertilizers and 6 packets of maize seeds, but during harvesting time, I harvest 2 or 3 bags of maize. I saw this is a loss and decided to plant sugar cane."

The farmers are overdependent on fertilizers and occasionally organic manure (Nyang'au et al., 2021). Prices of fertilizers have increased in recent times – due to the high and readily available market, and the inability of the farmers to produce organic manure. The farmers are still relying on traditional crops (mostly maize and beans) that are not resistant to climate change. There has been a decrease in the amount of rainfall in recent years. Farmers are dependent on rain-fed agriculture. They are not irrigating their farms.

B. Research Question 2: Information Needs

What are the information needs of these local smallholder farmers' in relation to climate change and farming productivity?

1. Digital tool to determine when to plant and what to plant

The farmers were excited that there could be a mechanism to provide them with information on when to plant and what to plant, in addition to how to cope amidst the effects of climate change. Such a tool would need to provide this information to them in a format and context that meets their needs and profile, such as language among others.

The farmers reported limited access to the local government agricultural extension, as the office is mostly closed and the officer in-charge is rarely available for consultation and support. Notably, 5% of the farmers interviewed have access to TVs and 90% have access to radios that they can use to access information on climate change. 90% have access to phones and of these, 5% have access to smartphones that they use to access news on social media and to assist their children with homework. However, they reported not having time to dedicate to listening or watching TV and radio programmes on climate change. They would create time to listen to radios and/or watch TVs in they expect important news or information.

The farmers have noticed a delay in the rains, and that rains are sporadic and unpredictable. The farmers have relied on birds and their flying patterns to predict the planting seasons, however, they also reported that these birds (Amagonga) fly in low numbers lately and do not form the patterns they would look out for. Additionally, these birds do not fly anymore when rains are expected. Farmers have also noted the younger generations do not understand the importance/meaning of the birds. They figure out when to plant when they notice consistency in the rains and if a few more neighbours too have begun planting for instance, somebody would plant when they notice that their neighbour is planting.

2. Mechanisms for irrigation on low water areas (information on how to minimize reliance on rain-fed farming)

During the three field visits to Isamwera, we observed deep gullies and rill erosion, mining and water pits, and there were heaps of non-biodegradable waste. We also observed that farmers had

created gabions from the banana trucks to control soil erosion on their farms. We noted that the farmers are cutting down heavy water user trees e.g., eucalyptus, and adopting traditional trees e.g., 'omokabiri'.... and plants/fruits such as 'chinsobosobo'. Further policy measures to help climate-proof the agriculture sector include: (i) increasing the adoption of drought-tolerant varieties, which can achieve 20-30 percent higher yields than no drought tolerant varieties; (ii) improving water management systems, such as efficient surface irrigation, precision irrigation, and sustainable harvesting of aquifers; and (iii) developing agro weather forecasting, monitoring and dissemination tools (World Bank, 2017, pp. 22-23). The farming practices in the area are mainly intercropping and mixed cropping, with minimal rotational cropping practices.

3. Digital tool to determine when to plant that meets farmer unique profile

The participants expressed enthusiasm about the possibility of having a mechanism that would furnish them with guidance on planting schedules, climate change, and crop selection. It is crucial for the tool to deliver this information in a manner that aligns with their requirements and preferences. Given the ubiquity of mobile phone ownership in Kenya, ICTs may continue to have increased importance in the sphere of agricultural extension. The aim of agriculture extension is to provide services and advice to rural farmers and their families so they may maximize the resources made available to them (Katz & Barandun, 2002).

C. Research Question 3: Continuous Learning

How can these information needs be met by designing a carbon literacy programme for continuous learning?

Climate change and effects, good and emerging farming practices, how to curb/mitigate the effect of climate change, information on creating value addition on their produce, information on market and market access for their produce, capacity building on land use and sustainable pesticides are mechanisms that support farmers. Lifelong Learning for Farmers (L3F) is a holistic model which emphasizes continuous learning among farmers using information and communication technologies (ICT), horizontal and vertical learning and networking with stakeholders. The L3F initiative focuses on linking human capital with social and financial capital. The initiative presents a model that is premised on the belief that an effective linkage of these three capitals will help in spiraling a self-sustaining development process.

Figure 3. Proposed Programme for Continuous Learning on Climate Change and Smallholder Farming

The Kisii University (KSU) Climate-U team (Qualitative project) met smallholder farmers at the Isamwera village, Itierio location, and based on their information needs, training materials were designed and developed for continuous learning on the effects and mitigations of climate change. These information needs, if properly addressed, would prevent and reduce the various problems faced by these smallholder farmers. In the following paragraphs, each category of the training module will be briefly explained.

The first section introduces the concept of global warming / climate change to smallholder farmers. The reason for climate change, its effects on farmers and why everyone should be concerned, are also addressed. This module proved to be very important to the smallholder farmers since most of them had been witnessing a rather strange pattern in the weather and farm produce over recent times (Nyika, 2022).

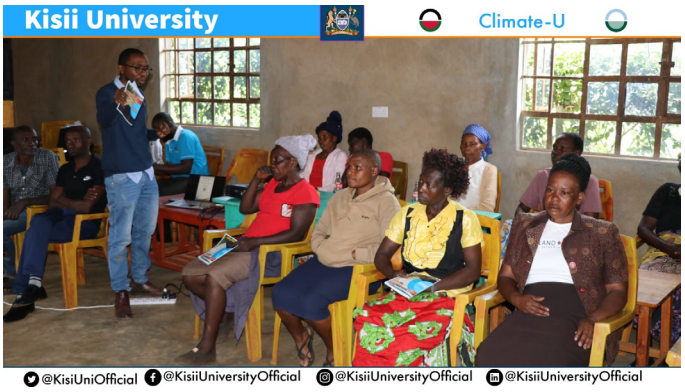

Figure 4. Farmers taken through Proposed Programme for Continuous Learning on Climate Change

The second section highlights how farming (crop farming and animal farming) contributes to climate change. Poor farming practices were highlighted, further stating how each of those practices negatively affected the environment (Wetende, Olago, & Ogara, 2018). The traditional practice of using fossil fuels as their main source of energy in their homes was discouraged. The use of pesticides, inorganic fertilizers and other toxic chemicals was likewise discouraged.

Climate-smart adaptation measures in the wake of climate change were introduced to smallholder farmers. Farmers were advised on using organic manure and other soil-conserving techniques such as crop rotation. Other important aspects critical to the farmers included changing planting and harvesting dates, following weather forecasts, agroforestry, use of drought-resistant and tolerant crop varieties (Chepkoech, Mungai, Stöber, & Lotze-Campen, 2020).

The fourth section elucidated various techniques that smallholder farmers could use to combat climate change including the use of renewable energy such as solar and wind, reducing food waste, organic agriculture, buying locally produced foods, and use of public transport, among other things (Hamid & Blanchard, 2018). These mitigation strategies would save the smallholder farmers' finances while promoting their locally produced foods.

The fifth section introduced to these farmers new and emerging farming practices that would see the preservation of natural ecosystems and promote eco-friendly farming strategies. Among the strategies brought out, permanent grasslands and permaculture seemed feasible strategies to be done by the locals (Eschen, Bekele, Mbaabu, Kilawe, & Eckert, 2021).

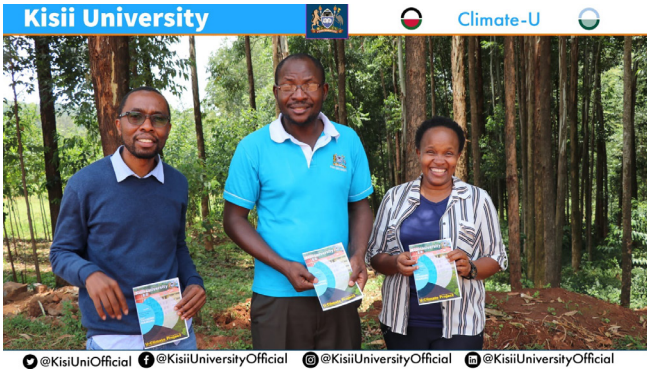

Figure 5. Kisii University Qualitative case members

Finally, in section six, smallholder farmers were educated on how to access information from government organizations and personnel, and at the same time, they were educated on how to access market markets and information of those markets, which is crucial to their trade (Mwangi & Crewett, 2019).

D. Research Question 4: Digital Tool

What digital tool might be leveraged to design and deliver this carbon literacy program for continuous learning?

The Kisii University (KSU) Qualitative project members upon answering RQ1, RQ2 and RQ3, designed and developed a digital prototype mobile application that ensures that smallholder farmers had access to their mobile phones / digital gadgets critical information contained in RQ3 (A programme for continuous learning on climate change and smallholder farming).

The digital application is the first step in ensuring smallholder farmers in Isamwera village, Itierio location, Bonchari Constituency have their information needs met. These information needs included information on climate change, better farming methods, and access to markets and governments for support.

This section outlines a schematic diagram of the application and the already-developed prototype application.

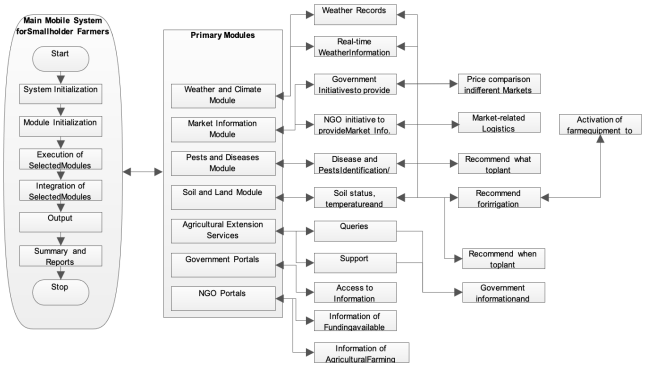

Figure 6. Schematic diagram of mobile application for continuous learning

Figure 6 shows a schematic diagram of an application that contains primary modules of the programme for continuous learning. The primary modules present avenues through which smallholder farmers can select the type of information they need. If for example, the smallholder farmer needs support from government organizations, then they can select government portals / agricultural extension services. If the farmers need to find out weather conditions in various parts of the country or their village, then they select the module for weather and climate where they will be redirected to either real-time weather information or past / present and predicted weather records. All other modules can be followed to ensure information is supplied to the smallholder farmer as required.

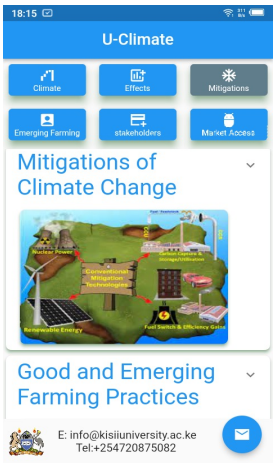

Figure 10. Home screen of the mobile application for continuous learning

Figure 10 shows the landing page of the digital application.

This is the home-screen that contains tabs (e.g. Climate, Effects, Market Access) for various content contained in the programme for continuous learning. The design is easy for anyone to get information on since it was designed with user involvement. On the bottom, there is a banner that shows the logo and contact information for the university since that's where the application was developed. There is a floating button for the user to send their feedback through email. A floating dialogue box appears, as shown below:

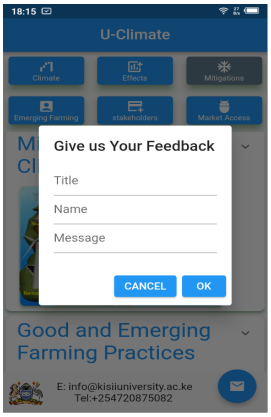

Figure 11. Feedback from smallholder farmers is enabled on the digital app

Finally, below is a dataflow diagram for the application showing how data moves within the application.

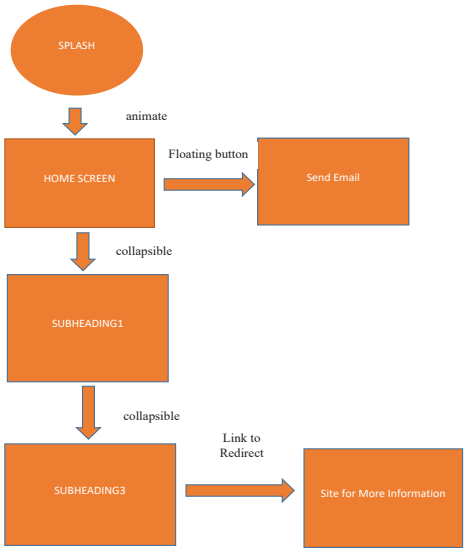

Figure 12. Dataflow diagram of app

Conclusion

While farmers in Kenya have overly depended on rain-fed agriculture, climate change has drastically affected reliability of the rains in most regions. For instance, the residents of Suneka in Kisii County have realized that birds such as "Amagonga" that would fly low to indicate on-set of rains rarely fly lately and when do, they are few and they make patterns unknown to the locals. This means that they cannot rely on these birds to correctly predict the onset of rains and therefore when to plan or prepare their farms. The effects of climate change have seen over-reliance on pesticides and fertilizers with low farm productivity. This study leverages a qualitative research approach to explore carbon literacy among these farmers and document their understanding of climate change and some of the challenges they experience. The study also identifies their information needs towards building climate change resilient farming practices, and derives a digital platform to enable these farmers to access information on climate-smart farming practices. It should be noted that the digital platform provides critical information regarding climate change and agricultural services to smallholder farmers. It also enhanced knowledge and awareness since the smallholder farmers have access to the latest information on matters dealing with climate change, weather forecasts, crop selection, and farming practices. The app would also probably help farmers understand the impact of their farming practices on the environment and how they can reduce their carbon footprint levels while improving their carbon literacy levels. Finally, the digital platform will facilitate communication and networking between all stakeholder such as farmers, government agencies, agricultural extension officers, etc. There are possible challenges that may arise in the course of implementing the digital app and these include language and literacy barriers that may limit the uptake and effectiveness of the app, but this may be mitigated through the use of simple intuitive user interfaces, the use of audio and visual aids, and translating the content into the local language (Ekegusii) or the national language (Kiswahili).

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Climate change is the most significant global challenge of our time, and many of its effects are felt most strongly in the poorest communities of the world. Higher education has a crucial role to play in responding to the climate crisis, not only in conducting research, but also through teaching, community engagement and public awareness. This study contributes to our understanding of how universities in low and middle-income countries can enhance their capacity for responding to climate change, through a focus on the cases of Brazil, Fiji, Kenya and Mozambique. In doing so, it contributes to the broader task of understanding the role of education in achieving the full set of Sustainable Development Goals.

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