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Long Paper

Information Needs of Smallholder Farmers in Lake Victoria Basin for Enhancing Climate-smart Agricultural Practices

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Abstract

Purpose – The purpose of this study was to bridge the awareness gap in agricultural information need and use by farmers to improve information access and utilization for enhanced adoption of Climate Smart Agricultural (CSA) practices.

Method – Using a mixed methods approach, the study examined the information needs of smallholder farmers in 5 counties in the Lake Victoria Basin, Kenya. Qualitative and quantitative data were collected from 382 farmers and 20 county directors of agriculture, ICT, meteorology, and crop production. Descriptive and inferential statistics were used to analyze quantitative data while thematic analysis was used on qualitative data.

Results – The findings showed that many farmers (82.46%) were aware of the existence of climate change which had reduced sorghum yield to 0.45 t/Ha. Therefore, farmers had initiated sustainable practices including planting different crop varieties (83.51%) and varying planting dates (65.18%). High yield was prevalent among farmers practicing crop rotation (95.1%) while those who practiced mono-cropping achieved low yields. Also, the use of inorganic fertilizers led to higher yields. Farmers who planted early maturing crops had log odds that were 1.647 points higher for being in a higher yield level than farmers who planted late maturing crops.

Conclusion – The study has the potential to enhance the adaptive capacity of farmers to climate change using suitable CSA practices based on readily available, accessible, and context-specific information.

Recommendations – The study recommends that farmers be provided with and/or have access to reliable, actionable, relevant, and timely information that matches their needs to enhance resilience through the adoption of climate-adaptive farming techniques.

Implications – These findings contribute to research by recommending context-specific information to help farmers bridge the information gap. The findings may contribute to policy by proposing CSA strategies that involve information-based support to smallholder farmers to implement sustainable farming practices.

Keywords – Climate-smart agriculture, information need, decision making, climate variability, adaptation, resilience, sustainable agriculture

INTRODUCTION

Understanding farmers' information needs and search is a critical step toward the successful implementation of climate-smart agriculture (CSA) for improved agricultural productivity. Information need is the desire to locate and obtain information to satisfy a conscious or unconscious need. On the other hand, information search focuses on gathering information about a phenomenon, augmenting levels of expertise and knowledge that is potentially useful in the future, and experiencing pleasure associated with the search process (Diekmann et al., 2009).

Developing and delivering user-centered content requires a better understanding of the context of information needs and seeking behavior. Similarly, a comprehensive evaluation of user characteristics, and their tasks, and analyzing physical and social environments upon which they operate is essential. Therefore, within the agricultural landscape, knowledge about farmers' information needs and searching behavior is critical both for restructuring existing agricultural information systems and for developing new systems. Despite their importance, few information studies on CSA have been conducted, particularly in the developing world thus creating a knowledge gap between agricultural information provided and those needed by farmers (Elly & Silayo, 2013).

LITERATURE REVIEW

Information Need and Searching Behaviour

Previous studies have recognized that due to limited contextualized information services, it is necessary to screen out farmers' information needs from a demand perspective using features recognizable within the operating environment. In this regard, Aboyade (1987) categorized the information needs of smallholder farmers as either information for increased agricultural productivity and/or income growth. This categorization was influenced by factors such as seed variety, fertilizer application, pesticide use, and farm mechanization methods among others. The study also found that the information on non-farm economic activities such as food processing; social amenities (sources of safe drinking water, the prevention of common diseases, nutrition, health, pre-and post-natal care); social participation, and political involvement were very critical in determining the level of farm production. In a study by Zhang and Jiang (2005), farmers' information needs were categorized into policy, knowledge, technology, market, and expert. This underscores the importance of understanding the micro and macro-environment upon which farmers and agricultural stakeholders operate. Chen & Lu, (2020) investigated factors influencing farmers' information needs and information access channels and found that individual characteristics such as age and gender; social factors such as regions, ethnic and religious beliefs; family factors such as income levels and information equipment; and environmental factors such as weather conditions and soil characteristics all influenced farmers' information needs and access channel preferences.

Comparable research on farmers in China by Zhang & Yu, (2009) found significant information requirements in agricultural technology, policy design, market information, and revenue creation. Widiyanti et al., (2020) in a study to identify farmers' information needs, information use level, and information-seeking behavior on climate change for sustainable agriculture in Indonesia, administered structured interviews to 3 farmer groups and reported that crop protection, climate adaptation strategies, and commodity selling prices are the information farmers require most. According to Carter & Ferdinand, (2020), agricultural sector players require information on crop research and development as well as climate services such as online platforms, software programs, and modeling systems for evaluating and exchanging climate data to suit users' needs. These studies highlight the factors that are critical in determining farmers' information needs and access models.

Research conducted in Botswana by Aina, (2012) indicated that agricultural stakeholders had a wide range of information needs, particularly on government programs and market identification for agricultural products. According to Benard et al. (2014), both male and female rice farmers in Tanzania have a range of information needs about marketing, weather conditions, agricultural loan/credit, new seeds, storage techniques, disease and pest management, and pesticide availability and use. Similarly, Elly & Epafra Silayo, (2013) used Wilson's Model of Knowledge Behaviour (1996) and discovered that rural smallholder farmers need information on crop and animal husbandry, as well as value addition. Also, Phiri et al., (2019) utilized the same model to analyze the information requirements and obstacles of rural smallholder farmers in Malawi and concluded that crop husbandry was the most important information need of rural smallholder farmers.

Bachhav, (2012) discovered that farmers needed information on seeds, crop output, pesticide availability, fertilizer availability, water management, and weather. While Babu et al., (2012) research found that farmers need knowledge of pest and disease control, pesticide and fertilizer administration, seed variety, and seed treatment. Further, Widiyanti and colleagues found that farmers needed information on quality seeds, growing techniques, agricultural technology, and market trends (Widiyanti et al., 2021). Yegbemey & Egah, (2021) reviewed seventeen (17) papers, reporting on sixteen (16) climate service experiences from twelve (12) countries, and found out that the most common weather information shared through climate services are rainfall, temperature, and wind speed.

From these studies, it can be noted that farmers' information needs and searching behavior are as varied as the number of studies and the context/environment upon which farmers and agricultural stakeholders operate. While some information needs were leaning more toward crop production, others concentrated on agronomic practices while others looked at marketing and the socio-economic status of the farmers. Interestingly, there was a major convergence in the findings that determined that farm-level decision-making was crucial for the success of agricultural activities (Ndimbwa et al., 2021). From the foregoing, farmers must get information that would help them to better manage their farms for better agricultural productivity and sale of surplus. This aligns with the findings of Islam & Ahmed, (2012) which concluded that the information needs of rural dwellers across most countries were largely related to the activities of their daily lives.

Therefore, focusing on timely access to adequate, reliable, and appropriate information is essential for farmers to make informed decisions for increased agricultural production, effective market access, and improved incomes for better livelihoods. Farmers require this information at every stage of the farm management process, from planning, implementing, and monitoring farm activities beginning with land preparation to the sale of surplus produce (Drafor, 2016a). Therefore, ensuring access to relevant data and information is vital in supporting farmers and improving farm outcomes (Taramuel-Taramuel et al., 2023)

Climate Variability in the Lake Victoria Basin

Lake Victoria Basin is experiencing the worst climatic conditions which are expected to intensify in the future (Ogega et al., 2023). This has resulted in numerous negative impacts on local people, including increased flooding and drought, which are disproportionately affecting marginalized and rural communities (Adaptation Fund, 2023, Marcus et al., 2023). This is because this region exhibits unique anthropogenic-influenced climate change, whose negative effects are expected to increase the vulnerability of the region, particularly due to increasing variability in rainfall patterns and increasing mean annual temperatures estimated to reach 3–4°C by the end of this century (Awange et al., 2013).

To reduce the impact of climate change on communities in the region, various projects have been developed. For example, the Lake Victoria Basin Commission (LVBC) Secretariat and United Nations Environment Programme (UNEP) developed a project titled Adaptation to Climate Change in Lake Victoria Basin (ACC-LVB) to reduce vulnerability to the negative effects of climate change in the five Lake Victoria Basin countries by building climate resilience strategies for communities (Marcus et al., 2023). This is an indicator that climate variability in the region is a significant issue that is already affecting local communities and is expected to intensify in the future. It is noteworthy that even though some projects are being developed to enhance the resilience of the communities in the target region while researchers are working to generate more realistic estimates of future weather patterns, much more contextualized strategies dependent on the power of information are required.

Sorghum Production as a Source of Livelihood for Smallholder Farmers

Sorghum (*Sorghum bicolor (L) Moench*) is an important cereal crop grown in arid and semi-arid areas. It is ranked as the fifth key cereal crop globally and Africa's second most important cereal and acts as a source of grain, animal feed, pasture, fodder, fiber, fuel, bioethanol, alcoholic beverages as well as building materials (Kazungu et al., 2023). It is the primary source of daily calories for 300 million sub-Saharan Africans. For Kenyan farmers, sorghum is also one of the few crops that grows well under local conditions because it is naturally drought and heat-tolerant thus performs well in drier areas, particularly, in western, northern Rift Valley, eastern, and some parts of Central Kenya (Gudu et al., 2012).

Sorghum remains an important food and feed crop in the semiarid tropics and an ideal crop for rural food security. This is because sorghum has been recommended as a famine relief food crop due to its resilience and ability to produce high yields even in marginal areas. However, in Western Kenya, around Lake Victoria Basin, its yield averages only 0.8t/ha compared to 2.25 - 3.8 t/ha obtained under research conditions (Kisilu et al., 2019, Agri Farming, 2023). This low yield is attributed to climate change-related effects such as moisture stress, poor soil, the occurrence of pests and new strains of diseases, *Striga* weed as well as lack of high-yielding varieties, poor research- extension, use of low-quality seeds and traditional farming practices (Muui et al., 2020). It is based on these characteristics of sorghum that the study utilized it as a reference crop.

Justification for the Study

Despite the availability of agricultural and climatic information, there exists a gap in determining the appropriate location-based agricultural and climatic information suitable for sorghum farmers in the Lake Victoria Basin. This is because it seems that there are no studies that have investigated the unique information needs of smallholder sorghum farmers in the context of climate change in the target region. This phenomenon is further exacerbated by the fact that the region exhibits unique characteristics influenced by culture, traditions, language, education, and socioeconomic norms when searching for information.

Further, it appears that existing studies on the concept of CSA in the region have majored in direct action to tackle climate change using agricultural interventions rather than enhanced understanding of farmers' information needs to provide relevant information to facilitate decision-making. The insufficient flow of appropriate, timely, and relevant information has led to reduced agricultural productivity given the significant impact of climate change on the agricultural sector along the Lake Victoria basin. This can be attributed to the fact that agricultural stakeholders require information contextualized within specific localities taking into consideration varying environmental and psychological needs.

Also, the scarcity of comparative studies that assess different climate-smart agricultural practices and their effectiveness in sorghum production in the Lake Victoria Basin hinders a comprehensive understanding of what works best in the region. This creates a gap between local farming knowledge and the broader understanding of effective agricultural practices. By implementing information-related strategies, it is possible to foster a more inclusive and collaborative research environment that promotes the adoption of effective climate-smart agricultural practices tailored to the unique needs and challenges affecting sorghum production in the Lake Victoria Basin. It is on this basis that the study sought to assess the information needs and searching behavior of smallholder farmers for optimal sorghum production in Lake Victoria Basin

METHODOLOGY

Theoretical Underpinning

The study was guided by Wilson's general model of information-seeking behavior, 1996 (Wilson, 1997) which was utilized because it provides a better framework for conveniently and comprehensively capturing user information behavior (Wilson, 2007). It therefore provided variables that informed the study design. The study also used the Information need theory (Taylor, 1968) which was necessary for understanding the parameters utilized by farmers to acquire tailored information accessible from user-friendly sources leading to quicker knowledge transfer and capacity building and continuous learning and adaptation by farmers.

Research Design

The study utilized a mixed research method and involved sorghum farmers in five counties bordering the Lake Victoria Basin in Kenya namely Migori, Homa Bay, Kisumu, Siaya, and Busia. The mixed-methods approach allowed for flexibility in interpreting field data, allowing for a better understanding of the study problem. It was also effective in establishing and examining the relationship between information gaps, improved information utilization, and sorghum production. Purposive sampling was used to select sorghum farmers in the region. Some of the inclusion criteria used were that the farmer must have been registered in the county agricultural database and had practiced sorghum farming. Thereafter, a simple random sampling method was used to identify 385 respondents. The purposive sampling technique was suitable since not all farmers in the target region were growing sorghum hence the need to target only sorghum farmers to save time and money given the wide geographical spread of the population. Similarly, the purposive sampling method was used to identify 20 extension officers and county directors of agriculture, ICT, and metrology in the target counties. This technique was suitable to this category of respondents due to the need to obtain information from specific individuals who had technical expertise in agriculture, ICT, and climate change.

Data Collection

Questionnaires and key informant interviews (KII) were created using data from farmer data types identified by the Technical Centre for Agricultural and Rural Cooperation. They were then evaluated for content validity before use by the Thesis Supervisor, and agricultural and ICT experts from the University and Migori County because of their proximity to the researcher. For content validity, the instruments were piloted to determine the clarity of the question items. The piloting occurred in all five counties, with 37 respondents representing 10% of the population participating. Questions that elicited ambiguous responses were modified. The study utilized Lawshe's equation to calculate Content Validity Ratio (CVR), (Lawshe, 1975). Thereafter content validity index (CVI) was computed whereby most items in the instrument were identified as essential with a CVI value of 0.877445696 which is above the recommended value of 0.80 (Davis, 1992). Data collected during the pilot test was also analyzed for reliability using Cronbach's alpha (α) coefficient method. the findings reveal Cronbach alpha values of 0.809 which is above the recommended threshold of 0.70.

Data Analysis

Questionnaires were administered to collect data from farmers while KII was used to collect data on policy direction from extension officers, and county directors of agriculture, ICT, and metrology. The quantitative data was processed and analyzed using descriptive and inferential statistics provided by SPSS version 27 and results were presented in tables and figures showing frequencies and mean values. Qualitative data was thematically analyzed using the Dovetail tool and results were presented in the form of word cloud and frequency charts. The results were used to derive broad generalizations in the form of research findings, then, conclusions were made as envisaged in Creswell, (2009).

RESULTS

To understand the information needs of farmers, the study analyzed the agronomic practices and climatic conditions affecting sorghum production in the target region. The findings from this analysis are presented in the sections below.

Level of Education and Language Use

The findings revealed that the majority of the respondents had the basic level of education with 49.48% having attained a Kenya Certificate of Secondary Education (KCSE) and 27.75% having a Kenya Certificate of Primary Education (KCPE). The rest of the respondents had post-secondary education with 17.54% having Diploma qualifications and 5.24% having a degree. This data was critical since it would inform the language preferences and preferred channels for sharing agricultural and climate information to facilitate decision-making on the farm.

The study revealed that most respondents (56.28%) preferred to receive climatic and agricultural information through local language. This corroborates the findings under the level of education which showed that most respondents had basic primary and secondary education. This suggests that the educational background of the respondents may influence their ability to understand and interpret complex technical information. It is therefore important to ensure that the information is accessible and easily understandable, regardless of the respondents' education levels. By catering to local languages, information can have a greater impact and be more effectively utilized by a wider range of farmers.

Sorghum production (agronomy)

The study collected data on the classification of sorghum varieties grown around the Lake Victoria Basin. The study found out that many of the sorghum varieties grown were medium maturing (61.78%) while 35.86% were early maturing and 2.36% were late maturing. This finding implied that the respondents preferred medium-maturing varieties since they could evade the challenges of drought and bird damage associated with either late-maturing or early-maturing varieties. This finding is corroborated by the findings on the susceptibility of various sorghum varieties to climatic stresses with results showing that the sorghum varieties grown were highly susceptible to bird damage with a weighted average of 2.57, followed by flood (2.36), pest (2.16), drought (2.08) and disease (2.06).

The study also collected data on the crop management techniques that were used by sorghum farmers in the Lake Victoria Basin. The study found that most farmers practiced the recommended crop management techniques with 93.72% of farmers practicing intercropping and 92.41% practicing crop rotation. The adoption of intercropping and crop rotation implied that farmers were cognizant of the importance of diversification and sustainable soil practices. These techniques can help mitigate risks associated with climate change, improve soil health, and potentially lead to increased yields.

The study also collected data on water management and found that 98.43% of the respondents practiced rainwater harvesting while 75.92% planted cover crops. Also, some respondents practiced mulching (35.86%) and zero or minimum tillage (38.74%). The high percentage of respondents practicing rainwater harvesting reflects a proactive response to the challenge of drought and water scarcity. By collecting rainwater during wet periods, farmers are better prepared to address water needs during drier periods. Similarly, planting cover crops demonstrates an understanding of the importance of soil health and water retention, contributing to sustainable water use in agriculture. These findings highlight the awareness and commitment of farmers to adopting water conservation practices as a means to address water scarcity and enhance their resilience to changing climate conditions.

In terms of water regime, the study found that 100% of the respondents depended on rainfed farming for their agricultural activities. This meant that none of the surveyed population were utilizing irrigation systems for their farming practices. This practice is widespread despite the challenges posed by erratic rainfall patterns and droughts attributed to climate change. The findings highlight the need for increased attention to water management strategies, particularly considering the changing climate and its impact on rainfall patterns. While some farmers engaged in rainwater harvesting, the overall dependence on rainfed agriculture underscores the potential vulnerability of agricultural production to variations in rainfall. The implication is that there could be an opportunity to explore and promote the adoption of irrigation systems as a means to enhance water availability and mitigate the risks associated with climate-related water shortages.

In terms of fertilizer use, the study found that 59.16% of the respondents used both organic and inorganic fertility followed closely by those who applied organic fertilizers 26.44%, inorganic fertilizer (12.04%) with just a mere 6.02% not using fertilizers. This continued use of fertilizer could be attributed to depleted and degraded soils requiring amendment for improved production. The study also raises awareness about the potential environmental impact of inorganic fertilizers use which can have negative consequences on the environment, harming other organisms and disrupting the natural balance of the soil ecosystem. This emphasizes the need for sustainable soil management practices that consider both agricultural productivity and environmental conservation.

Sorghum Yield

The study also collected data on the average yield over the last five years as shown in Table 1. The finding in Table 1 shows that most farms, comprising 40.84% of respondents, reported producing less than 5 bags of 90kg each from their fields. This suggests that a significant portion of farmers are experiencing low crop yields. The study noted that most of the respondents had fields of 2 acres or smaller. Given this field size and the reported yields, the average yield per hectare (Ha) was estimated as 0.45 tons per hectare (t/Ha). The calculated yield of 0.45 t/Ha falls significantly below the optimal yield range of 2.25 - 3.8 t/Ha, which is commonly recommended for sorghum. The low yields reported by a significant portion of farmers may be influenced by various factors, including soil quality, water availability, farming practices, and the challenges posed by climate variability. This finding is necessary to determine the context in which the farmers operate to tailor the information to the specific needs of the farmers.

Table 1. The average quantity of sorghum seeds/grains produced in the last five years

Average Quantity	Frequency
Less than 5 bags	40.84%
5 - 10 bags	28.01%
11 - 15 bags	15.18%
16-20 bags	9.95%
More than 20 bags	6.02%

Phenomena Associated with Climate Change

The study collected data on the phenomenon associated with climate change that farmers had observed over the last 10 years as shown in Table 2. The findings in Table 2 revealed that 82.46% of respondents had observed changes in rainfall patterns followed by increased frequency and intensity of droughts at 65.71% while only 8.90% of respondents agreed that the rainfall had increased. Due to changes in rainfall patterns, climate change has become of concern with 96.60% of respondents indicating that they are unable to plan farming activities leading to a decline in crop yields as indicated by 90.31% of the respondents. These findings demonstrate the tangible challenges that farmers are facing due to changing climate patterns, especially in terms of planning, planting, and ultimately crop yields. The data underscores the need for strategies that help farmers adapt to these changing conditions, such as implementing climate-resilient agricultural practices, improving water management, and adopting climate-smart approaches. Such strategies can contribute to mitigating the negative effects of climate variability on agricultural productivity and livelihoods.

Table 2. Observed climate change phenomena over the last 10 years

Climate Change Phenomena	***Frequency***
Increase in temperature	47.64%
Increase in rainfall	8.90%
Decrease in rainfall	48.43%
Change in rainfall patterns	82.46%
Increased frequency and intensity of floods	24.08%
Increased frequency and intensity of droughts	65.71%

Current Practices to Respond and Adapt to the Effects of Climate Change on Farming Activities

The study collected data on the activities adopted by respondents as an adaptation response to the effects of climate change on farming activities. The findings are shown in Figure 1.

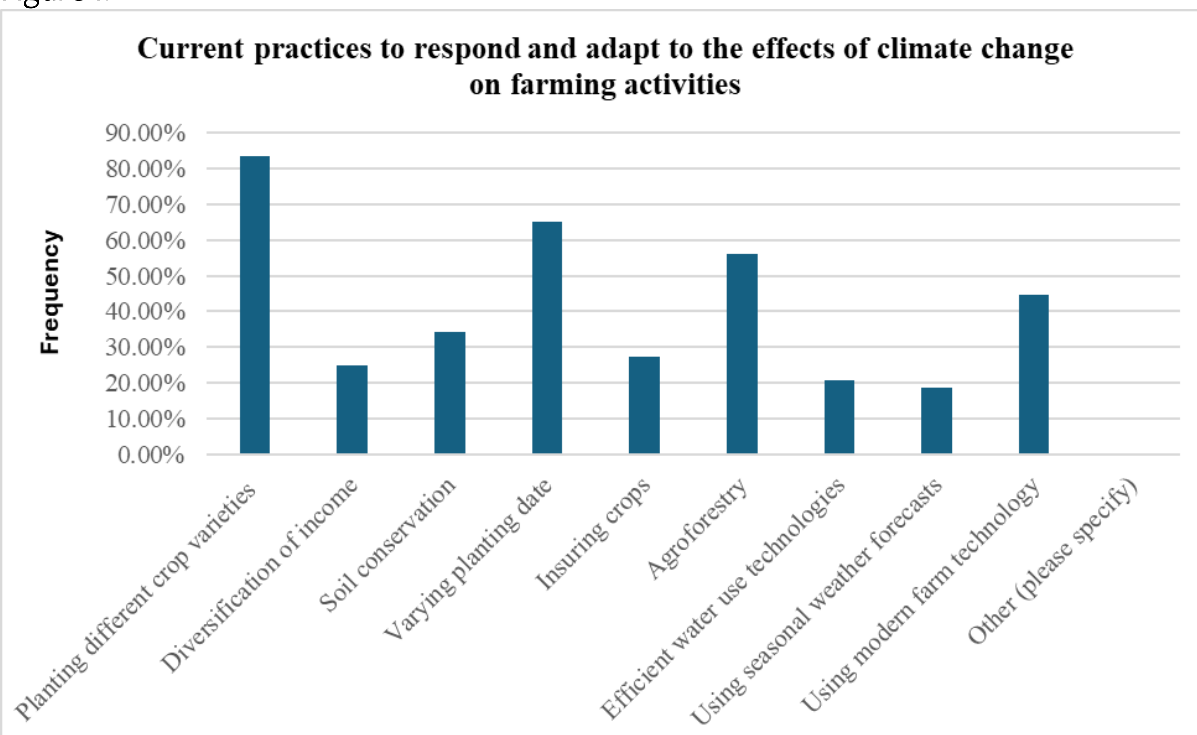

Figure 1. Practices to respond and adapt to the effects of climate change on farming

The findings in Figure 1 indicate the adoption of various agronomic practices by farmers in response to the effects of climate change. The majority of the population, accounting for 83.51% of the respondents, reported planting different varieties of crops implying that farmers were exploring and using crop varieties that are better suited to changing climate conditions. This was followed by variation of planting dates with 65.18%

of the respondents as an adaptive response to shifts in climate patterns, aiming to optimize planting based on changing weather conditions. 56.02% of the respondents reported engaging in agroforestry practices contributing to both environmental conservation and diversified farm production.

A significant portion (44.76%) of respondents reported adopting farm technology as a means to enhance efficiency and productivity. Also, 34.29% of respondents reported adopting water conservation practices that align with the need to manage water resources more efficiently in the face of changing precipitation patterns. A notable percentage (27.49%) of respondents reported using crop insurance as a proactive approach to managing the risks associated with uncertain climate conditions.

Additionally, 24.87% of respondents reported diversifying their income sources by engaging in non-farming activities which could help mitigate the vulnerability of relying solely on agricultural income. Lastly efficient water use technologies (20.68%), and use of seasonal weather forecasts (18.59%) were also practiced to optimize water resources and make informed decisions based on weather predictions. These findings implied that to some extent the farmers had already begun adapting to the effect of climate change. The findings underscore the proactive measures taken by farmers to adapt to the effects of climate change. The adoption of diverse agronomic practices reflects an awareness of the need to adjust farming strategies to cope with shifting climate conditions. By adopting these practices, farmers are demonstrating their willingness to engage in climate-smart approaches that can contribute to increased resilience and sustainable agricultural production in the face of climate variability.

Analysis of Qualitative Data

Using KII, the study interviewed a total of 20 county directors and officers responsible for ICT, Agriculture, and meteorology, as well as county officers in charge of crop production. Using content analysis, the collected data was organized into themes and analyzed using an artificial intelligence-based Natural Language Processing application called Dovetail. The findings are shown in Figures 2, 3, and 4.

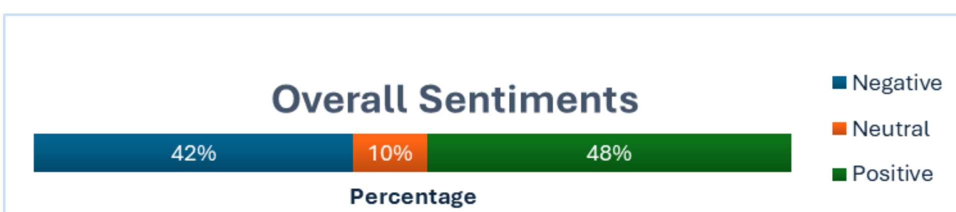

Figure 2. Overall Sentiments

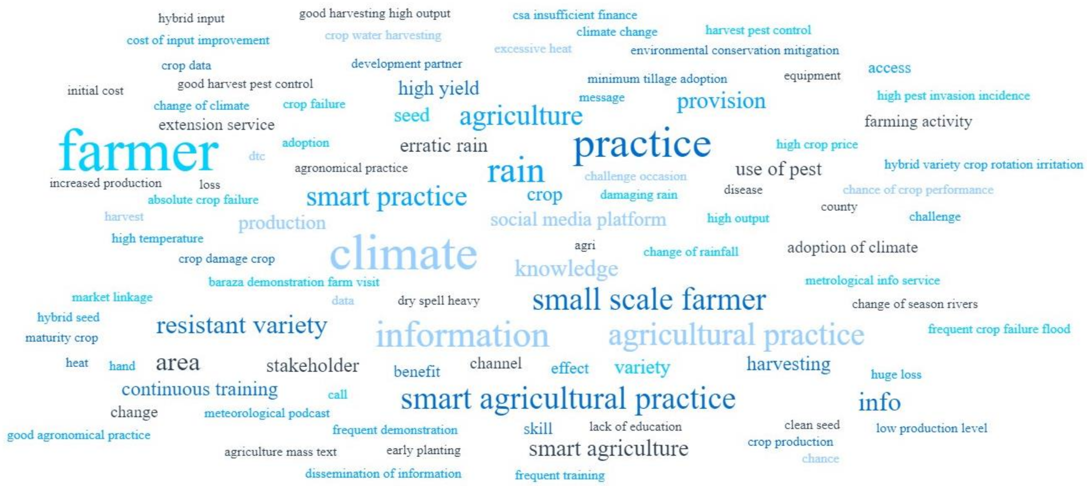

Figure 3. Word cloud (content analysis)

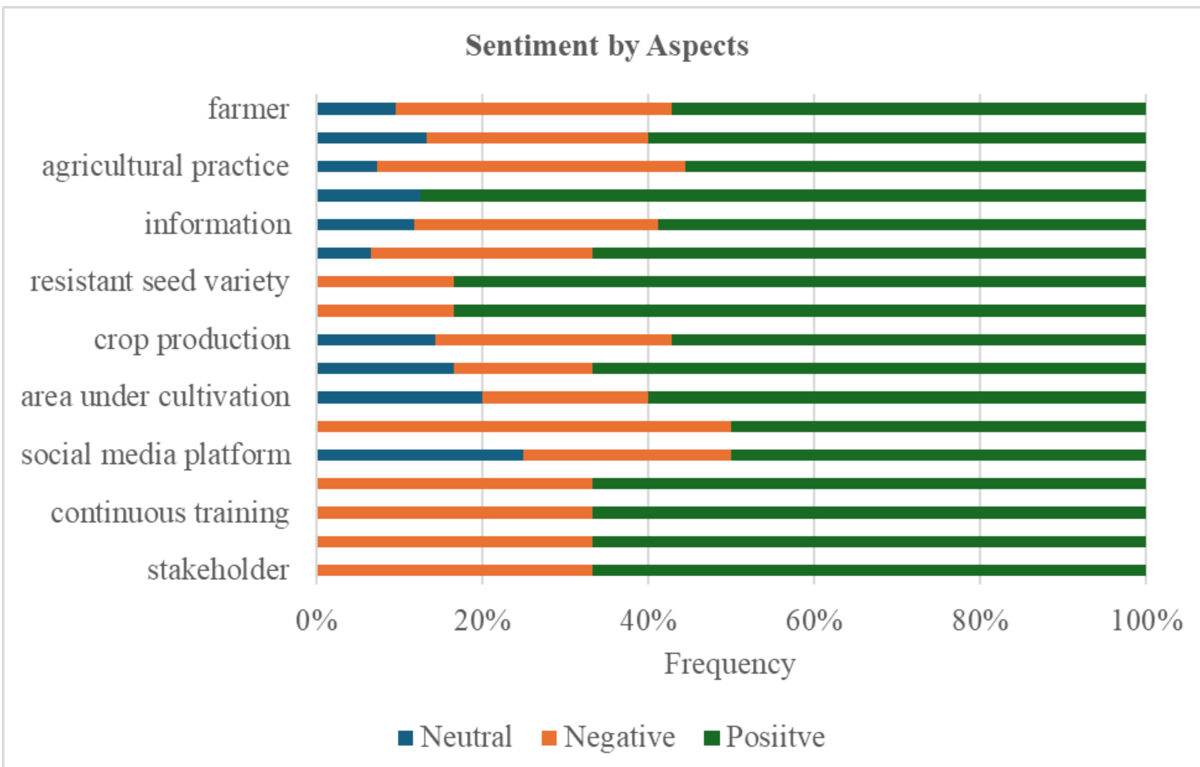

Figure 4. Sentiments by Aspects

The sentiment analysis using Dovetail revealed that 48% of the sentiments were positive, 42% were negative, and 10% were neutral as shown in Figure 2. This suggests that while there is some positive progress being made by the government in promoting climate-smart agricultural practices, there is still room for improvement. The content analysis in the form of a word cloud in Figure 3 indicates that words/phrases such as farmer, practice, climate, information, and smart agricultural practices featured prominently among the respondents. This was similar to the results of the analysis of sentiments by aspects which showed more positive aspects as compared to negatives as shown in Figure 4.

Effect of Crop Maturity on Yield

This study employed ordinal logistic regression analysis to examine the effect of crop maturity on yield. The results of the model fit are summarised in Table 3.

Table 3. Model Fitting Information

Model	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood	**Chi-Square**	**df**	**Sig.**
Intercept Only	33.524			
Final	24.489	9.035	2	0.011

As shown in Table 3, the Chi-square results were statistically significant showing that the final model was a significant enhancement in fit over a null model (i.e., the model with the intercept only) ($X^2(2)$ =9.04, p=0.011), demonstrating a good model fit. Additionally, results in Table 4 provide information comparing each yield category against the reference category (low yield).

Table 4. Model Parameter Estimates

Parameter		**B**	**Std. Error**	**Hypothesis Test**			**Odd Ratio**
				Wald Chi-Square	**df**	**p**	
Threshold	[Yield=1(*Low*)]	2.133	1.0559	4.081	1	0.043	8.443
	[Yield=2 (*High*)]	3.012	1.0610	8.060	1	0.005	20.335
[Crop Maturity=1 (*Early*)]		1.647	1.0694	2.371	1	0.012	5.190
[Crop Maturity=2 (*Medium*)]		1.176	1.0659	1.217	1	0.027	3.241
[Crop Maturity=3 (*Late*)]		0[a]	.	.	.	.	1
(Scale)		1[b]					

Dependent Variable: Yield Categories
Model: (Threshold), Crop Maturity
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

According to the data shown in Table 4, it can be observed that low crop maturity emerged as a significant predictor of yield. On average, farmers who planted early maturing crops had log odds that were 1.647 points higher for being in a higher yield level than farmers who planted late maturing crops. The likelihood of farmers who opted for early maturing crops achieving a higher yield category was 5.190 times greater than those who chose late maturing crops.

Furthermore, it was shown that the medium crop maturity substantially impacted the yield. The likelihood of a farmer who cultivated medium-maturing crops achieving a higher level of yield was 3.421-fold greater compared to a farmer who cultivated late-maturing crops. The findings of this study suggest that farmers who opted for early-maturing crops achieved higher yields than those who chose medium and late-maturing crops. Similarly, farmers who selected medium-maturing crops also obtained higher yields than those who planted late-maturing crops. Therefore, the availability of information on crop variety maturity rate would help farmers to make informed decisions on the variety to plant.

Crop Management Practices and Yield

The study compared various crop management practices associated with climate-smart agriculture and their effect on yields. The results are shown in Table 5.

Table 5. Crosstabulation of Crop Management Techniques and Yield

Crop Management Techniques		**Crop Yield**			**Total**
		Low Yield	**Medium Yield**	**High Yield**	
Intercropping	*n*	247	56	55	358
	%	93.9%	**96.6%**	90.2%	93.7%
Agroforestry	*n*	230	44	36	310
	%	**87.5%**	75.9%	59.0%	81.2%
Mixed cropping	*n*	189	43	32	264
	%	71.9%	**74.1%**	52.5%	69.1%
Crop rotation	*n*	242	53	58	353
	%	92.0%	91.4%	**95.1%**	92.4%
Mono cropping	*n*	199	37	45	281
	%	**75.7%**	63.8%	73.8%	73.6%
Total	***n***	**263**	**58**	**61**	**382**
	%	**68.8%**	**15.2%**	**16.0%**	**100.0%**

Notes. % - Proportion within yield. Percentages and totals are based on respondents.

Results presented in Table 5 show that low crop yield was prominent among the respondents who practiced agroforestry (87.5%) and mono-cropping (75.7%) crop management techniques. Additionally, it can be seen that medium crop yield was prominent among the respondents who practiced intercropping (96.6%) and mixed-cropping (74.1%). However, the high yield was prevalent among farmers who practiced crop rotation techniques (95.1%). The findings highlight the effectiveness of specific crop management techniques in influencing crop yields. While agroforestry and mono-cropping were associated with low yields, intercropping, mixed-cropping, and crop rotation were linked to medium to high yields in the region. The observed variations in crop yields based on management techniques underscore the importance of considering local environmental conditions, soil health, climate, water availability, and nutrient levels when selecting and implementing crop management practices.

The findings emphasize the critical role of providing farmers with accurate, timely, relevant, context-specific, and actionable information on suitable crop management practices. Enhancing farmers' awareness, skills, and practices on relevant crop management practices, can promote sustainable agriculture, food security, and resilience in the target region.

Water Conservation Practices and Yield

The study compared water conservation practices associated with climate-smart agriculture as a predictor of yields. The results are presented in Table 6.

Table 6. Crosstabulation of Water Conservation Practices and Crop Yield

Water Conservation Practices		Crop Yield			Total
		Low Yield	Medium Yield	High Yield	
Rainwater harvesting	*n*	259	58	59	376
	%	98.5%	**100.0%**	96.7%	98.4%
Planting cover crops	*n*	230	37	23	290
	%	**87.5%**	63.8%	37.7%	75.9%
Mulching	*n*	123	12	2	137
	%	**46.8%**	20.7%	3.3%	35.9%
Zero or Minimum Tillage	*n*	130	13	5	148
	%	**49.4%**	22.4%	8.2%	38.7%
Total	***n***	**263**	**58**	**61**	**382**
	%	**68.8%**	**15.2%**	**16.0%**	**100.0%**

Notes. % - Proportion within yield. Percentages and totals are based on respondents.

Results of a crosstabulation between water conservation practices and crop yield presented in Table 6 showed that low crop yield was predominant with farmers who practiced planting cover crops (87.5%), mulching (46.8%), and zero or minimum tillage (49.4%). Medium crop yield was experienced by farmers who practiced rainwater harvesting (100.0%). The findings suggest that rainwater harvesting, is more effective than planting cover crops, mulching, and zero or minimum tillage, in terms of influencing crop yields among sorghum farmers in the Lake Victoria Basin.

The effectiveness of rainwater harvesting as a water conservation practice may be attributed to the region's climatic conditions, particularly high temperatures. In environments where water dries out significantly faster due to extreme heat, methods like rainwater harvesting can provide a more reliable and sustainable water supply for crop irrigation, thereby supporting better yields compared to other conservation practices. Based on the findings, sorghum farmers in the Lake Victoria Basin may benefit from prioritizing rainwater harvesting as a primary water conservation practice to enhance crop yields, particularly in areas experiencing high temperatures and rapid water evaporation rates. While other practices like planting cover crops, mulching, and zero or minimum tillage may offer additional benefits such as soil conservation, erosion control, nutrient management, and biodiversity enhancement, their effectiveness in improving crop yields may be limited under specific environmental conditions or contexts.

Soil Fertilization and Crop Yield

Results of the crosstabulation between soil fertilization and crop yield are presented in Table 7. As shown in Table 7, low yield was prevalent among farmers who used both organic and inorganic fertilizers (63.5%) and who never used any of the organic or inorganic fertilizers (6.5%). Additionally, medium crop yield was common among farmers who used organic fertilizers (32.8%) whereas farmers who utilized inorganic fertilizers reported high crop yields (41.0%). The findings show that the performance of sorghum was better when inorganic fertilizer was applied, indicating that the inorganic fertilizer formulation was ideal for the nutrient availability, absorption rate, soil composition, soil interactions, soil pH levels, crop management practices, environmental conditions, and specific crop requirements in the target region. Therefore, by understanding these factors and adopting an integrated nutrient management strategy, and practices, farmers can optimize crop productivity while minimizing potential risks associated with fertilizer use and environmental impacts.

Table 7. Crosstabulation of Soil Fertilization and Crop Yield

Soil Fertilization		**Crop Yield**			**Total**
		Low Yield	**Medium Yield**	**High Yield**	
Organic Fertilizer	*n*	74	19	8	101
	%	28.1%	**32.8%**	13.1%	26.4%
Inorganic Fertilizer	*n*	14	7	25	46
	%	5.3%	12.1%	**41.0%**	12.0%
Both Organic and Inorganic Fertilizer	*n*	167	33	26	226
	%	**63.5%**	56.9%	42.6%	59.2%
None of the above	*n*	17	3	3	23
	%	**6.5%**	5.2%	4.9%	6.0%
Total	*n*	263	58	61	382
	%	68.8%	15.2%	16.0%	100.0%

Percentages and totals are based on respondents.

DISCUSSION

The study sought to assess the information needs of smallholder farmers for optimal sorghum production in Lake Victoria Basin. The need was characterized by information on agronomic practices and climate change. The findings showed that most farmers had a basic level of education and hence would require information delivered in simpler forms using local languages for ease of comprehension. The findings also showed that farmers needed information on (i) the crop maturity rate of various sorghum varieties which was a predictor of yield with early maturing crops achieving 5.19 times greater scores than the rest; (ii) crop management with those practicing crop rotation technique (95.1%)

achieving higher yields; (iii) water conservation with many of those practicing rainwater harvesting (100%) achieving medium to high yields; and (iv) soil fertilization method with many of those using inorganic fertilizer (41.0%) achieving higher yields. These findings are comparable to those of Widiyanti et al., 2020, Phiri et al., 2019, Bachhav, 2012 and Babu et al., 2012).

The findings also showed that the majority of farmers were aware that climate change was a real phenomenon with many of them witnessing changes in rainfall patterns (82.46%) and increased frequency and intensity of droughts at 65.71% while only 8.90% of respondents agreed that the rainfall had increased. This has led to a reduced sorghum yield of 0.45 t/Ha which falls significantly below the optimal yield range of between 2.25 - and 3.8 t/Ha (Kisilu et al., 2019, Agri Farming, 2023). The findings also showed that some efforts were already being championed by the government to promote climate-smart agricultural practices albeit to a smaller extent (Marcus et al., 2023). The mixed sentiments with an average performance of less than 50% in the content analysis reflect a combination of positive progress (48%) and ongoing challenges (42%) that need to be addressed. Words such as climate, farmer, practice, information, and agricultural practice appeared prominently among the respondents implying high awareness of the CSA phenomenon.

These findings suggest that shifts in weather patterns, temperature changes, and other climate-related factors had direct consequences on agricultural practices. On a positive note, small-scale farmers in the area were aware of the impacts of this phenomenon which could have likely motivated them to seek solutions and adapt their practices accordingly. This awareness led them to start adopting climate-smart agricultural practices to mitigate the effects of climate change to improve crop yields and minimize losses. On the other hand, the government had also taken steps to promote climate-smart agriculture by introducing interventions like the use of smartphones, and data-driven agriculture, but the effectiveness of these efforts was still limited. Despite the awareness and motivation, there were still some barriers such as low education levels, language barriers, and growing of sorghum varieties that were susceptible to bird damage, flood, pests, drought, and diseases preventing farmers from fully adopting these climate-smart practices. Therefore, the study contributed to a better understanding of the information needs of farmers thus making the farming stakeholders including the policymakers and government institutions provide context-specific information on climate-smart agriculture.

Overall, the findings highlight the need to understand the information needs of farmers and raise awareness among small-scale farmers on the benefits of adopting climate-smart practices. This can be achieved by providing relevant and timely information to farmers so that they can make informed decisions about their farming practices and build resilience to climate change. Addressing the information needs of farmers is therefore a crucial component for building climate resilience in agriculture. It can empower farmers to optimize their sorghum production and improve their livelihoods in the face of ongoing climate challenges. These findings concur with the study by Ndimbwa et al. (2021) which found that delivery of and access to timely and relevant agricultural information and knowledge, appropriately packaged, is one of the critical problems undermining smallholder farmers' efforts to increase their production. This is also similar to a study by (Taramuel-Taramuel et al., 2023 & Drafor, 2016a) which found that farm-level decision-making requires timely, adequate, and appropriate information.

CONCLUSIONS AND RECOMMENDATIONS

The study sought to assess the information needs of smallholder farmers for optimal sorghum production in Lake Victoria Basin. Addressing the specific information needs of smallholder sorghum farmers is crucial for promoting optimal sorghum production and enhancing resilience to climate change. By focusing on accurate, actionable, and timely information dissemination strategies, stakeholders can empower farmers to adopt climate-smart agricultural practices, thereby ensuring food security, livelihood improvement, and sustainable development in the region. This is in recognition of the unique environmental factors such as weather conditions and soil characteristics and the source of livelihood of the people in this region. The study results show that farmers in the region mainly required information on water conservation, fertilizer use, crop management, and maturity rate of various seed varieties. The provision of such information will enhance the farmer's farm management decision-making capacity and thus make their agricultural practices more sustainable.

The study recommends the provision and access to accurate, actionable, relevant, and timely information that meets the needs of farmers to build resilience and adopt farming practices that can adapt to the effects of climate change.

IMPLICATIONS

These findings contribute to practice by bridging the information gap of farmers by championing the provision of timely, relevant, and region-specific information on suitable agricultural practices to adapt to changing environmental conditions. This will ensure that farmers make informed decisions regarding sorghum production in the Lake Victoria region, ultimately enhancing access to information and optimizing sorghum production thus contributing to sustainable food security and livelihoods of smallholder farmers in the region.

The findings contribute to policy by proposing climate-smart agricultural strategies that involve support for smallholder farmers to implement sustainable farming practices. It can also facilitate collaboration among stakeholders, including government agencies, agricultural organizations, and research institutions, to work together in promoting climate resilience and food security.

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DECLARATIONS

Conflict of Interest

The researcher declares no conflict of interest in this study.

Informed Consent

This study has been submitted with the express authority of the thesis supervisors. Respondents were requested for their consent to participate.

Ethics Approval

The study was approved by the National Commission for Science, Technology, and Innovation and the School Graduate Studies of Kibabii University, Kenya

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