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ASSESSMENT OF THE KNOWLEDGE AND PERCEPTION OF YELLOW MAIZE FARMERS IN HOMA-BAY COUNTY, KENYA

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ABSTRACT

Although yellow maize is the least preferred among the Kenyan populace, its production and consumption are common in Western Kenya, especially in Homa-Bay County. This study aimed to assess the knowledge and perceptions of yellow maize farmers in the area to understand what makes this community unique in terms of yellow maize production and consumption. Data was collected through a survey by interviewing 385 yellow maize farmers in the region. The results show that both men and women are involved in yellow maize cultivation, primarily among youths and middle-aged individuals aged 18 to 60 years. Most farmers had primary or secondary education, accounting for 70%, while 13% had no formal education. Yellow maize farming was mostly rainfed, small-scale, and practiced with low input levels, yielding less than 1 ton per hectare for subsistence. Overall, farmers displayed good knowledge and positive attitudes. They recognized the importance of fertilizer use, with most favoring inorganic over organic fertilizers, although application was limited since the crop is regarded as low-input. Yellow maize was deemed nutritious by 70%, however, only 60% were aware of its nutritional status in terms of Vitamin A and the vulnerable groups that need to be targeted. Over 70% of farmers considered early maturity, high yields, good taste, and tolerance to abiotic and biotic stresses as very important traits. Most respondents were aware of climate change and its perceived impacts, mainly addressing them through intercropping and agroforestry, with radio programmes and indigenous knowledge serving as primary sources of agricultural and weather information. Farmers have a strong attachment to yellow maize with attributes perceived to make it superior to withstand various stresses and still guarantee food for the household. Key challenges include low yields and low nutritional awareness that need to be overcome to ensure the potential of this crop to provide food and nutritional security is realized.

Key words: Yellow maize, Vitamin A, Homa-Bay, survey, Knowledge, perception, traits, climate change

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INTRODUCTION

For a country to be food secure, all its people should physically and economically have constant access to adequate, safe and nutritious food supply that meets their food preferences and dietary needs [1]. However, food systems in developing countries especially in the rural areas, go against this requirement as most of the populace are usually faced with poverty, hunger and malnutrition [2,3]. In Kenya, the most cultivated staple food and strategic crop in the country is maize. However, the current yields of 1.4 t/ha according to FAOstats [4] has not kept pace with the increasing human population, coupled with the adverse effects of climate change. This is a huge setback in achieving SDG 1,2,3 – No poverty, Zero hunger, Good health and well-being putting the country in derision as it has been ranked 94 out of 121 food insecure countries globally and is currently a maize net importer [5,6].

Due to low yields, focus has been placed on yield enhancement to urgently address food insecurity especially in the remote rural areas. Currently, there is a shift towards quality food that is not only safe but healthy and nutritious [7]. For this to be realized, food must be available and affordable even to people with low level of incomes and encompass staple foods that are the main daily dietary intake. It is, therefore, critical that production of local nutritious crops is not undermined. Among such crops is yellow maize, a heritage locally adopted variety grown, consumed and domiciled in the rural western region of the country providing food and nutritional security to the people. This is evident by the crop being prevalent in homes where it was cultivated and commonly known in the local Luo dialect as '*Nyamula*', meaning yellow [8]. Nutrition-wise, the maize contains carotenoids which is a precursor for vitamin A (VA) [9]. It ,therefore, can offer a cheap source of VA as other food alternatives; fruits, vegetables and animal products tend to be highly perishable and expensive while supplementation, biofortification and fortification have had limited access in the rural areas [10]. Furthermore, yellow maize is also highly demanded in the livestock sector as a major constituent in commercial feed, with the major source, unfortunately, being through importation [11]. The crop has been underutilized and marginalized by the general Kenyan population as people find it to be inferior, with unappealing sensory attributes that most find unattractive [12].

Regardless of this, the western region of Kenya and parts of the coastal areas are uniquely known for yellow maize production [10]. Understanding the reasons behind farmers' commitment to this crop is critical as it can be applied to influence the uptake of yellow maize among the general population that may even extend to neighboring and to uttermost regions of the country. This study, therefore, sought to assess the knowledge and perception of yellow maize by farmers in Homa-Bay County and the possible knowledge gaps and how these have influenced yellow maize production and utilization in the region.

MATERIALS AND METHODS

Study area

A household survey was conducted in Homa-Bay County, situated at an altitude of approximately 1,220 meters above sea level covering 3,154.7 km^2 and located at 0°31'38.3" S and 34°27.428' E latitude. It has a population of 1.1 million people with a total of 262,036 households out of which 43.7% live in extreme poverty [13]. The region experiences a bimodal rainfall pattern with long rains falling between March and May averaging 300-800 mm and the short rains in September and November averaging 100-400 mm with annual mean temperatures of 26-34^{0}C [14]. The region covers the upper and lower midland Agroecological zone and mainly consists of Humic Andosols, Orthic and Plinthic Acrisols soil types [15]. Agriculture is the main economic driver with key activities being fishing, due to proximity to Lake Victoria, and farming, especially maize, sorghum, and millet.

Sample Size and Sampling Technique

The minimum population sample size of 384 respondents was as described by Aguk *et al.* [16]. Briefly, this followed the equation (1)

$$n = \frac{z^2pq}{d^2} \qquad (1)$$

Where z= 95% confidence (1.96)

p= Percentage of farmers growing yellow maize. Since it is unknown 0.5 was adopted to provide as precise as possible maximum required sample size

q=1-p

d= Margin of error (0.05%)

therefore $\frac{1.96^2 \times 0.5 \times 0.5}{0.05^2} = 384$

Ndhiwa sub-county in Homa-Bay was purposively sampled as it is a major yellow maize growing region [17]. This involved random interviewing of 385 households distributed according to population data obtained from local administration offices in four identified wards as follows: 36% in Kanyamwa Kologi, 17% in West Kanyamwa, 27% in Riana West and 20% in Central Kanyamwa.

Determination of respondents' knowledge and perception

Knowledge consisted of 16 items. The correct answer or an incorrect answer, and don't know response was given 1 point. The score ranged from 0 to 100% and the level of knowledge was categorized according to Bloom [18] as <60 being low level, 60-80 being moderate level and >80 being high level. To gauge their knowledge of striga weed, farmers were asked to mention the effect of striga weed on yellow maize plant. The respondents who could mention more than three effects were regarded as having high level of knowledge while those who mentioned three or fewer were considered to have low knowledge. Sources of information on striga weed were also determined. On perception, farmers were given some criteria for growing yellow maize and requested to select attributes they preferred in yellow maize and to rate them from not important, somewhat important, fairly important, very important, according to Likert [19]. To determine their awareness of climate change, respondents were given a yes or no choice. They were also given a list of options to determine their perception of the effects of climate change on weather conditions and their livelihood, the mitigation measures they have taken and sources of information.

Data collection

Data collection was done using Open Data Kit (ODK) data collection software (v1.22.4) administered by trained local enumerators conversant with the region and fluent in the local Luo dialect. Before the interview, the enumerators clearly explained to the participants, the objective of the study and obtained their consent. Participation was purely voluntary, with respondents assured of their confidentiality.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20 was used for data analysis. Continuous data and categorical data were used to analyze Chi-square or Fisher's Exact tests. The descriptive statistical analysis was undertaken for demographic variables. A P-value was considered statistically significant at a 95% confidence level ($P \leq 0.05$, 2-tailed test).

RESULTS AND DISCUSSION

Demographic characteristics of yellow maize farmers

The demographic characteristics of yellow maize farmers show that the majority were female, and almost three-quarters of the respondents were married with each household consisting of an average of five people to provide a ready source of farm labor (Table 4.1). About 80% were in the youth (18-35 years) and middle-aged (36-60 years), an active and productive age bracket. They highly relied on farming as their main source of sustenance, underscoring the importance of agriculture in the region.

Regarding farming characteristics, yellow maize was cultivated on 1-3 parcels of land in 93% of cases. The land sizes were decreasing from 3 acres, according to CIDP-Homa-Bay County [20] to an average of 0.4 hectares, due to increased human population and the cultural practice of subdivision through inheritance, leading farmers to prioritize food production [16]. Yellow maize production was rainfed, with

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only 68% of farmers intercropping it with legumes—an eco-friendly, climate-smart strategy that reduces risks and offers yield advantages [21]. Given the small land plots, this sustainable and intensive cropping system can be leveraged to maximize benefits and incorporate water conservation measures, such as irrigation, to support multiple cropping cycles per year for this early-maturing variety, which matures in approximately 90 days. Unfortunately, most farms reported yields of less than one ton per hectare of yellow maize, largely due to poor agronomic practices that limit its potential. For example, over-reliance on maize led 81% of respondents to continuously farm the same land, a practice associated with low soil fertility and increased prevalence of pests and weeds—common issues in the region [22]. Additionally, 31% of farmers did not use any agricultural inputs, especially fertilizers. These findings were supported by Akenga *et al.,* [23], who reported limited use of agrochemicals among farmers in Homa-Bay County, most preferring to rely on on-farm resources for autonomy.

Education levels in relation to demographic characteristics

Gender, age, marital status, and source of income were significantly associated with education levels (Table 4.2). Most yellow maize farmers had primary and secondary education at 34% and 36%, respectively. However, half of the respondents did not complete these levels, mainly due to high dropout rates likely driven by poverty and early pregnancies and marriages [24]. The number of females with no formal education was twice that of males, while in the tertiary level of education, females were 1.5 times fewer, indicating lower school enrollment and retention rates for females in the region. All youths had access to education, with 10% attaining tertiary education. In contrast, respondents over 60 years old had the highest number with no education (14%) and the fewest with tertiary education. This suggests that education was becoming more valuable and accessible across generations, driven by changes in cultural beliefs and attitudes [25]. Those with primary and secondary education (48%) mainly relied on farming, tertiary-educated were mostly employed while those with secondary education engaged in entrepreneurship. This underscores the critical role education plays in shaping career paths and income levels.

Knowledge on yellow maize production and consumption

The overall level of knowledge for the 385 respondents showed that 40% had high level of knowledge. Those with moderate and low levels of knowledge were 34% and 26%, respectively. The highest score registered was 100% while least scored was less than 10%.

In terms of production, 75% of farmers considered yellow maize to have better yields than hybrid white maize under a low fertilizer regime (Table 4.3). This is one of the main reasons that keeps these farmers loyal to yellow maize; as a native cultivar, it is hardy under adverse conditions and requires little to no operational cost. It is also seen as natural/chemical-free, therefore safer compared to hybrids that depend heavily on chemical inputs. Great concerns remain about its low productivity, with farmers rarely having enough for household needs, let alone surplus for sale. The low-input system has also caused severe soil degradation in the County, evidenced by the widespread presence of striga weed, with 93% of respondents confirming the presence of the weed in their farms. Despite this, 80% of yellow maize farmers still recognize the importance of integrating both organic and inorganic fertilizers to increase yields, highlighting a significant gap between knowledge and application among the respondents, attributed mainly to limited financial capacity of farmers to purchase inputs. Fertilizer application remains crucial for a sustainable food system, emphasizing the need for financial support to help farmers buy inputs, improve production, and maintain on-farm profitability [26]. Given the low-input scenario, particularly regarding fertilizer use, 70% of farmers preferred inorganic fertilizers over organic fertilizers, likely because inorganic options are easier to apply, require less labor, and produce immediate yields—whereas organic fertilizers are bulky, labor-intensive, and take time before benefits are seen [27]. This suggests that farmers would prefer conventional fertilizer if they were accessible, considering that organic resources are limited in the farm due to their many alternative uses as livestock feed, fuel, craft, and for house construction among others.

Yellow maize was considered by 90% of the respondents as a better food option due to its high nutritional value compared to white maize. However, only 57% were aware of the specific nutritional benefits of yellow maize in terms of vitamin A (VA). This had a significant impact on dietary choices within households, as only 52% and 58% recognized the importance of feeding VA-rich foods to children and women of reproductive age, respectively—key vulnerable groups susceptible to VA deficiency. Their lack of awareness may expose them to nutrient deficiencies, as their daily diets may not be tailored to meet specific nutritional needs, especially those of vulnerable populations. This could explain why, in the study by Othoo *et al.* [28], pregnant women attending a hospital in Homa-Bay County were found to be VA-deficient despite mainly consuming maize, presumed to be yellow maize due to its prevalence in the region. Almost all respondents viewed yellow maize as tastier because of its superior flour and cooking qualities, making it a daily occurrence among households. However, 80% of respondents considered the crop to have low marketability, citing low preference and negative perceptions among the general population, thereby reducing the income potential that could help improve livelihoods [16].

Since intercropping was considered relevant by the respondents, there was a need to confirm the relevance of legumes in yellow maize production and utilization. Seventy-four percent (74%) of the respondents viewed legumes as important sources of protein, and 64% considered a diet combining legumes with yellow maize to be of high quality. However, about 60% of the respondents were unaware that feeding children exclusively on a maize-based diet could lead to protein deficiency. Similar to yellow maize, the knowledge on the groups most vulnerable to protein nutrient deficiency was low among the respondents, which may cause legumes to be underprioritized, limiting their production and consumption. This can have similar consequences of malnutrition, leading to Kwashiorkor and stunted growth in households where children are weaned and fed poor diets, mainly consisting of maize [29]. A study by Bello and Kholowa [30], confirmed that poor farmers' knowledge about the nutritional value of legumes limited their use at home as nutritional supplements, with most farmers opting to sell the legume crops for income generation. This is a key knowledge gap, especially as land becomes increasingly scarce and economic constraints restrict most underprivileged rural populations to just a few food options that lack diversity.

Respondents were highly knowledgeable on the role of legumes in soil management and in crop-enhanced performance, as 80% of the farmers were aware of the capability of legumes in enhancing soil fertility, while 82% reported that it also improved crop yields. This, therefore, has the potential to reduce reliance on synthetic inputs and improve overall farm profitability, hence financially and environmentally friendly, given the low-resource agriculture system of most farms [31].

Knowledge on Striga weed on yellow maize and management

Most farmers could identify striga weed due to the characteristic purple-colored flowers, with 60% considering it a threat to yellow maize production. This shows that the weed has become increasingly prevalent in the region, as it has become a signature feature in the maize fields as one traverses the County. The most common damage of striga weed on yellow maize mentioned were stunted growth (32%), lowered yields, and dry/dead leaves each with 22% respondents. A few respondents extended to include total crop failure and folded leaves. These symptoms may, however, be confused with abiotic or pest stresses; hence for proper diagnosis, farmers indicated they relied on the emergence of the purple flowers. Farmers perceived that the weed had economic implications with 52% of farmers resorting to weed-uprooting, while 16% and 13% deep ploughed and used herbicide in that order, while the rest did nothing. The common practice of manual uprooting was also confirmed by Chitere and Omolo [32]. Diagnosing and uprooting the weed at flowering is considered too late, as damage to the host plant is already significant with severe yield impact by the time the weed emerges from the soil, though, to some extent, it may obviate the weed’s seed production [33]. The presence of striga weed is also a key indicator of soil infertility, a major problem in the region [34]. Regardless of this, yellow maize still portrays promising potential as it has been observed to be tolerant to the weed compared to other varieties including hybrids under similar conditions [35]. This could provide genetic resources for breeding striga-resistant high-yielding maize varieties.

Perception of farmers on yellow maize good attributes

Yellow maize attributes that were highly considered by respondents, with over 70% response, included early maturity, high yield, drought tolerance, and striga resistance (Figure 4.1). These are key traits of a climate-resilient crop with minimal impact on yields despite adverse conditions [36]. The yellow grain color and taste of maize were of very low importance among respondents, which contrasts with the wider population, who find it unpleasant with a bad taste [21]. Home-grown production can help prevent the rancid off-flavor responsible for the bad taste caused by long storage periods due to bulk imports [34,35]. Generations and years of consuming yellow maize may have also conditioned people in this region to its organoleptic properties (taste and appearance). It is therefore possible to overcome prejudice against yellow maize, foster familiarity, and boost overall consumer confidence by incorporating yellow maize into diets from a young age, as elicited by Pillay *et al.* [39].

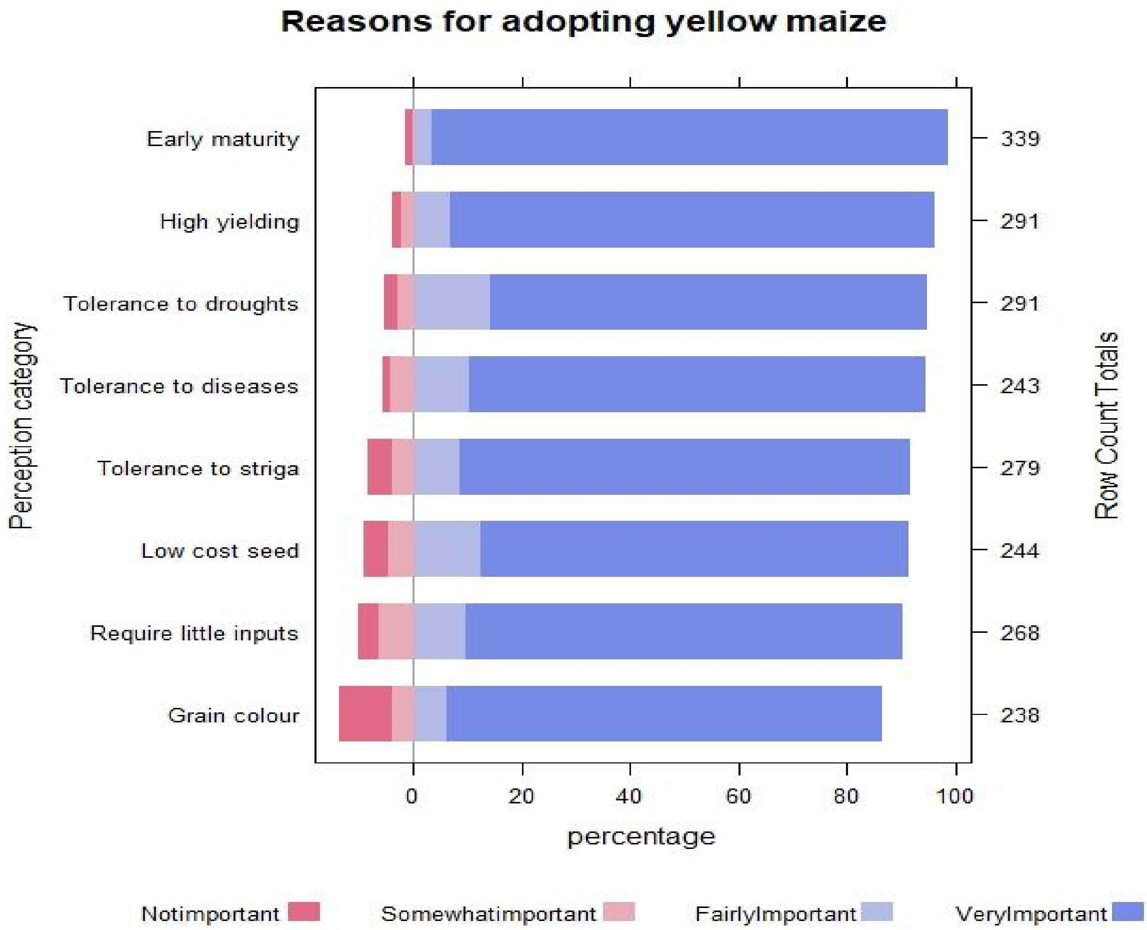

Figure 4.1: Farmers' perception of yellow maize

Perception of yellow maize farmers on climate change, their mitigation measures and sources of information

About 78% and 82% of the respondents were aware of the term climate change and able to perceive changes in weather conditions respectively while 74% of the respondents gave a yes response in both cases (Figure 4.2).

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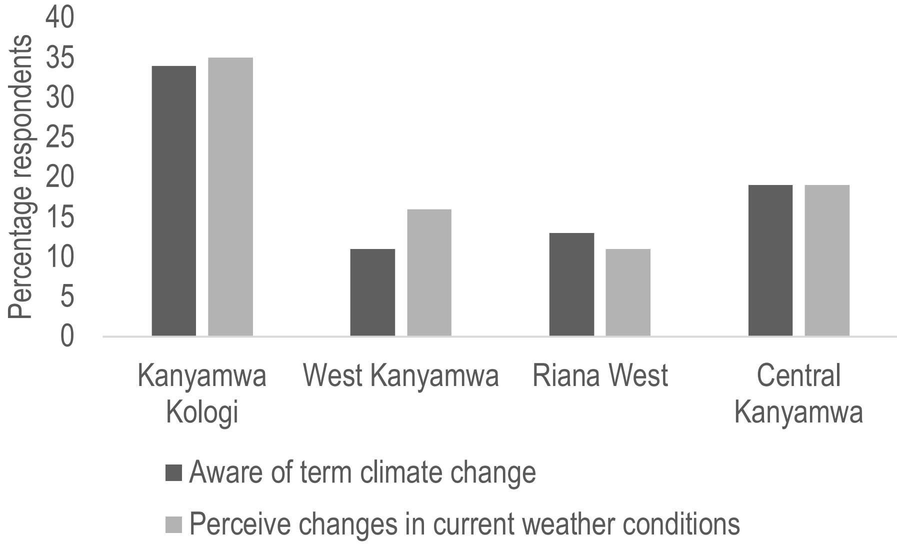

Figure 4.2: Respondent's awareness of the term climate change and perception in its effect to weather conditions. Different letters for an attribute indicate significant difference at $p < 0.05$

About 80-70% indicated increased temperature, rainfall intensity and duration, erratic weather pattern, drought and floods, all of which were considered to have high magnitude levels with many indicating that the weather was becoming increasingly unpredictable and unreliable (Table 4.4). The farmers acknowledged that it was becoming difficult to determine onset of rains compared to the past, which has disrupted traditional planting seasons and made it difficult to schedule farm activities.

Farmers majorly perceived reduction in crops, fodder and livestock yields to be the key effects of climate change at 80%, 51% and 40% respectively (Figure 4.3) and associated this with loss in agricultural productivity, which concurs with the finding by Barskin and Barskin, [40]. This is due to high dependence on rain-fed agriculture, making farmers highly vulnerable to adverse weather conditions. However, respondents from Kanyamwa Kologi seemed to be more aware of other advanced effects of climate change that were not directly related to yields.

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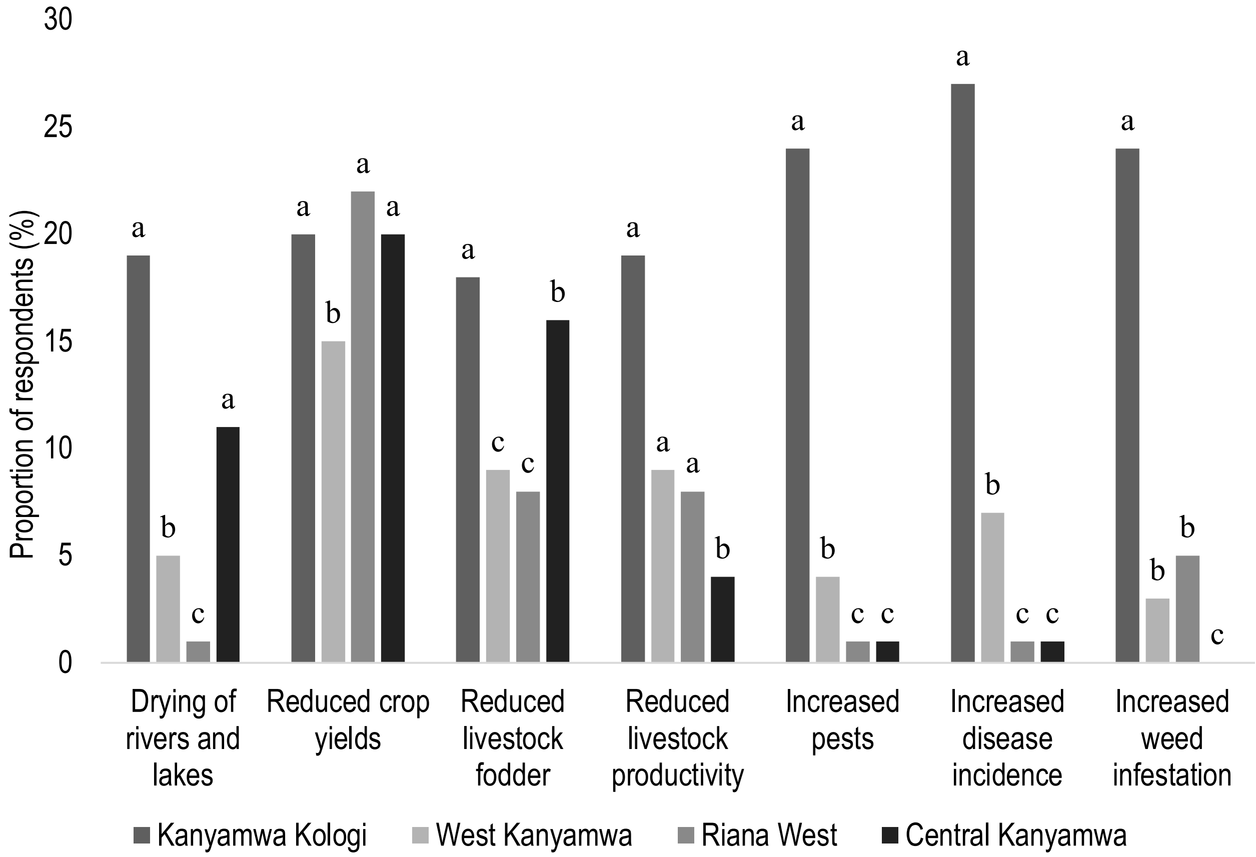

Figure 4.3: Effects of climate change in Homa-Bay County

In response to climate change, 86% of the respondents applied different coping strategies which mainly involved intercropping and planting trees (Figure 4.4). These were noted to be low-cost strategies, though with potential to significantly improve livelihoods through better yields. Reports of prevalence of intercropping as a coping strategy against effects of climate is coherent with findings by Arslan *et al.,* [41] and appears to be the most sensible strategy, especially given its important contributions to agricultural sustainability and resource use efficiency [21]. Tree planting may, however, have limited success since, according to the CIPD-Homa-Bay County [20], residents heavily rely on wood and charcoal as their source of fuel unless aggressive large-scale reforestation initiatives are instigated, coupled with sourcing for cheaper, environmentally friendly alternative fuel options for households. The farmers were therefore generally low adopters with 65% implementing the two coping strategies, while only 3.8% of the farmers were high adopters, undertaking more than four strategies.

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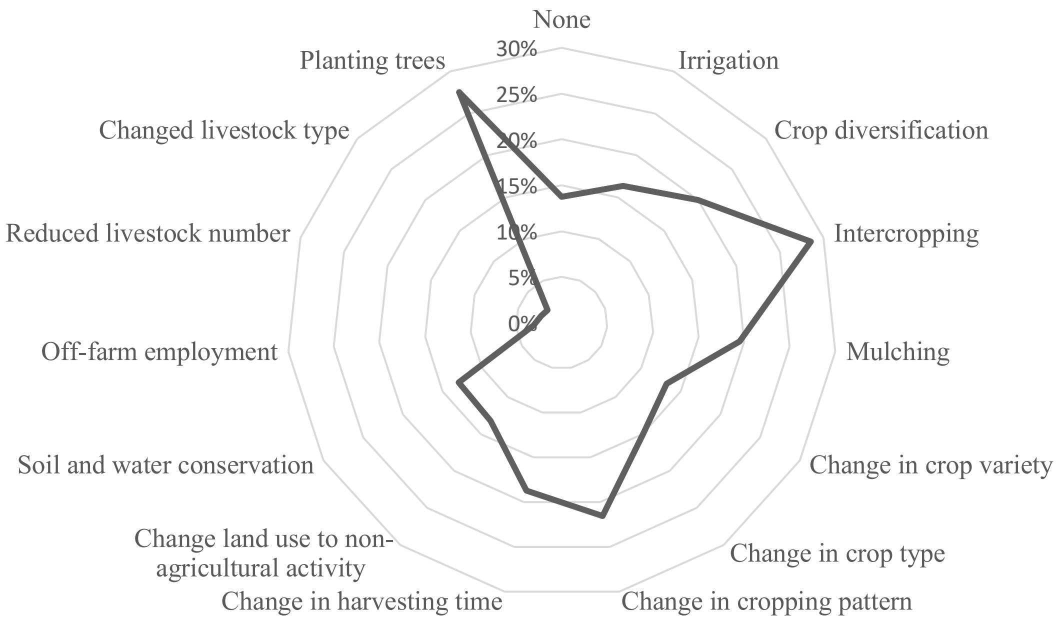

Figure 4.4: Mitigation measures against the effects of climate change

Respondents mainly depended on indigenous knowledge, radio programmes and advice from other farmers as sources of information to help determine and plan their farming activities (Figure 4.5). This is largely due to their ease of accessibility and affordability in the rural set-up hence key avenues to employ when disseminating information in the region. Reliance on extension advice was rather lower and totally lacking in two of the wards. A large disparity therefore exists that hinders farmers' access to technical advice and other agricultural support services usually provided by government extension officers, calling for urgent intervention in terms of staffing and accessibility of remote areas [42]. Use of social media and the internet was a scarcity in the County, calling for the improvement in the communication infrastructure in the region. There is therefore a need to complement conventional sources of farmers' information with contemporary scientific methods to improve the accuracy of weather predictions and add new knowledge and technologies for improved, sustainable and climate-resilient agricultural production [43].

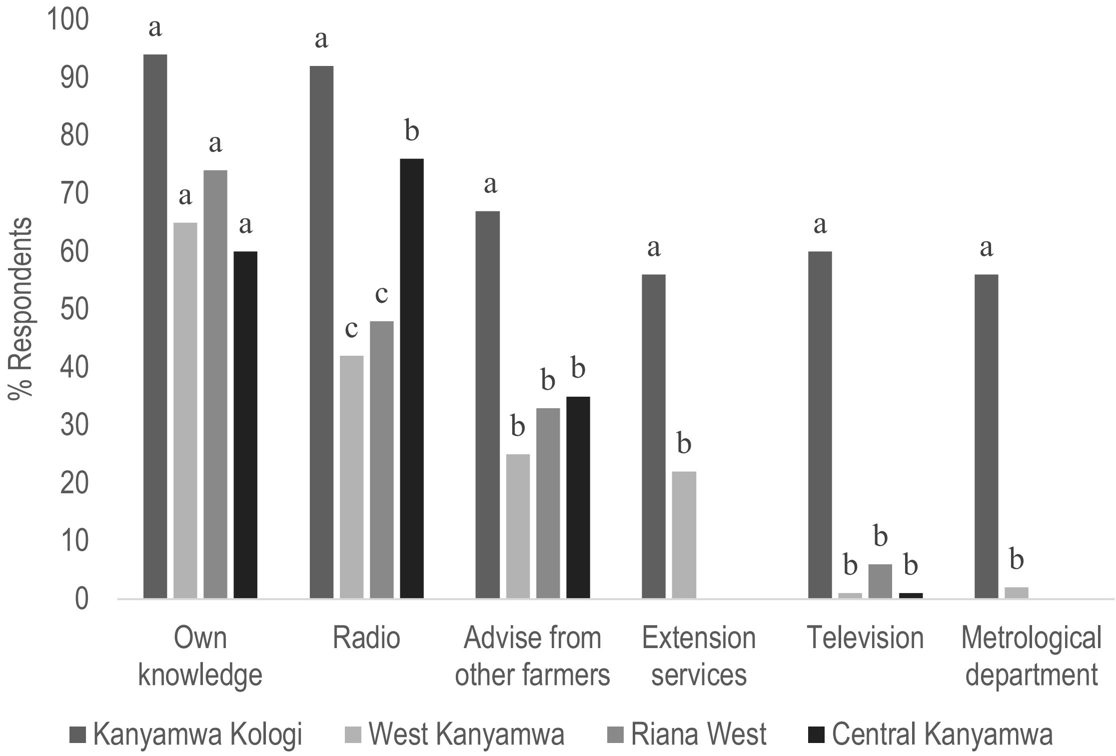

Figure 4.5: **Sources of information on weather and agriculture. Different letters indicate significant difference at $p < 0.05$**

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Yellow maize is a crop of great importance and a cultural heritage among farmers in this region. Application of basic production practices is limited due to financial constraints, beliefs, and limited sources of information. Major challenges include low yields, striga weed, adverse weather effects, and low marketability of yellow maize, with farmers adopting low-cost strategies to cope. Intercropping, a common practice among farmers, can be leveraged to take advantage of its multiple benefits. This early-maturing crop is cost-effective, possessing resilient traits to adverse weather, drought, and striga; valuable attributes that make it more reliable in challenging conditions compared to improved varieties, in addition to its nutritional superiority. This crop contains valuable genetic resources that can be tapped to enhance productivity. Nutritional awareness of the variety needs to be created both within and without the County to reach and create a market niche of interested consumers. This local yellow maize cultivar needs to be enabled to ensure food and nutrition security in the County and beyond.

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Conflict of interest

The authors declare no conflict of interest.

Table 4.1: **Demographic characteristics of respondents**

Socio-economic characteristics	**Categories (%)**		
Gender	**Male**	**Female**	
	43	57	
Age	Youth (18-35 years)	Middle Aged (36-60 years)	>60 years
	35	48	17
Marital status	Married	Single	Widowed/Widower
	72	8	20
No. of parcels of land	1-3	3-6	>6
	93	5	2
Main source of income	Farming	Employed/Salaried	Business/retail activities
	65	9	25

Table 4.2: Demographic characteristics of the respondents in relation to the education level

Socio-economic characteristics	**Categories**	**Education level (%)** No formal Educ.	**Prim. Educ.**	**Sec. Educ.**	**Tert. Educ.**	**p**	**χ^2**
Ward	Kanyamwa Kologi	5	9	13	10	0.001	52.192
	West Kanyamwa	2	9	4	2		
	Riana West	6	12	6	3		
	Central Kanyamwa	1	5	12	2		
Gender	Male	4	10	19	9	0.001	23.567
	Female	9	24	17	6		
Age	Youth (18-35 years)	0	10	15	10	0.001	129.973
	Middle Aged (36-60 years)	5	18	19	5		
	>60 years	9	6	1	1		
Marital status	Married	6	25	27	14	0.001	72.216
	Single	0	1	5	2		
	Widowed/Widower	8	8	4	1		
No. of parcels of land	1-3	14	31	34	14	0.242	7.949
	4-6	0	2	2	1		
	>6	0	1	0	1		
Main source of income	Farming	12	27	21	5	0.001	118.075
	Employed/Salaried	0	0	2	7		
	Business/retail activities	2	7	12	4		

Educ= Education, Prim=Primary, Sec=Secondary, Tert=Tertiary

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Table 4.3: Knowledge on yellow maize production, attributes and importance of legumes

Knowledge Statements	Right (%)	Wrong (%)	Don't know (%)
Yellow maize production			
Yellow maize has higher yields with little fertilizer application than white maize	75	12	13
Application of inorganic fertilizer alone is enough to increase yellow maize yields*	15	70	16
Application of organic fertilizer has no impact on soil fertility but rather a waste of time and money*	63	23	14
Application of both organic and inorganic fertilizer is important for better maize yields	78	6	15
Striga weed hampers maize growth and development	93	2	5
Attributes of yellow maize			
Yellow maize is more nutritious than white maize	91	2	7
Yellow maize contains vitamin A than white maize	57	5	38
Yellow maize is beneficial to pregnant and lactating women	52	4	44
Feeding children yellow maize enhances their immunity and eye sight	58	2	41
Yellow maize is tastier than white maize	96	0	3
Yellow maize has low marketability than white maize	84	8	8
Importance of legumes			
Feeding children exclusively on maize diet may lead to Kwashiorkor	42	8	49
Legumes are good source of protein	74	4	22
Intercropping maize with legume increases land productivity and insures against crop failure	82	4	14
Legumes help improve soil fertility levels	80	4	16
Consuming yellow maize combined with legumes provide a balanced diet	64	6	30
Knowledge Mean	69	10	21

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Table 4.4: **Changes in weather conditions and their perceived level of magnitude**

		% Magnitude		
Climate parameter	**% respondents**	**High**	**medium**	**low**
Temperature	73	83	12	4
Rainfall intensity	77	73	22	5
Rainfall duration	73	77	16	8
Erratic rainfall pattern	67	52	28	20
Drought	69	53	22	26
Floods	68	77	16	6

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