Assessment of the Impact of Climate Resilient Agricultural Practices on the Livelihood of Smallholder Cereal Farmers in Kenya: The Case of Embu County

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Abstract- Climate change is one of the greatest challenges threatening agricultural dependent and livelihood sustainability of developing economies of the world in the 21st century. It is estimated that the cereal sector in Kenya experiences post-harvest losses of 10 - 30% of the grains produced with the major losses occurring at the farm level due to poor post- harvest handling and management practices. As part of the efforts to provide solution to the issue of climate change facing smallholder cereal farmers in Kenya, the Government of Kenya in partnership with International Fund for Agricultural Development (IFAD) has created the Kenya Cereal Enhancement Programme and Climate Resilient Agricultural Livelihood window programme to contribute to national food security and smallholder income generation on a sustainable basis. It is against this backdrop that this study assesses the impact of climate resilient agricultural practices on the livelihood strategies of smallholder cereal producers in Embu County, Kenya. Smallholder farming system on a small scale basis comprising of mixed farming were selected for the study. This study adopts a survey design and the concept of climate smart agriculture to constitute the conceptual framework. A multi-method research strategy which includes qualitative and quantitative research approach for data collection and analyses will be adopted in a bid to complement the validity and reliability of the study's results. Stratified random sampling technique will be employed in carrying out the survey. Both primary and secondary data was used with 387 respondent sampled. The study employed structured questionnaire, Focus Group Discussion (FGD) and in-depth interview as the main instruments of the survey. Findings indicate that there is significant variation between climate smart agricultural practices and the cereal production on one hand, and geographical location of cereal farmers is significantly influenced by cereal production on the other.

Index Terms- climate change, smallholder farmer, food security, cereal production

I. Introduction

Climate change is increasingly emerging as one of the most serious global problem affecting many sectors (Huq *et. al.*, 2006; IPCC, 2007). It is considered to be one of the most serious threats to sustainable development with adverse impact on environment, food security, human health, natural resources and physical infrastructure (Huq *et. al.*, 2006; IPCC, 2007). Climate change will have adverse impact on socio-economic systems, especially of people whose livelihood are directly dependent on natural resources, such as those that depend on agriculture and forestry for their livelihood. So understanding the impact of climate change especially at local context, as well as analysing vulnerability and resilience is very important (Kassam *et al.*, 2011). Climate change brings a cascade of risks from physical impacts on (agro-)ecosystem, agricultural production, and food chains to economic and social impacts on livelihoods, income and trade, food security and nutrition (FAO, 2016). Similarly, Africa's population continues to grow with an estimated annual growth of 2.4% and the population is predicted to double its current 0.9 billion people by 2050. Crop production needs to increase by 260% by 2050 to feed the continent's projected population growth. Thus Africa's agriculture must undergo a significant transformation to meet the simultaneous challenges of climate change, food insecurity, poverty and environmental degradation. Sub- Saharan Africa is the only developing region in the world where food insecurity has worsened in recent decades (Ringler *et al*., 2010 and FARA, 2014). Limited economic development and institutional capacity has made African countries some of the most vulnerable to the impacts of climate change (FARA, 2014). Africa technical and political leaders recognise the significance and need to address the issue of climate change and one of the ways of addressing climate change as embedded in the Comprehensive Africa Agricultural Development Programme is ―the adoption of Climate Smart Agriculture as a combined policy, technology and financing approach to achieve sustainable agricultural development under climate change. (Msaki *et. al.*, 2015)

Specifically, in Kenya there is a strong sense that more should be done to make the Kenyan society better prepared for future climate change incidences. According to the Stockholm Environment Institute, if climate change in Kenya is not addressed, the economic costs of its impact are estimated at 3 per cent of GDP per year by 2030, and could reach 5 per cent by 2050. The agriculture sector, which contributes over 25 per cent of annual GDP, is particularly affected by changing climatic conditions. Nearly 98 per cent of crop production is rain-fed, and almost 50 per cent of animal production occurs in arid and semi-arid lands ASALs (IFAD, 2015). The increased incidence of drought and unreliable rainfall are expected to significantly affect the sector with the agriculture sector forming the backbone of Kenya's economy, employing 70 per cent of the rural population and accounting for 65 per cent of export earnings (IFAD, 2015). Moreover, it is estimated that the grain sector in Kenya experiences

post- harvest losses of 10 - 30% of the grains produced with the major losses occurring at the farm level due to poor post-harvest handling and management practices (IFAD, 2016). These include drying and grading practices; inadequate access to efficient technologies for shelling/threshing; poor storage conditions including inadequate capacity, design and standards of the storage structures (IFAD, 2016).

The overall goal of the Kenya Cereal Enhancement Programme - Climate Resilient Agricultural Livelihoods Window (KCEP-CRAL) programme is to contribute to national food security and smallholder income generation by supporting farmers to increase the productivity and profitability of key cereal commodities - maize, sorghum, and millet, and associated pulses and supporting smallholder farmers in graduating from subsistence to commercial agriculture. In view of the aforementioned. Therefore the aim of this study was to assess the impact of climate resilient agricultural practices on smallholder cereal farmer‘s livelihood in Embu county of Kenya.

II. Materials and Methods

1. 1 Study Area

The study was conducted in Embu County which is one of the Counties in the Eastern Region of Kenya. It has a total area of 4,736km2, a density of 33.68km2 with latitude 2o30I35.1II (2.5097o) N, longitude 31o53I4.1II (31.8845o) E and an elevation of 928 metres (3,045 feet) (Mapcarta, 2016). The county has two agricultural seasons (April, May, June & October, November, December); the main crops grown include Maize, Millet, cowpea, green-gram, kart, and sorghum. The county comprises a population estimate of 159,500 (KBS, 2016) with 50.4% (that is 67,279) of the population as women while 49.6% (that is 66,227) of the population are men. In terms of urbanization, 89.8% (119,913) of the entire population are rural dwellers while 10.2% of the population are urban dwellers (Brinkhoff,2016).

KCEP-CRAL is being implemented in thirteen counties in the eastern and coastal regions of Kenya (IFAD, 2016) with a combined population of over 5 million people. Five of this counties are in the maize production zones (Bungoma, Kakamega, Nakuru, Nandi and Trans Nzoia) and eight in the semi-arid areas growing maize, sorghum and millet (Embu, Kilifi, Kwale, Kitui, Machakos, Makueni, Taita Taveta and Tharaka-Nithi). Due to financial and time constraints, the scope of the study was narrowed to Embu County with 11 sub counties. However 6 sub counties within this 11 sub counties was focused on which are Mwea, Makima, Mbeti South, Nthawa and Evurore. Based on the 2009 Kenya Population and Housing Census Report, Embu County covers an area of 2,818 km2 with a population of 516,212 people (KIA 2018). Embu County lies some 120 Kilometers north east of Nairobi on south eastern side of Mount Kenya. The County is found within agro-ecological zone of the Kenyan agricultural.

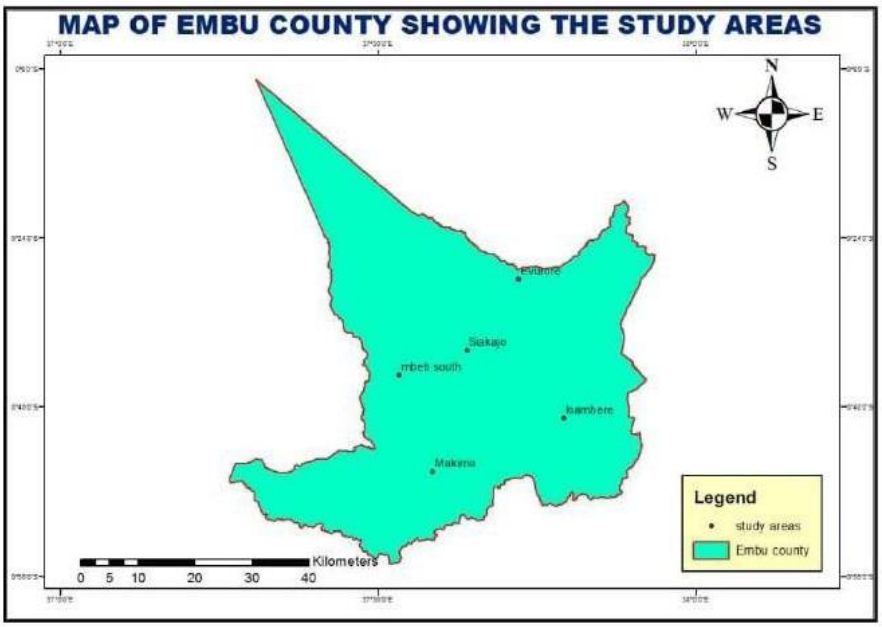


Fig 1: Map of Embu County Showing the Five Study Point

1.2 Nature and Sources of Data

In this study, the quantitative approach adopted is a smallholder farmer survey questionnaire which was used to collect data on the economic effects of KCEP on farmers‘ livelihoods before and after CRAL adoptions. This method addressed Objective 1, 2, 3 and 4 of the study by capturing several quantifiable aspects of farmers‘ livelihoods before and after CRAL inception. The qualitative research approaches employed are Focus Group Discussions (FGDs) and key informant interviews which sought to address Objective 1, 2 and 4. FGDs was used to convene key stakeholders such as KCEP- CRAL farmer groups‘ representatives whose discussions assisted in informing the research more on farmer‘s challenges, resilience strategies

and perception as regards its climate change and cereal production. On the other hand, key informant interviews with KCEP-CRAL implementing Agency‘s staff, Kenya Agricultural and Livestock Research Organisation (KALRO) Staff, National Drought Management Authority Staff and Agro- dealers from Mbeere were conducted on vital issues around climate resilience effects on production as it relates to their area of specialisation.

1.3 Sampling Technique and Data Collection

In other to carry out the smallholder farmer survey, it was important to ensure that the chosen respondents from KCEP - CRAL farmer groups gives a relatively accurate picture of the whole Embu county project area (the five sub counties). This way, the study sought to be considerably representative, replicable and unbiased by gathering information from a substantial number of cereal farmer groups in order to make judgments about the larger county project area. Therefore, the quantitative part of the research employed stratified random sampling; a probability sampling (every element of the population has a known, non-zero chance of being selected for the sample) approach relevant to capture subgroups within the population (Scheyvens and Storey 2003). It encompassed choosing cereal farmer groups (Sorghum and Green-grams,) from the five sub-counties in Embu County to serve as representative strata for the total population of farmers involved in KCEP- CRAL. This was done by having a random selection of cereal farmer groups from the project‘s total register of benefitting farmer groups using an Excel document application. From the new groups cereal farmer group that was provided after the randomised function application in Excel, an application of non-probability snowball sampling selection of 5 cereal farmer was applied per each cereal farmer group to whom a smallholder cereal farmer survey was administered.

The qualitative part of the study makes use of purposive sampling; According to (Gray *et. al.*, 2007), this sampling approach purposely selects certain groups or individuals for their relevance to the issue being studied. As such, three Focus Group Discussions (FGDs) was purposely organized according to their proactivity in KCEP- CRAL thereby targeting the most active in each of the five sub-counties. This was done with the help of Sub County agricultural officers at Mbeere South and North, who helped convene the FGD participants using their communication networks. Three key informants (KCEP- CRAL) were purposely and conveniently selected for interviews.

The study employed both quantitative and qualitative research (mixed methods) approaches for data collection and analyses in a bid to complement the validity and reliability of the study‘s results through triangulation and corroboration of reported information and figures. A smallholder cereal farmer survey questionnaire was used to collect data on the awareness level and effect of CRAL on KCEP after its adoptions. This method addressed Objective 1 and 3 of the study by capturing income diversity (sources and levels) and awareness levels, after KCEP- CRAL inception. For data analyses and discussions, descriptive statistics and regression models was done using SPSS and JMP software then presented in tables and levels of statistical significances.

The qualitative part employed three (3) key informants‘ interviews and eleven (2) Focus Group Discussions (FGDs, to address Objective 1, 2 and 4) from each sub-county. FGDs convene KCEP - CRAL farmer groups‘ representatives to inform the research more on farmers‘ experiences and perspectives on the KCEP- CRAL. Key informant interviews collect vital information from KCEP- CRAL staff, sub county officer and other stakeholders on their experiences as extensionists and on institutionalization of KCEP- CRAL.

1.4 Methods of Data Analyses

Data processing and analysis was done by compiling information collected using different data collection methods. Therefore, both numeric and non- numeric data analysis software was used, depending on the type of data collected. The qualitative data from key informant interviews, focus group discussions, and observations was coded and analysed using the Qualitative Data Analysis software (MAXQDA) version10 and it was presented in form of descriptions (texts, photos, tables) and quotes. Quantitative data from questionnaire was analysed using Statistical Package for Social Sciences (SPSS) software Version 20. Descriptive statistics was processed to generate frequencies and percentages. Cross-tabulation will also be made, particularly for the multiple response questions. This will allow comparison of different study parameters among villages in the district.

III. RESULTS AND DISCUSSION

3.0 Social – economic Characteristics of Respondents

A dominant male household head was recorded with about 94.1 % of the household head being male headed while the female headed was 5.1%. The result implied that household head in the study area is male dominated. Furthermore, the study also revealed a slight dominant of male respondents as against female, with over half of the respondents (56.8%) being male. In analysing the location of respondents, it was revealed that about 63.6% of the respondents are from Mbeere South and 15.3% from Mbeere North and about 21.2% did not clearly specified their district location. It can be implied that majority of the respondents are from Mbeere South. Analysis of respondents‘ house-hold size revealed that about 56.7% of the respondents are live in household size of 1-5, 39.8% lived in size between 6-10 while those of 11-15 and above 15 takes 1.7% of the distribution respectively. Hence, majority of the respondents in the study area are cereal farmers. In analysing the educational structure of household head, the study revealed that 34.7% of the household head had secondary school education while 33.1% had either college or university degree as their highest level of education. It can be implied that the average household size ranges between 1-5 and can still be considered as small sized household group. In addition, the study revealed that 36.4 of this household are not working while household size of 1-3 has about 55.1% of working. The occupational structure of household head reveals that 89.8% main occupation is cereal farming. Hence, apart from the majority being cereal farmers, it can also be posited that these respondents have above primary education as their highest level of educational qualification, hence a relatively high literacy rate of respondents (See Table 1). A positive association between high literacy and increased climate change awareness has been reported in several studies as there is an increased exposure to educated farmers to information on climate change and best agricultural practices (Ndambiri *et al*., 2013, Ofuku, 2011, Kangi *et al*., 2021).

2. 2 Household Income and Expenditure

From the survey, it was revealed that 95% of the sampled respondents engaged and received their income from agricultural activities (Figure 1a). This implies that agriculture is the mainstay of the economy in this region. Through the in-depth interviews and focus group discussions (FGD) carried

Table 1: Social Economic Characteristics of Respondents

Social economic characteristics	Frequency	Percentage
Household Head		
Man	111	94.1
Woman	6	5.1
Male Youth	0	0
Female Youth	1	.8
Total	118	100.0
Sex		
Male	67	56.8
Female	51	43.2
Total	118	100
District		
Mbeere South	75	63.6
Mbeere North	18	15.3
Not specified	25	21.2
Total	118	100`
Household Size		
1-5	67	56.7
6-10	47	39.8
11-15	2	1.7
Above15	2	1.7
Total	118	100
Numbers of household working		
Not working	43	36.4
1-3	65	55.1
4-6	8	6.7
7-9	2	1.6
Total	118	100
Highest Education of Household Head		
No formal education	8	6.7
Primary	20	16.9
Secondary	41	34.7
Vocational Training	9	7.6
College/University	39	33.1
Total	118	100
Main occupation of household head		
Not engaged	2	1.7
Cereal Farming	106	89.8
Off-Farming	6	5.1
Others	2	1.7
Total	118	100
Main occupation of household head		
Not engaged	2	1.7
Cereal Farming	106	89.8
Off-Farming	6	5.1
Others	2	1.7
Total	118	100

out, it was discovered that nearly all the farmers participate in alternative source of income generating source aside Green-gram and Sorghum intervention from KCEP-CRAL which includes both agricultural sources (On-Farm,) and non-agricultural sources (Non-Farm, Off - Farm). However, focus group discussion revealed more that the most income source for farmers in generated

through cereals cultivated within the period of KCEP-CRAL intervention. Furthermore, the study revealed that 83% of the sampled respondents engaged in sales of crops (Figure 1b). This further confirms that majority of the respondents are involved in agricultural activities as their major source of income, especially sales of their cereal crops after harvest to already prepared market such as Sorghum to Kenyan Breweries through linkages created by KCEP-CRAL with the farmers as well as other exploring other market channels locally as derived from the Focus Group Discussion (FGD) conducted with the cereal farmers. On- Farm income however refers to the profits incurred through the operation of the farm.

The survey carried out revealed from the study that about 63% of the sampled farmers still receive some measure of non-farm income as against 37% who only depend on on-farm income alone (as shown in Fig. 1c). This further helped to understand how cereal farmers well-being and income as improved since involvement in KCEP-CRAL intervention in 2017. Since the non-farm income refers to the portion of farm household income obtained off the farm, including nonfarm wages and salaries, and interest income earned by cereal farmer families.

The study carried out to determine if the respondents also engage in off- farm income to support their mainstay revealed that 71% of the respondents do not respond to this, possibly because they do not have other source apart from the on-farm income which is mainly sales of crops. However, it was revealed 11% of the respondents work as agro dealers selling chemicals such as pesticides, fertilizers to supplement their On-Farm income generated through cereals and other associated pulses (shown in Fig 1d).

From the study carried out on the annual income the farmers received from on-farm activities in the previous year (2018) it was revealed that 45% of the respondents received less than 10001Kenya shillings from in the previous year, 21% received between 10001-20000 ksh while others received relatively to none for higher income above 30000ksh (Figure 1e). This implies that the farmers income from engaging in cereal farming is not significant though there have been increase in yield.

Further study was carried out to determine non-farm activities engaged in by the respondents, it was observed 64.4% of the respondents do not attempt this, most probably because they do not engage in non-farm activities, and 28.8% ascertained clearly that do not engage in non- farm activities, while 4.2% engages in livestock production (Fig. 1f). Furthermore, the study revealed that relatively no significant income for non-farm activities as majority do not engage in non-farm activities (Figure 1g)

To ascertained if the respondents received income from family and friends away from home revealed that 81% of the sampled respondents do not received income from family and friends while 19% received from family and friends from home (Figure 2a). Although income received from family and friends is minimal, further study was carried out to ascertain the level of income from this source. It was revealed that about 12% received between 1000-10000 Kenyan shillings while majority do not receive (83.1%) any income family and friends (Fig. 2b).

It was revealed from the study 64% of the sampled respondents do not have existing loans while 36% have existing loans (as shown in Fig. 2c). This result implies that majority of this respondents mainly depend on their agricultural activities as their main source of finance and relatively do not engage the banks for loans or source of money from family and friends.

The study further revealed the interest charged on loans was relatively insignificant as majority do not engage in loans. About 5.9% are charged between 1001-2000 and above 7001 respectively (Fig. 2d). The study showed that 53% of the sampled respondents hired labor in 2018 while 47% do not hire labour in 2018 (Fig. 2e).

3.3 Perception of Small-holder Cereal Farmers on Climate Resilient Agricultural Practices

In scoring cereal farmers‘ perception on climate change, each respondent was required to score his/her level of agreeing with the notion that each of the identified perspectives on climate change is the most prominent view on climate change using a 4-point Likert scale, scaled as follows 1 point for_Strongly disagree‘ (SDA); 2 points for _Disagree‘ (D); 3 points for _Agree‘ (A) and 4 point for _Strongly Agree‘ (SA) (See Table 2).

3.3 Climate Resilient Practices of Smallholder Cereal Farmers

3.3.1 Types of Crops Grown

The study revealed that only (39.8%) engage in mono-cropping planted green gram while majority (69.2%) engages in mixed cropping with different variations of crop with green gram. It can be implied that green gram is the dominant crop in the study area and that the most plausible reason for mixed cropping might be due to the farmers resilient to livelihood despite the unfavourable weather condition prevalent in the study area (See Table 3).

3.3.1 Introduction to Bulking/seed Multiplication

The study revealed that 72% of the respondents have been introduced to seed multiplication/bulking and 28% have not been introduced to seed multiplication. This implies that majority of the respondents who are cereal farmers have been introduced to seed multiplication (Table 4). In order to assess the level of resilience of cereal farmers involved in KCEP- CRAL, they were asked about their involvement in farming methods organized by the KCEP-CRAL.

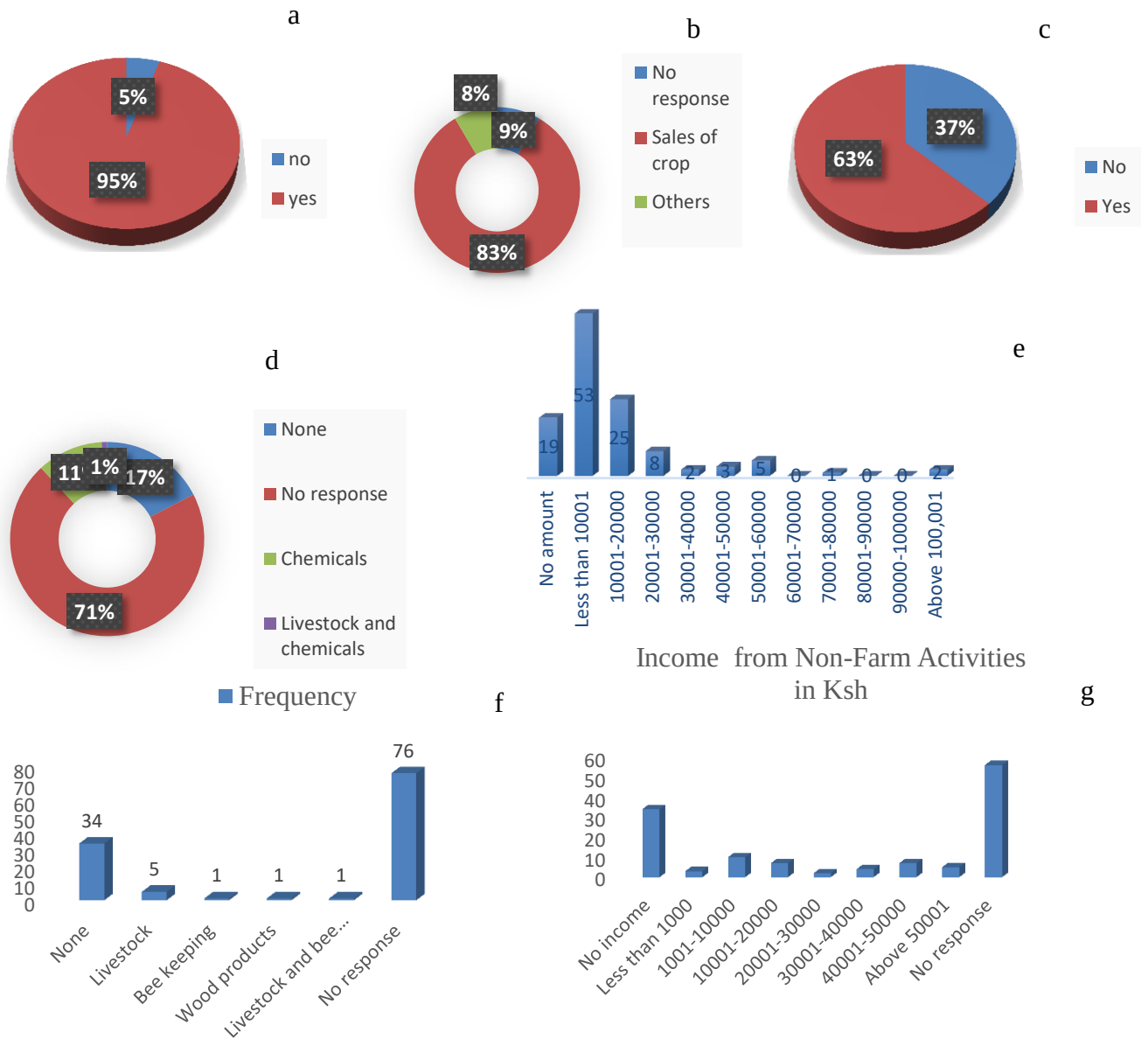


Figure 1: a. Income from Agricultural Activities, b. Type of On- farm Income, c. Income from Non-Farm Income, d. Type of Off-Farm Income, e. : Annual Income from On-Farm Activities, f. Type of Non-Farm Activities, g. Income from Non-Farm activities in Kenya Shillings

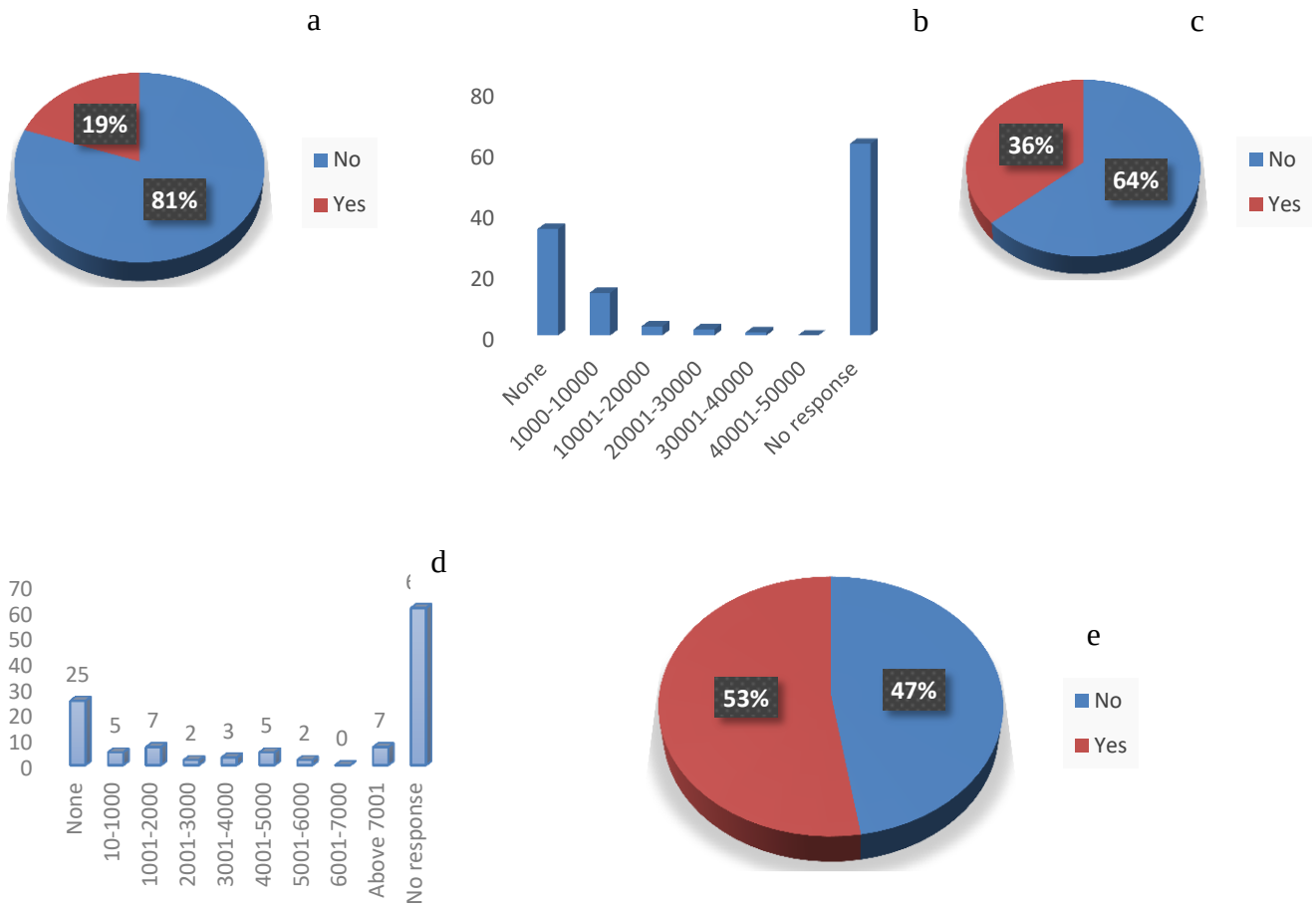


Figure. 2: a. Income from Family/Friends away from home, b. Amount Received from Family/ Friends, c. Existing Loans, d. Interest on Loans in Kenya Shillings, e. Hire Labour of in 2018

Table 2: Observed Changes before 2016 and after 2016 when KCEP project was introduced

Observed changes	Before 2016			After 2016		
	Agreed	Disagreed	No changes	Agreed	Disagreed	No changes
There was an increase in temperature	73(61.9%)	27(22.9%)	18(15.3%)	72(61.0%)	5(4.2%)	41(34.7%)
Experienced more extreme temperature	70(59.3%)	35(29.7%)	13(11%)	26(22.0%)	39(33.1%)	53(44.9%)
Experienced less extreme temperature	79(66.9%)	34(28.8%)	5 (4.2%)	39(33.1%)	14(11.9%)	65(55.1%)
Experienced scorching sun	67 (56.7%)	40(33.9%)	11(9.3%)	51(43.2%)	26(22%)	41(34.7%)
Summer was getting warmer	64(54.2%)	41(34.7%)	13(11%)	52(44.1%)	11(9.3%)	55(46.6%)
Winter was getting warmer	103(87.3%)	13(11%)	2 (1.7%)	65(55.1%)	13(11%)	40(33.9%)

The result revealed that majority of the respondents participated in demonstration plots as 89% affirmed to be involved in demonstration plots and about 62.7% are involved in farmer field school and 41.5% are involved in study tours (Table 5). It can be implied that the KCEP-CRAL cereal farmers prefer demonstration plots and farmers filed school methods to farm trials and study tours.

On the crop production technologies farmers have been introduced to, it was revealed that 96.6% of the respondents have been introduced to new crop varieties such as KAT, Sorghum-k80, Green Grams-N 26, 89% have been introduced to crop rotation and about 90.7% introduced to Integrated Pest Technologies (IPM) but relatively few introduced to conservation agriculture (30.5%) and 22.5% adopted other methods (Table 6). The relatively high knowledge of new crop varieties might be due to the activities of the KCEP-CRAL in these areas, as they introduced the cereal farmers to new crop technologies that are climate resilient and of higher yield. It is possible that the high level of new crop varieties might be due to the high acceptability of demonstration plots that many of the farmers participated in.

Table 4: Bulking/ Seed Multiplication

Been introduced to seed multiplication /bulking	Frequency	Percentage
No	33	28.0
Yes	85	72.0
Total	118	100.0

Table 5: Farming Methods Participation of Farmers

Farming Methods	Frequency	Percentage
Farmer Field School		
No	44	37.3
Yes	74	62.7
TOTAL	118	100.0
Farm Trials		
No	59	50.0
Yes	59	50.0
TOTAL	118	100.0

3.3.2 Level of Adoption of Crop Technologies

In analysing the level of adoption of crop technologies, table revealed that majority of the respondents do not answer this question. This might be because of the difficulty they might have in determining the level of their adoption of these technologies or better still adopted more than one of these methods in varying measures. However, the study revealed a slight dominance of full adoption as against partial and no adoption (see table 7). Hence, it can still be inferred that there is widespread level of adoption of these technologies even though the level of adoption by the respondents was not ascertained by them.

Table 6: Crop Production Technologies Introduced

Crop production technologies	Frequency	Percentage
New Crop Varieties		
Yes	114	96.6
No	2	1.7
Missing	2	1.7
Total	118	100
Crop Rotation		
Yes	105	89.0
No	6	5.1
Missing	7	5.9
Total	118	100
Integrated Pest Technologies		
Yes	107	90.7
No	5	4.2
Missing	6	5.1
Total	118	100
Conservation Agriculture		

Yes	36	30.5
No	6	5.1
Missing	76	64.4
Total	118	100
Others		
Yes	26	22.0
No	16	13.6
Missing	76	64.4
Total	118	100

3.3.1 Rate of Performance of the Training by Cereal Famers

The cereal farmers were asked to rate the performance of the training methods received. It was revealed that many of the respondents did not respond effectively to this section as this can be observed by the number of no responses among the respondents (See Table 8). Furthermore, on average, the respondents find FFS methods and demonstration method more helpful than farm trials and other methods.

3.4 Challenges Faced in Small-holder Cereal Farmers in Adopting Climate Resilient Practices

Analysis of whether respondents experienced agricultural yield increase since the introduction of KCEP-CRAL revealed that 61% of the respondents agreed that they have experienced agricultural increase since the introduction of KCEP-CRAL while 39% disagreed. It can be implied that many of the respondents experienced yield after the introduction of KCEP-CRAL (See Table 9).

Table 7: Level of Adoption of Crop Technologies

Level of adoption	Frequency	Percentage
New crop varieties		
No response	79	66.9
Full adoption	26	22.0
Partial	9	7.6
None	4	3.4
Crop Rotation		
No response	82	69.5
Full	33	28.0
Partial	3	2.5
None	36	30.5
Integrated Pest Technologies (IPM)		
No response	83	70.3
Full	23	19.5
Partial	7	5.9
None	5	4.2
Conservation Agriculture		
No response	52	44.1
Full	49	41.5
Partial	11	9.3
None	6	5.1
Others		
No response	51	43.2
Full	54	45.8
Partial	9	7.6
None	4	3.4
N	118	100.0

Table 8: Rate of Performance of the training

Rate of performance of training by methods	Frequency	Percentage
FFS		
No Response	23	19.5
Very helpful	33	28.0
Helpful	22	18.6
Not helpful	40	33.9
Farm Trials		
No Response	22	18.1
Very helpful	12	10.2
Helpful	9	7.6
Not helpful	75	63.6
Study tours		
No Response	21	17.7
Very helpful	19	16.1
Helpful	11	9.3
Not helpful	67	56.8
Demonstration Method		
No Response	16	13.5
Very helpful	45	38.1
Helpful	29	24.6
Not helpful	28	23.7
Other Methods		
No Response	30	25.4
Very helpful	17	14.4
Helpful	30	25.5
Not helpful	41	34.7
N	118	100.0

Table 9: Increase in Yield since the introduction of KCEP-CRAL

Increase in yield since KCEP-CRAL/ any other agricultural project inception	Frequency	Percentage
Agree	72	61.0
Disagree	46	39
Total	118	100

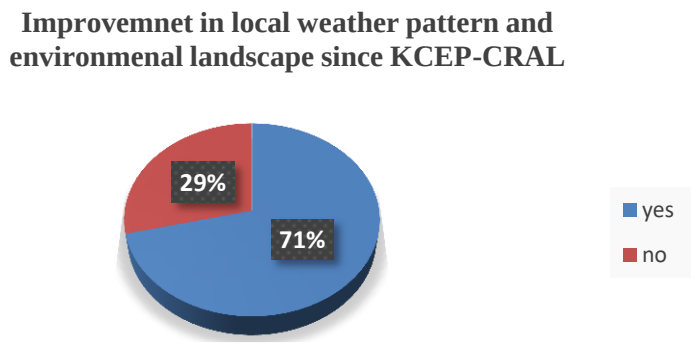
3.4.1 Level of Improvement in Local weather pattern and Environmental landscape Since the introduction of KCEP-CRAL

It was gathered from the study that 71% of the respondents agreed that there have been improvements in local weather pattern and environmental landscape since the introduction of KCEP- CRAL in 2017 (See Fig 3).

3.3.1 Reasons for Change in Local Weather pattern since the introduction of KCEP-CRAL in 2017

Furthermore, the reason for the observed change in local weather pattern and environmental landscape was presented in Table 10. The dominant reason among the reasons advanced by the respondents was that there has been an improvement in knowledge as it relates to weather forecasting. The next important reason was the planting of drought resistant crops. It can be implied that the introduction of drought resistant seedlings by the KCEP- CRAL and the increase in awareness of change in local weather has given these local farmers ability to successfully make projections and predictions about their likely yield despite the harsh weather.

Fig 3: Level of Improvement in Local weather pattern and environmental landscape since KCEP



3.5 Effect of Climate Resilient Practices on Cereal Production

To determine cereal farmers' resilient measures to climate change before 2017 and after 2017 when KCEP-CRAL was introduced, it was revealed that majority of the respondents gave no responses on the measures taken (64.4%) with relatively few having initiated the measures. However, from 2017 after the introduction of KCEP-CRAL it was observed that about 40.7% initiated resilient measures in crop production, 42.4% changes to cash crops there was relatively insignificant difference in their use of quantity of seeds and fertilizers used before 2017 and after 2017 as majority (64.4%) did not ascertain if they initiated these measures or not. It is observed that there is significant difference in the level of initiation as observed before 2017 and after 2017, the reason might not be far-fetched from the efforts of the KCEP-CRAL and other similar initiatives. It can have deduced that there is dependence on the program by the cereal farmer especially in areas of improved seedlings and fertilizer provision as many of these farmers might not be able to afford this based on their level of productivity (see Table 13).

Table 10: Reasons for change in Weather Pattern and Environmental Landscape since KCEP introduction

Reasons for responses for improvement in local weather pattern and environmental landscape	Frequency	Percentage
No reasons given	29	24.6
Increase in knowledge as it relates to weather forecasting	40	33.9
Drought resistant crops	35	29.7
Harsh weather	14	11.8
Total	118	100.

Hypothesis One

There is no significant association (influence) between Climate Resilience Agricultural practices and Cereal Production. The Table (12) below summarizes the result of the Chi Square test that shows the relationship between the level of adoption of climate resilience agricultural practices on Cereal Production. The Chi Square results indicate that new crop technologies, crop rotation, Integrated Pest Technologies are not statistically significant association on Cereal production. However, for green gram there is statistically significant relationship (influence) of Conservation Agriculture and other methods level of adoption on cereal production (green gram). However, it is the other resilience measures carried out by farmers that is statistically significant for sorghum. It was observed that majority of the respondents do not adopt (either fully or partially) these climate resilience agricultural Hence, not statistically significant influence of the measures.

Table 11: Resilient Measures Taken in Response to Climate Change

Resilient Measures initiated before	Initiated	Not initiated	No response	Resilient measures after 2017	Initiated	Not initiated	No response

2017							
Resilient measures initiated in crop production	23 (19.5%)	19(16.1%)	76(64.4%)	Resilient measures initiated in crop production	48(40.7%)	70 (59.3%)	0
Change to more of cash crops	26(22.0%)	16(13.6%)	76(64.4%)	Change to more of cash crops	50(42.4%)	68(57.6%)	0
Spacing between the rows/plants	24(20.3%)	18(15.3%)	76(64.4%)	Spacing between the rows/plants	45(38.1%)	73(61.9%)	0
Quantity of seeds used	24(20.3%)	18(15.3%)	76(64.4%)	Quantity of seeds used	19(16.1%)	23(19.5%)	76(64.4%)
Quantity of fertilizer application	23(19.5%)	19(16.1%)	76(64.4%)	Quantity of fertilizer application	21(17.8%)	21(17.8%)	76(64.4%)

4.7 Hypothesis Two

There is no significant difference between cereal productions across geographical locations. The Chi square results to test if there is significant relationship (influence) of geographical locations (districts) of cereal farmers on cereal production (Green Gram) is presented in the table below. (N = 83, Chi square = 24.807, df = 28, $p < 0.638$). This indicates that there is no statistically significant difference between cereal productions across the districts in the study area. It can be observed that majority of the respondents do not indicated their location; this might also have influenced the effect of location on level of production. Also, it can also be observed that these districts are within the same geographical zone (see Table 13).

Table 12: Chi Square result testing the significant difference (Influence) of Climate Resilience Agricultural Practices on Cereal Production

Climate Resilience Agricultural Practices variables	Chi square value	Df	Significance
Green Gram			
New Crop Varieties	83.222	72	.172
Crop Rotation	49.636	48	.408
Integrated Pest Technologies	68.470	72	.596
Conservation Agriculture	167.212	102	.000
Others	166.870	102	.000

Sorghum			
New Crop varieties	42.909	51	.783
Crop Rotation	32.271	34	.553
Integrated Pest Technologies	49.035	51	.552
Conservation Agriculture	61.560	51	.148
Others	166.870	102	.000

Table 13: Chi Square Table for Green gram production across Districts

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.807[a]	28	.638
Likelihood Ratio	25.474	28	.602
Linear-by-Linear Association	1.524	1	.217
N of Valid Cases	83		

IV. Conclusions

Subsistence/Smallholder Cereal farmers in Embu County who are beneficiaries of KCEP- CRAL have been aware and are implementing climate resilience agricultural practices since the commencement of the program in 2016 when it was introduced through activities of roles and responsibilities played by different partners involved in achieving certain outcomes as a way to increase resilience and coping strategy with the ensuing impacts of climate change and variability. With the research structured around component 1, which aims to build capacity for climate-resilient productivity enhancement and NRM, activities have been raised not just to identify climate resilient initiatives but also carry out sensitization and capacity building within targeted communities among other measures in place. KCEP-CRAL beneficiaries are also keen on adopt climate resilience practices and interventions that would transform their agricultural practices into a relatively more productive, higher-income earning, and build resilience to climate change as well as to improve food and nutrition security.

Conflicts of interest

The author declares no conflict of interest

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