IFAD PROJECT RESEARCH REPORT

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 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. Thus Africa's agriculture must undergo a significant transformation to meet the simultaneous challenges of climate change, food insecurity, poverty and environmental degradation.

The study in view of this employed both quantitative and qualitative research (mixed methods) approaches for data collection and analyses. The scope of the study was narrowed down to 6 sub counties with 134 questionnaires administered to beneficiaries together with 2 focus group discussions (FGDs) and 4 key informant interviews (KIIs) were held to improve reliability of information gathered. Data collected helped determine the impact of KCEP-CRAL among beneficiaries alongside resilient practices, challenges to adoption as well as impact on food and nutrition security.

Findings indicated that (39.8%) are engaged in mono-cropping planting of green gram while majority (69.2%) engages in mixed cropping with different variations of crop with green gram. Result also reveals that majority of the respondents participated in demonstration plots as 89% aff irmed to be involved in demonstration plots. Test of Hypothesis indicated there is no significant difference between cereal productions across geographical. The study in line with the objective further revealed from 2016 after the introduction of KCEP-CRAL it was observed that about 40.7% initiated resilient measures in crop production, with 42.4% changes into cash crops and there was relatively insignificant difference in their use of quantity of seeds and fertilizers used before 2016 and after 2016.

There is a significant observable change observed to beneficiaries of KCEP-CRAL prior to joining the intervention and after with a great rise in the income level of farmers as well as enhanced yield against the observable weather condition pattern militating in the study area. However, it is important to take note of environmental, gender and socioeconomic factors. Farmers should be provided with continuous education, training, information, improved extension services and access to credits; existing policies should be enforced and amended to align with future challenges and opportunities; farmers should mobilize to form associations that will further assist benefiting members of KCEP-CRAL

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

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). According to the Resilience Alliance (2002), resilience has three distinct characteristics, i.e., system capacity to undergo change and still be in the same state, capability of self-organization and ability to build and increase capacity of learning and adaptation.

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) because of limited economic development and institutional capacity, African countries are among 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)

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 vast majority of Kenyan climate change research has focused on the arid and semi-arid lands (ASALs) in general, where rainfall is "always" a constraint on productivity and pastoralism (Jones *et. al*., 2009).

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, this study therefore aims to assess the impact of climate resilient agricultural practices on smallholder cereal farmer's livelihood in Embu county of Kenya.

1.2 Statement of Problem

Climate resilient agricultural livelihoods projects have been embraced in the recent past as a viable means of cereal enhancement for developing countries. They have been taken up by international and national development agencies to promote Kenya cereal enhancement programme while reducing poverty and ensuring food security through 'climate-smart agriculture'. However, the real influence of these projects is yet to be realized as researchers and development critics raise questions on their viability.

Since its inception, the Kenya cereal enhancement programme – Climate resilient agricultural livelihoods window (KCEP-CRAL) has aimed at gradually reducing poverty levels of small-holder farmers in Kenya by boosting their farm yields and food security. This is done by promoting sustainable agriculture and linking them to profitable agricultural markets while improving their natural resource management capacity and resilience to climate change. This endeavour set the basis of investigating the impact of climate resilient agricultural practices on the poor smallholder cereal farmer's livelihood since the programme's inception.

1.3 Justification of the Study

Resilience to climate change by smallholder farmers still remain a challenge in many developing countries. Yet, the smallholder farmer remains the major crop producers in these countries. Moreover, the UN (2013) observed that smallholder farmers', options for coping strategies to climate change tend to focus on fixing crises rather than long term sustainable adaptation and resilient strategies.

With regard to climate change, there is an increasing demand for information about the real impact of climate resilient agricultural projects in the developing world. However, there are no studies that have shown the potential livelihoods transformation through the economic

gains that come with such investments (Antle *et al*., 2007). Many international agencies and agricultural research organizations have adopted a variety of programmes and funds to demonstrate how climate resilient practices in agriculture can work and produce successful human development outputs in cereal production.

KCEP-CRAL is progressively aimed at reducing poverty by boosting farmers' yields and food security through sustainable agriculture and linking small-scale farmers to profitable agricultural markets while generating cereal credits. An assessment of the impacts of KCEP-CRAL will shed light on the projects actual impacts on the ground and inform future project implementation processes. This is crucial in reconciling the divergent narratives of project implementers and the project's beneficiaries. This research study will also help widen researchers' and climate change practitioners' varied perceptions on climate resilient agricultural based initiatives in light of WB's 'climate smart' agriculture concept.

1.4 Research Questions

This study was guided by three research questions through with instruments prepared and data collected. The research questions are:

1. What constitutes the present livelihood resilient strategies in cereal production by smallholder farmers?
2. What is the perception of smallholder cereal farmers on climate resilience agricultural practices?
3. What are the challenges faced by smallholder cereal farmers in adopting climate resilience practices and effect of climate resilience practices on cereal production?

1.5 Study Aim and Objectives

The study aims to assess the impact of climate resilient agricultural practices on the livelihood of smallholder cereal producers in Embu County, Kenya. The study objectives are:

1. To analyse the present livelihood resilient strategies of smallholder cereal farmers.
2. To assess the perception of smallholder cereal farmers on climate resilience agricultural practices.
3. To examine the challenges faced by smallholder cereal farmers in adopting climate resilience practices.
4. To evaluate the effect of climate resilience practices on cereal production.

CHAPTER TWO: MATERIALS AND METHODS

2.1. Introduction

This chapter highlights the specific methodologies and procedures that were used in the study. The methodologies include the description of the study area, sampling criteria and study instruments used. Data collection methods, data analysis and data interpretations for the study are also described.

2.2. 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.

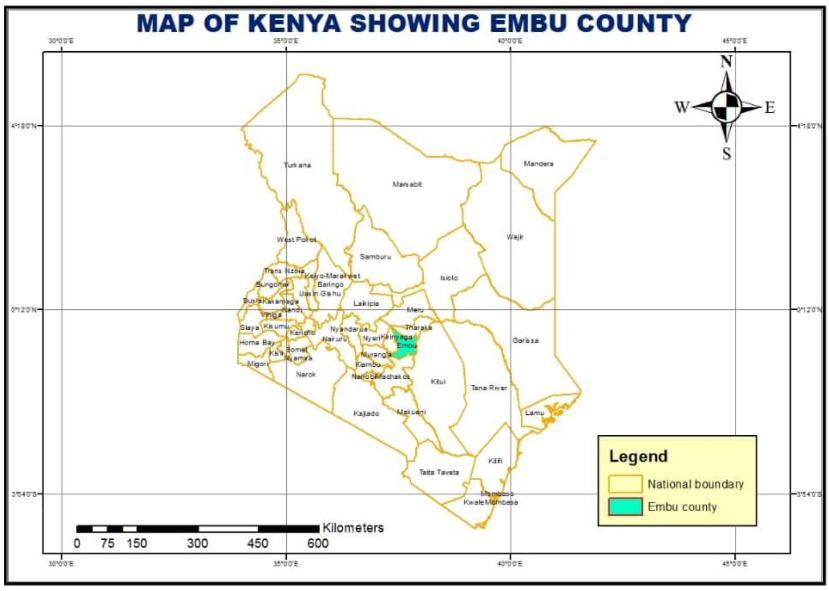


Fig 2-1: Map of Kenya Showing Embu County

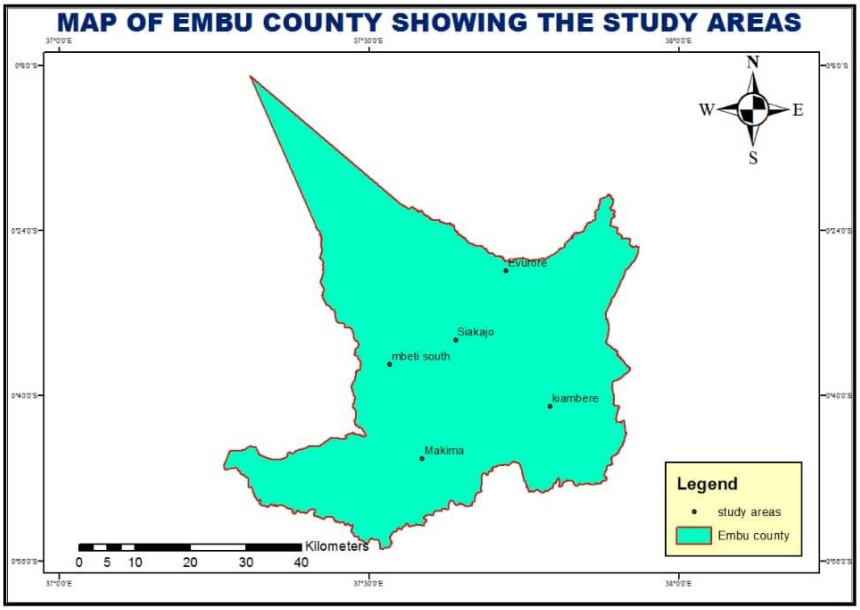


Fig 2-2: Map of Embu County Showing the Five Study Point

2.3 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.

Fig. 2-3: Data collection from smallholder farmers at Mbeere North Sub-county

Fig. 2-4: Data collection from smallholder farmers at Gachoka, Mbeere South

Fig. 2-5: Focus group discussion with women farmers at Makema, Mbeere South

Fig. 2-6: Data collection from smallholder farmers at Siakago, Mbeere North

Fig. 2-7: Data collection from smallholder farmers at Mbeti South

Table 2.0: Data Collection and Method.

S/N	Objectives	Data Collection	Methods

		(Source of data)	
1	Analyse the present livelihood resilient strategies of smallholder cereal farmers.	Sample survey (questionnaire), Key Informants interview (KII).	134 questionnaires administered, KII with one respondent from Kenya Agricultural and Livestock Research Organization (KALRO) and two Sub county agricultural office.
2	Assess the perception of smallholder cereal farmers on climate resilience agricultural practices.	Sample survey (questionnaire),	134 questionnaires administered,
3	Examine the challenges faced by smallholder cereal farmers in adopting climate resilience practices	Focus group discussion, In-depth interview, Key Informants interview	134 questionnaires administered, 2 FGD conducted at Mbeere south and North respectively. KII with an agro-dealer and ward crop officer
4	Evaluate the effect of climate resilience practices on cereal production	Sample survey (questionnaire), Key Informants interview (KII)	134 questionnaires administered, KII with one respondent from National Drought Management

2.4 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.

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 then presented in tables and levels of statistical significances.

CHAPTER THREE: RESULTS AND DISCUSSIONS

3.0 Data Presentation and Analysis

Introduction

The study was undertaken to examine the impact of climate resilient agricultural livelihood on smallholder cereal farmers in Embu County in order to understand their challenges, adoption level as well as resilience strategies adopted in cereal production. The purpose of this chapter is to present the general finding based on careful analysis of survey information and discuss the results.

Social Economics Attributes of Small Holder Farmers in Kenya (KCEP-CRAL)

3.1 Age of Respondents

A total of 118 questionnaires out of 134 were successfully retrieved. Analysis of age of respondents revealed that about 28% of the respondents are within the age bracket 41-50 and 51-60 respectively while those between 71-80 are 3.4%. The least age was 26 years while the highest was 75. It can be inferred that majority of the respondents in the study area are within the age bracket of 41-60 years as about 92.4% are between age 31-70. (See Table 3.0)

Table 3.0: Age of Respondents

Age of respondents	Frequency	Percentage
26-30	5	4.2
31-40	22	18.6
41-50	33	28.0
51-60	33	28.0
61-70	21	17.8
71-80	4	3.4
Total	118	100

Source: Field Work, Analysis, 2019

3.1.2 Other Social Economic Characteristics

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' household 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 and 72% of household spouse are also engage in cereal farming. Furthermore, 20.3% of the household head spouse had primary education and 15.3% had either a college or university degree. 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 3.1)

Table 3.1: 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**
District		
Mbeere South	75	63.6
Mbeere North	18	15.3
Not specified	25	21.2
Total	118	100`

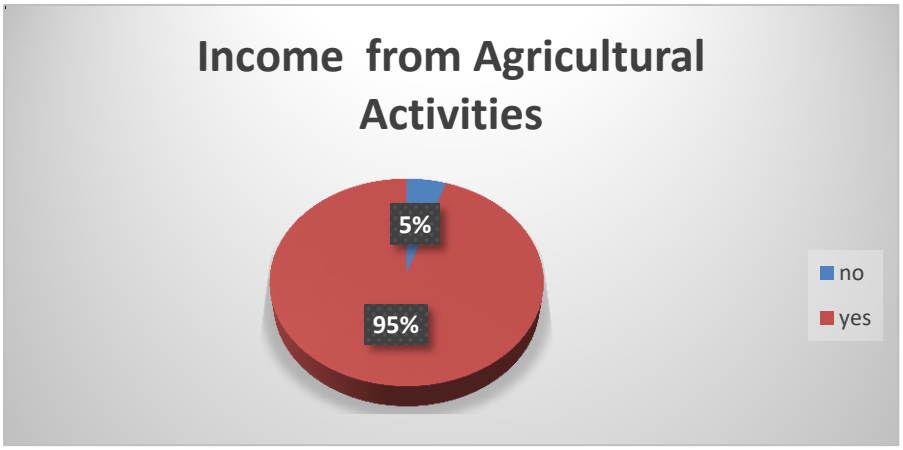
Household Size		
1-5	67	56.7
6-10	47	39.8
11-15	2	1.7
Above15	2	1.7
Total	118	100
Numbers of household working		
Not working	43	36.4
1-3	65	55.1
4-6	8	6.7
7-9	2	1.6
Total	118	100
Highest Education of Household Head		
No formal education	8	6.7
Primary	20	16.9
Secondary	41	34.7
Vocational Training	9	7.6
College/University	39	33.1
Total	118	100

Source: Field Work, Analysis, 2019

3.2 Household Income and Expenditure

From the survey, it was revealed that 95% of the sampled respondents engage and receive their income from agricultural activities (Figure 3.1). This implies that agriculture is the mainstay of the economy in this region. Through the in-depth interviews and focus group discussions (FGD) carried 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.

Figure 3.1: Income from Agricultural Activities

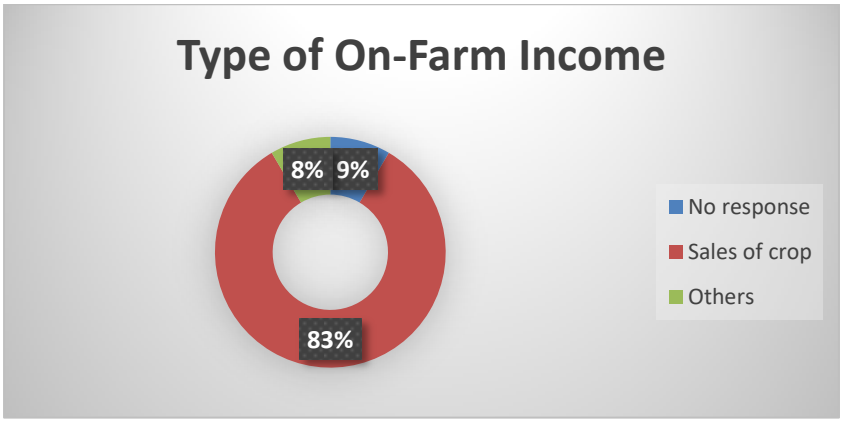


Source: Field Work, Analysis, 2019

3.2.1 Type of On-Farm Income

Furthermore, the study revealed that 83% of the sampled respondents engaged in sales of crops (Figure 3.2). 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.

Figure 3.2: Type of On-Farm Income

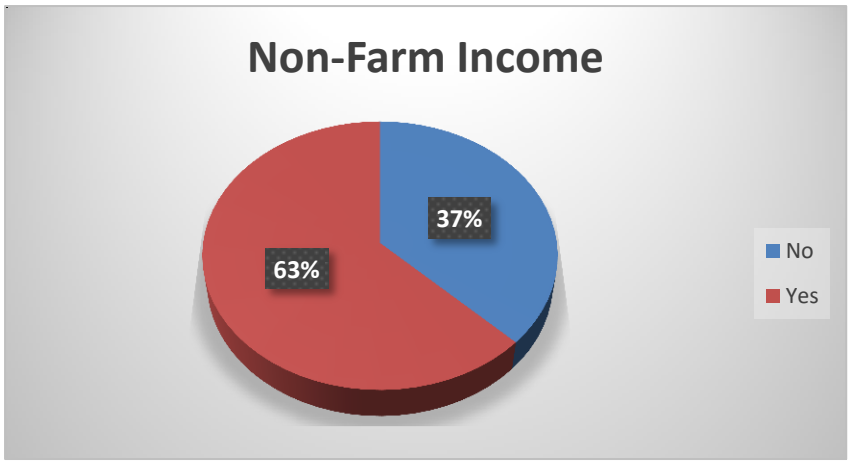


Source: Field Work, Analysis, 2019.

3.2.2 Income from Non-Farm Income

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.3.3). This further helped to understand how cereal farmers well-being and income as improved since involvement in KCEP-CRAL intervention in 2016. 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 farmers' families.

Figure 3.3: Income from Non-Farm Income

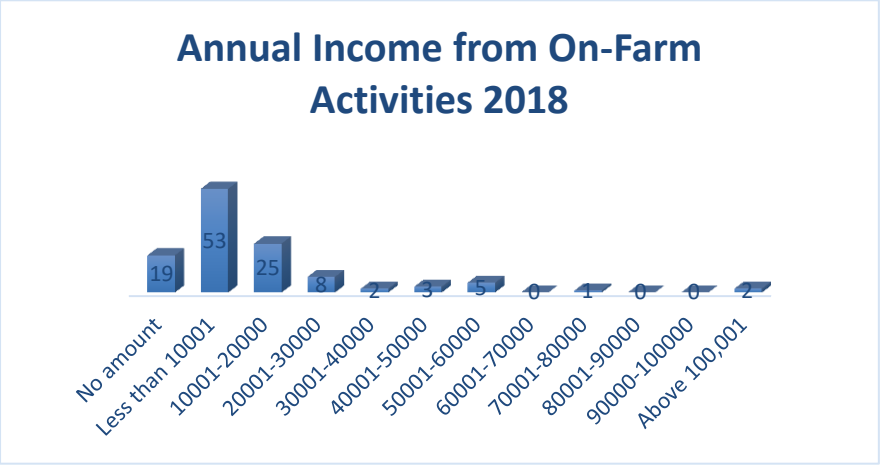


Source: Field Work, Analysis, 2019

3.3 Annual Income from On –Farm Activities in the previous year (2018)

The study carried out on the annual income the farmers received from on-farm activities in the previous year (2018) 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 3.4). This implies that the farmers' income from engaging in cereal farming is not significant though there have been increase in yield.

Figure 3.4: Annual Income from On-Farm Activities

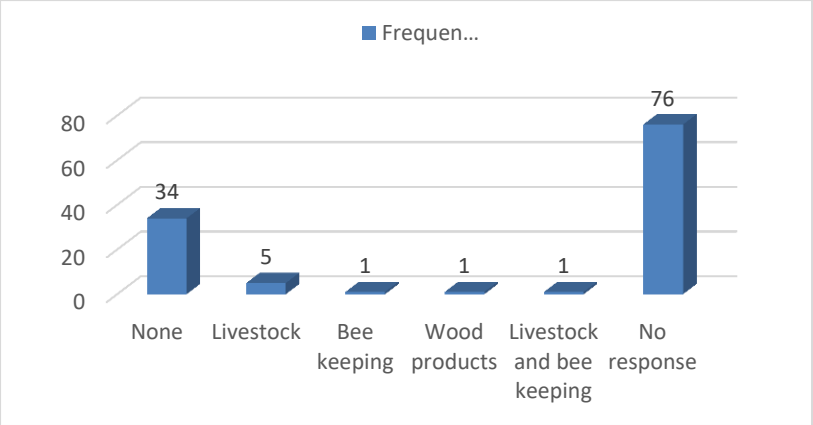


Source: Field Work, Analysis, 2019

3.4 Type of Non-Farm Activities

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. 3.5)

Figure 3.5: Type of Non-Farm Activities

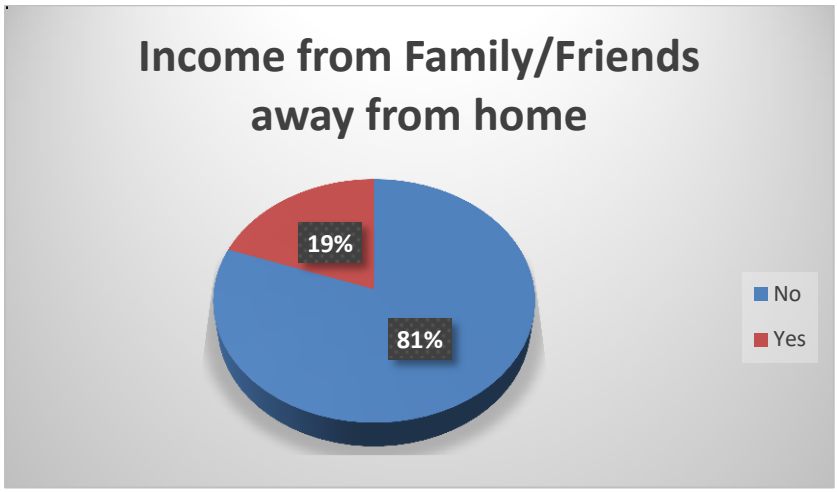


Source: Field Work, Analysis, 2019

3.5 Income Received from Family/ Friends away from home

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 3.6).

Figure 3.6: Income from Family/Friends away from home



Source: Field Work, Analysis, 2019

3.6 Appraisal of the Livelihood Resilient Strategies of smallholder cereal farmers

This section examined the analysis of livelihood resilient strategies of smallholder farmers in the study area. The variables considered includes the type of cereals grown, average crop yields, seed multiplication, crop production technologies and technologies trained for the crop production technologies.

3.6.1 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 3.2).

Table 3.2: Types of Cereals grown on land

Type of Cereals grown on land	Frequency	Percentage
No cultivation	5	4.2
Green Gram	47	39.8
Green Gram and Sorghum	32	27.1
Green Gram and other crops (maize, beans etc.)	1	0.8
Sorghum and other crops	1	
Green Gram, sorghum and Millet	4	3.4

Green Gram, Sorghum and other crops (maize, beans etc.)	23	19.5
Green Gram, Sorghum, Millet and other crops	5	4.2
Total	118	100

Source: Field Work, Analysis, 2019

3.6.2 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 3.3).

Table 3.3: Introduction to Bulking/ Seed Multiplication

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

Source: Field Work, Analysis, 2019.

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 partners. 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 3.4) It can be implied that the KCEP-CRAL cereal farmers prefer demonstration plots and farmers filed school methods to farm trials and study tours.

Table 3.4: Participation in Farming Methods

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
Study tours		
No	69	58.5
Yes	49	41.5
TOTAL	118	100.0
Demonstration Plots		
No	13	11.0
Yes	105	89.0
TOTAL	118	100.0
Others		
No		
Yes		
TOTAL	118	100.0

Source: Field Work, Analysis, 2019.

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 3.5). 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 3.5 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

Source: Field Work, Analysis, 2019

3.6.3 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 difficult 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 3.6). 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 3.6: 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

Source: Field Work, Analysis, 2019.

3.6.4 Test of Research Hypothesis

There is no significant association (influence) between Climate Resilience Agricultural practices on Cereal Production. The Table 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 in association with 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). Noted 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 practices. Hence, the not statistically significant influence of the measures.

Table.3:7 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

3.7 Impacts of crop technologies on household livelihood

Presented in Table is the summary of the impacts of crop technologies on household livelihood. Crop rotation has the greatest impact as 73.7% of the respondents agreed that crop rotation has the greatest yield while majority of respondents do not ascertain the impacts of crop technologies on their livelihood. This is plausible because majority of these cereal farmers operate in the informal sector where they do not calculate their profit margins nor document such over time.

3.7.1 Technologies Cereals Farmers are trained on and their level of Adoption

The study revealed that 58.5% of the respondents are trained on demonstration plots, 52.5% on FFS method, 48.3% on Farm trials and 45.8 were trained on other methods. However, considering level of adoption farm trials and demonstration have relatively a little above 30%

full adoption rate while about half of the respondents do not adopt the technologies trained on. (See Table 3.8) This might be the reason for the low level of yield observed despite the efforts put in place by KCEP or other agricultural projects. Hence, efforts should concentrate more on the implementation process for the purpose of optimal result.

Table 3.8: Technologies Trained and Level of Adoption

Technologies learnt	Frequency	Percentage
FFS		
Yes	62	52.5
No	44	37.2
No Response	12	10.2
On Farm Trials		
Yes	57	48.3
No	49	41.5
No Response	12	10.2
Study tours(learning points)		
Yes	19	16.1
No	87	73.7
No Response	12	10.2
Demonstration Plots		
Yes	69	58.5
No	42	35.6
No Response	7	5.9
Others		
Yes	54	45.8
No	31	26.3
No Response	33	28.0
Level of Adoption		
FFS		
Full adoption	8	6.8
Partial adoption	27	22.9
None	66	55.9
No Response	17	14.4

On Farm trials		
Full adoption	38	32.2
Partial adoption	30	25.4
None	35	29.7
Study Tours		
Full adoption	8	6.8
Partial adoption	10	8.5
None	85	72.0
No Response	15	12.7

Source: Field Work, Analysis, 2019.

3.7.2 Observed changes before introduction of KCEP-CRAL (2010-2016) and after its introduction (2016 till date)

It was gathered from the study that more than half of the respondents agreed that there were observed changes both before 2016 and after the introduction of KCEP project after 2016. For instance, 61.9% and 61% of the respondents both agreed that there was an increase in temperature before 2016 and after 2016 respectively, 56.7% experienced scorching sun in 2016 as against 44.1% after 2016. (See Table 3.9).

Table 3.9: Observed Changes before 2016 and after 2016 when KCEP project was introduced

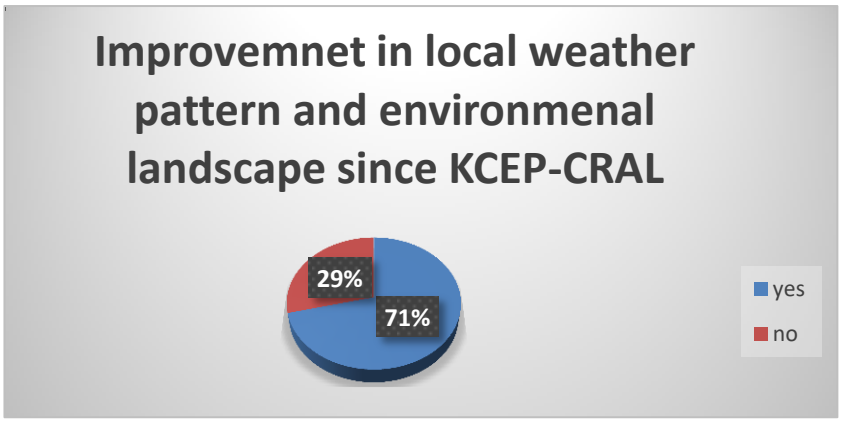
Observed changes	Before 2016			After 2016		
	Agreed	Disagreed	No changes	Agreed	Disagreed	No changes
There was an increase in temperature	73(61.9%)	27(22.9%)	18(15.3%)	72(61.%)	5(4.2%)	41(34.7%)
Experienced more extreme temperature	70(59.3%)	35(29.7%)	13(11%)	26(22.0%)	39(33.1%)	53(44.9%)
Experienced less extreme temperature	79(66.9%)	34(28.8%)	5 (4.2%)	39(33.1%)	14(11.9%)	65(55.1%)
Winter was getting warmer	103(87.3%)	13(11%)	2 (1.7%)	65(55.1%)	13(11%)	40(33.9%)

Source: Field Work, Analysis, 2019

3.7.3 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 2016 (See Fig 3.7).

Fig 3.7: Level of Improvement in Local weather pattern and environmental landscape since KCEP



Source: Field Work, Analysis, 2019

3.7.4 Reasons for Change in Local Weather pattern since the introduction of KCEP-CRAL in 2016

Furthermore, the reason for the observed change in local weather pattern and environmental landscape was presented in Table 3.8. 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 (See Table 3.10).

Table 3.10: 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.

Source: Field Work, Analysis, 2019

3.7.5 Average Crop yields per unit area of land

The study revealed that the numbers of crop yield for Sorghum before KCEP-CRAL is highly insignificant as 68.7% do not reflect any yield in crops before KCEP-CRAL. For green gram also, there was little significant increase as 87.4% of the respondents only observed yield between 1-3 bags.

3.8 Farmers understanding on Effects of Climate Resilience Practices on Production and Livelihood.

The study revealed about two-thirds of the respondents (66.9%) agreed that January to March as the time for land preparation for the planting of cereals while about 22.0% gave no response in the two periods under review. This infers that the land preparation period falls within the first quarter of the year which is often marks the end of the dry season. Before 2016, about half of the respondents (53.4%) do not indicate when they sow their seed, however, after 2016, majority (72.0%) claimed to sow their seed between January to March.

On distribution of rainfall before 2016, about 73.7% do not give response, this might be because they could not remember vividly while at present a little above average (55.9%) claimed the rain is highly intensive while 33.9% claimed the rain to be highly scattered. Considering germination of seeds before 2016, 47.5% assumed that it was poor while in post -2016, about two-thirds (66.9%) agreed that seed germination was average. There could be many reasons for these perceived changes in seed growth, especially considering the efforts of KCEP since 2016 in providing new crop varieties for farmers.

Further investigation carried out on the study revealed that 44.1% sees disease incidence as normal in 2016 and 64.4% in post 2016. The reduction in disease incidence might be due to collective actions by all stakeholders ranging from the farmers to even international organizations such as KCEP-CRAL. The study showed that 27.9% of the respondents affirmed that types and numbers of diseases are less in 2016 compared to 52.5% in post 2016. This implies that there has been a great reduction in the types and numbers of diseases within

the relatively short term period. This might be connected to measures adopted either by the locales or initiated by other organizations. However, considering the level of yield between the time period, it was revealed that there has been persistent low level of yield (38.1% in pre 2016 and 53.4% in post 2016. This implies that the measures taken so far have not translated into better productivity for the farmer (See Table 3.11).

Table 3.11: Impacts of Climate change on production aspects of Cereals

	Statement	Before 2016	After 2016
	Month of Land of preparation		
	No response	26(22.0%)	27(22.8%)
	January-March	79(66.9%)	79(66.9%)
	April – June	0	0
	July-September	13(11.0%)	12(10.2%)
	October-December	0	0
	Total	118	118
	Date of Sowing		
	No Response	63(53.4%)	27(22.9%)
	January –March	5(4.2%)	85(72.0%)
	April- June	4(3.4%)	0
	July- September	31(26.2%)	6(5.1%)
	October-December	15(12.7%)	0
	Total	118	118
	Distribution of Rainfall		
	No Response	87(73.7%)	11(9.3%)
	HS	23(19.5%)	40(33.9%)
	HI	4(3.4%)	66(55.9%)

	NC	4(3.4%)	1(0.8%)
	Total	118	118
	Germination of seeds		
	No Response	6(5.1%)	0
	Poor	56(47.5%)	29(24.6%)
	Average	38(32.2%)	79(66.9%)
	Good	18(15.3%)	7(5.9%)
	Total	118	118
	Growth of crops		
	No Response	1(0.8%)	3(2.5%)
	Poor	48(40.7%)	32(27.1%)
	Average	40(33.9%)	76(64.4%)
	Good	29(24.6%)	7(5.9%)
	Total	118	118

Source: Field Work, Analysis, 2019.

3.9 Resilient measures taken in Response to Climate Change

To determine cereal farmers' resilient measures to climate change before 2016 and after 2016 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 2016 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 2016 and after 2016 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 2016 and after 2016; 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.

CHAPTER FOUR: CONCLUSIONS AND RECOMMENDATIONS

4.1 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.

All the respondents are implementing at least two (crop rotation and new crop varieties) climate resilient agricultural practices introduced/given to them. Crop rotation and new crop varieties usage of Sorghum and Green Gram are the two most widely adopted practices (crop rotation, new crop varieties, integrated pest technology, conservation agriculture and other resilience practices) because of their believe that crop rotation is easy, cost effective and can double yields and income and improved crop varieties are generally in use as part of inputs received from KCEP-CRAL to beneficiaries.

Adoption of climate resilience agricultural practices on beneficiaries' household livelihood was observed to be of great impact with the use of crop rotation among other practices. The adoption of new crop varieties came close to crop rotation in terms of its impact level as most agreed that there is incremental rise in annual yield with the use of the improved varieties (Sorghum and Green Gram). Interestingly, this improved varieties are not just drought resistance but also have higher tolerance to diseases, insect pests and other stress factors with great improvement also in nutritional thus increasing the yield of benefiting smallholder cereal farmers to generate more income and further improve their standard of living.

In terms of challenges and barriers in adopting climate resilience agricultural practices, more respondents agree that there are militating challenges being faced across the value chain in cereal production which are associated to climate change. Constraints such as changes in timing of precipitation, changes in environmental temperature, Increase in drought as well as variation in planting season. Part of the reasons responsible can be attributed to changes in local weather pattern and environmental landscape and geographical positioning of communities involved.

4.2 Recommendation

As a way to upscaling climate resilience agricultural practices among smallholder cereal farmers in Embu county, there is need to critically analyse the challenges farmers face as documented here to have better understanding of necessary steps to take that will benefit farmers and facilitate more adoption. These include developing appropriate and feasible Climate resilience agricultural practices that will lead to increase in productivity, yield, income generation as well as food and nutrition security.

Farmers' awareness of the benefits of climate resilient agricultural practices as well as trainings on land management, soil and water conservation/harvesting and growing resistant cereal seedlings, as well as appropriate climate resilient agricultural practice implementation should be a top priority of development partners. Practices that encourage sustainable land and drought management which includes soil, nutrient and water management as well as rehabilitation of agricultural land should be part of the training modules for farmers.

The perception of farmers on climate change and resilience practices together with socio-economic factors is important in developing a feasible and appropriate practice. Availability of new technologies alone is not a sufficient condition to bring about the change. Equally important is the need to periodically appraise climate resilience technologies and practices with a view to understanding which practices or technologies are working as expected and which one are not. This should include action steps to correct or bridge identified gaps that will further increase the success and adoption of good practices and technologies.

In view of the aforementioned, there is need to consider capacity building and ensure that farmers fully understand the climate change problems and can apply climate information effectively through education, trainings and strong monitoring to identify success and failures.

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APPENDIX

APPENDIX A: QUESTIONNAIRE

ASSESSMENT OF THE IMPACT OF CLIMATE RESILIENT AGRICULTURAL PRACTICES ON LIVELIHOOD OF SMALLHOLDER CEREAL FARMERS IN KENYA (KCEP-CRAL)

My name is Abiola Mohammed. We are conducting research in Kenya in collaboration with the Center for Sustainable Development, University of Ibadan in Nigeria and International Fund for Agricultural. I do not represent the government or any political party. The purpose of this research is to learn about Climate Resilient Agricultural Practices and how this practices as impacted the livelihood of cereal farmers. All information you may provide will be confidential and will be used solely for this study. Your participation is voluntary and you can choose to not participate. With your permission, I will ask you a set of questions related to this research, and this should take about 20 minutes. I will be taking some brief notes as you answer the questions.

Please tick (√) where necessary and provide suggestions where required. Thank you.

Section A: Socio Economic Information

1. Gender of Respondent [ ] Male [ ] Female 2. Age _____ (Years)

3. Who is the head of your household? Man [ ] Woman [ ] Male Youth [ ] Female Youth [ ]

4. Location: _____ 5. County: _____ 6. District: _____

7. Household Size_____? 8. Number of household members working ___?

9. What is the highest level of education?

Highest Education Level	None	Primary	Secondary	College/University	Vocational Training
Household Head					
Household Spouse					
Oldest child					

10. Main occupation of household head? Cereal Farming [ ] Off-Farm [ ] Others Please specify_____
11. Main occupation of household head spouse Cereal Farming [ ] Off-Farm [ ] Others Please specify_____
12. What is the total land area owned by household_____(ha)

13. What is the total area of land allocated to cereal farming_____(ha)
14. What is the land ownership status? Private with titles [ ] Private with no titles [ ] Communal land others (please specify): ……

Section B: Cereal Farmers Perception on Climate Change

S/N	Statement	SA	A	DA	SDA
1.	There is change in timing of precipitation				
2.	There are changes in environmental temperature				
3	There is no variation in rainfall pattern due to climate change adaptation				
4	Climate change resilience affects the cereal yield				
5	There is increase in disease/ pest infestation				
6	Climate change resilience will increase agricultural Production				
7	There is no effect on sorghum-green gram farming due to climate change resilience				
8	There is increase in number of droughts				
9	It is hard to predict weather/ forecast weather through meteorologists				
10	There is change in current farm management Practices				
11	Climate change resilience improves the standard of living of cereal farmers				
12	Climate change resilience is beneficial for cereal Farming				
13	Climate change resilience need urgent preparedness				
14	Climate change resilience is not a problem				
15	Climate change resilience is an important environmental issue				
16	There is change in the pattern of cold winds and heat winds				
17	Uncertainties due to climate change seriously affects the ability to invest in cereal business				
18	There is change in growth (germination) behaviour of cereal crops				
19	Climate change affects the productivity of cereal crops				

Note: SA = strongly agree A = Agree DA = Disagree SDA = strongly disagree

Section C: Household income and expenditure

A. Do you receive income from agricultural activities that you are engaged in?

1. No.....2. Yes.....

If yes, which kind(s) of on-farm income? .....

and how much per year in Kshs? ..... (Last year)

B. Do you receive any off-farm income?

1. No.....2. Yes.....

If yes, which kind(s) of off-farm income? .....

and how much per year in Kshs? ..... (Last year)

C. Do you receive any non-farm income?

1. No.....2. Yes.....

If yes, which kind(s) of non-farm income? .....

and how much per year in Kshs? ..... (Last year)

D. Do you receive any money from family members/ friends away from home?

1. No ..... 2. Yes.....

If yes, how much per year in Kshs? ……. (Last year)

F. Do you have any existing loans? 1. No .....2. Yes.....

If yes, how much interests do you pay in Kshs? ……..... (Last year)

G. Did you hire any labor last year? 1. No .....2. Yes.....

If yes, what was the approximate total cost of the labour in Kshs? ..... (Last year)

Section E. Impacts of CRAL on Cereal Farmers

Part One: *Livelihood Resilient Levels of Cereal Farmers*

What constitutes past and present resilient pillars among different groups of farmers in the KCEP-CRAL area? What is the difference between past and present resilient pillars among the different groups of farmers in the KCEP-CRAL area?

A. What type of cereals do you grow on your land?

1. Green Gram ....., 2. Sorghum....., 3, Millet…… 4. Others…….

B**.** What are the average crop yields per unit area for each of the crop?

Cereals	**Area covered (acres)**	**Crop yields (Last year)(kg)**
Sorghum		
Green Gram		

C. Is your group involved in KCEP-CRAL? 1. No..... 2. Yes.....

D. How can you describe your current agricultural practice compared to three years ago? .....

E**.** Have you been introduced to seed multiplication/bulking? Yes ..... No .....

F**.** What has been the impact of seed multiplication/bulking?

1. Better access to certified seeds .....; 2. More affordable certified seeds .....

3. Improved income ..... , 4. New house owned ..... 5. New assets owned .....

6. Others (**please specify):.....**

G**.** Did you participate in any of the following activities? You can tick more than one

1. Farmer Field School (FFS) 2. Farm Trials 3. Study tours 4. Demonstration plots 5. other Trials _____

H**.** What technology were you trained on using the above methods and level of adoption (level of adoption =LOA)

Methods	**Technologies learnt**	**LOA, fully Partially Not adopted**	**Rate the performance of the training. Very helpful, Helpful , Not Helpful**
FFS			
On farm trials			
Study tours (learning point)			
Demonstration Plots			
Others (please specify)			

Part Two*: Perception of Cereal Farmers*

A. Perception of cereal farmers on climate change.

S/N	Observed Changes	Response					
		Before 2016			After 2016		
		Agree	Disagree	No Changes	Agree	Disagree	No Changes
1	There was increase in the temperature						
2a	Experienced More extreme temperature						
b	Experienced Less extreme temperature						
3a	Experienced Scorching Sunshine						
B	Summer was getting warmer						
4a	Winter was Getting warmer						

Part Three: *Challenges Faced in Adopting Climate Resilient Practices*

What are the economic challenges on farmers' livelihoods (i.e. share of income from adoption of CRALs or other sustainable agricultural practices)?

What are the agronomic and environmental challenges on farmers' livelihoods (i.e. impacts on food security, local climate and the environment)?

A. Has your agricultural yield increased since KCEP-CRAL /any other agricultural project inception? 1. No..... 2 Yes .....

i) If yes, how many bags of green gram and sorghum per acre did you harvest before and after KCEP /any other agricultural project inception? 1. Before: Green Gram..... sorghum..... 2. After: Green Gram..... sorghum.....

ii) If no, why do you think so?.....

iii) How many months in a year were/are you able to feed your family before and after KCEP-CRAL /any other agricultural project inception? 1. Before..... 2 After.....

iv) In terms of nutrition, which other types of crop do you cultivate in order to supplement the staples (Sorghum and Green Gram)?.....

C. Has the local weather pattern and environmental landscape improved since KCEP-CRAL /any other agricultural project inception? 1. No..... 2. Yes .....

i.) If yes or no, how? Please explain

D. Which of these types of challenges are you facing .

Type of challenges	**2010 – 2016** (Strongly Agree =1, Agree = 2, Indifferent = 3, Disagree = 4, Strongly disagree = 5)	**2016 - Present** (Strongly Agree =1, Agree = 2, Indifferent = 3, Disagree = 4, Strongly disagree = 5**)**
Non availability of timely inputs(seeds, pp chemicals, fertilizers etc)		
Market (price, access, processing)		
Non availability of labour		
Crop problems (Low yields, health, grain size or variety),		
Farm management (machinery, technology, skills)		
Household decisions (farm succession, health/death, etc)		
Regulation changes (subsidies, taxes, restrictions)		
Higher cost for land		
Climate change (scarcity of water, increase in temperature, lack of information about long term climate change)		
Non availability of irrigation facility		
Lack of storage facility in the village		
Poor transport facility and high cost		
Lack of knowledge about post harvest technology		
Lack of knowledge regarding appropriate adaptations		
(scarcity of water, increase in temperature) Other (Specify)		

Part Four: Farmers Understanding on Effects of Climate Resilience Practices on Production and Livelihood

A. Impact of climate change on production aspects of cereals

S/no	Statement	Response	
		Before 2016	**After 2016**
1	Month of Land preparation		
2	Date of sowing		
3	Distribution of rainfall during crop growth period	HS/HI/NC	HS/HI/NC
4	Germination of Seeds	Good/Average/Poor	Good/Average/Poor
5	Growth of crop	Very good/Average/Poor	Very good/Average/Poor
6	Incidence of disease	Severe/Normal/Not severe	Severe/Normal/Not Severe
7	Type and number of disease	More/Average/Less	More/Average/Less
8	Yield(Acre)`	High/Normal/Low	High/Normal/Low

(HS-Highly scattered, HI-Highly intensive, NC-No change)

APPENDIX B: INTERVIEW GUIDE FOR FOCUS GROUP DISCUSSION

1: Resilient Strategies of Cereal Producers

To what extent do you think farmers have been able to adapt to climate change owing to KCEP-CRAL intervention?

To what extent do you think farmers have been able to adopt KCEP-CRAL practices?

2 Challenges of cereal farmers in adopting resilience practices

What are your comments on; - KCEP-CRAL and poverty alleviation

- KCEP-CRAL and food security

- KCEP-CRAL and livelihoods diversification

3: Perception of small holder cereal farmers

What are your comments on; - KCEP and Climate resilient agricultural practices