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Original Article

Adaptation Strategies and Interventions to Increase Yield in Green Gram Production Under a Changing Climate in Eastern Kenya

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ABSTRACT

Climate change has increased the magnitude, intensity and frequency of extreme climate events. Farmers are employing different strategies to adapt. Green gram (Vigna radiata L. Wilczek) is one of the crops grown in the Arid and Semi-Arid areas of Kenya because of its adaptability to drought conditions. Despite its adaptability farmers are facing challenges during its production. This study carried out in Kibwezi East Sub-County, Makueni County, Kenya identified interventions and coping strategies employed by farmers towards safeguarding and increasing yields. It also identified the gaps to be bridged to increase yields, create resilience and enhance climate change adaptation. A household survey involving a sample of 395 respondents was carried out. The most cited challenges were prolonged droughts by 91% and increased incidences of crop pest attacks by 9%. Some adaptation strategies employed were, changing the green gram variety (53.2%,) early planting (35.7%) and use of integrated pest management practices (31.1%). There was a significant correlation (P< 0.05) between adaptation measures and green gram production. Among the respondents, 37% indicated that they had received assistance from the county government and other stakeholders. Over 32.9% had benefited from subsidized farm inputs and the agricultural extension services were at 28.4%. Provision of market linkage services was acknowledged by 46% of the respondents whereas 38% indicated that there was no adequate infrastructure. There was a significant correlation (P< 0.05) between interventions and green gram production. These results indicated the need for more strategies and interventions to increase yields. Climate change adaptation levels were low therefore more adaptability options are needed to strengthen the capacity of farmers for increased production.

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INTRODUCTION

The climate in Kibwezi East sub-county (Latitude = -2.41^0 and Longitude = 37.97^0) is hot and dry (Nyandiko *et al.*, 2015). The study location has two rainfall seasons from October to December (OND) the short rains while the long rains are from March to May (MAM). The mean annual rainfall ranges between 200mm-350mm while temperatures range from 18 ºC to 25 ºC (Muia *et al.*, 2024). October and February are the hottest months of the year with an average temperature of 30.2^{0}C while July is regarded as the coolest month with average temperatures of up to 15.7^{0}C (MCIDP, 2013). The world's diverse climate is changing thus, severe and location-specific impacts on agricultural production are anticipated (Altieri *et al.*, 2015). Similarly, for the last few years, the effects of climate change have become more severe in Kibwezi East sub-county affecting a large population of farmers in this region who mostly practice rain-fed agriculture (GoK, 2013; Wambua *et al.*, 2017).

Green gram farming has significantly contributed towards food security, economic growth and provision of employment to rural households (World Bank, & CIAT, 2015). This is attributed to its resilience to low rainfall amounts, high temperature and prolonged drought conditions (Jincy *et al.*, 2021). Studies on climate change in Eastern Kenya show no trend and lack of correlation in rainfall amounts and year-to-year variation in annual minimum and maximum temperatures (Gichangi *et al.*, 2015). A study by Kangai *et al.*, 2021 showed that the annual temperatures had increased by 0.02 ºC to 0.03 ºC in Eastern Kenya in the last 40 years. Recent climate change projections by Demissie *et al.* (2019) under the *Stichting Nederlandse Vrijwilligers (*SNV) climate resilient agribusiness for tomorrow (CRAFT) project reported that during the MAM and OND rainy seasons, temperatures in the green gram growing areas of Western and South Eastern Kenya are expected to rise. Temperature increases with the associated spatial-temporal changes in rainfall will affect green gram production negatively (Muchomba *et al*., 2023, SNV, 2018). Rising temperatures and changing precipitation patterns are increasingly threatening not only crop yields but also food security and food systems stability (Palombi, & Sessa, 2013; Man, &Thiede, 2021). Warm temperatures during the day are critical for crop growth. However, there are temperature thresholds beyond which crop productivity is affected. These thresholds are different from one crop to another (Hatfield, & Pruege, 2015; World Bank, 2021).

Rainfed agriculture is the dominant source of stable food production in Kenya. Moderate drought events are experienced every 3-4 years and major drought events every 10 years since the year 2000 (World Bank, 2001). The average green gram yield in Kenya is 0.5 tonnes ha^{-1} against the global average

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of 0.73 tonnes ha^{-1} (MoALF, 2016). In some parts of Kenya such as Makueni County, the yields are below 0.5 tonnes ha^{-1}. Reports by the Ministry of Agriculture indicated a decline in yields from 0.460 tonnes ha^{-1} in 2010 to 0.380 tonnes ha^{-1} in 2013 (MoALF, 2015). The decline of green gram yield can greately be attributed to the effects of climate change in the study area. Therefore, this study will help to determine the climate change-induced challenges that farmers are facing and interventions employed to address these challenges. The objectives of this study were to determine (*i*) climate change-induced challenges in green gram production and (*ii*) the interventions implemented in safeguarding green gram production in Eastern Kenya. Results from this research will contribute to the formulation of policies, sustainable strategies and climate risk management in green gram production in Kibwezi East and other areas with similar agro-climatic conditions.

MATERIAL AND METHODS

Study Location and Data Collection

This study was carried out in Kibwezi Sub-County, Makueni County, Kenya. Kibwezi East Sub-County has four wards (Table 1). The four wards lie at an altitude of 731 to 1075 m above sea level and experience annual mean rainfall ranging from 113.02 to 118.62 mm (Table 1).

Table 1: Description of the Study Area

Loc.	Administration	Geographic Location			Ppt. (mm)	Temp.(^{0}C)	
	Wards	Lon.	Lat.	Alt.	Mean	Min.	Max.
Kibwezi East	Thange	37.96^{0}E	2.49^{0}S	918m	113.02	17.04	28.18
	Ivingoni	38.06^{0}E	2.64^{0}S	1075m	NA	10.81	23.8
	M.Andei	38.17^{0}E	2.69^{0}S	731m	118.62	17.88	29.58
	Masongaleni	38.05^{0}E	2.48^{0}S	844m	118.18	17.19	28.44

Loc.= Location, Lon. =Longitude, Lat.=Latitude, Alt.= Altitude, Ppt. = Precipitation, Temp. = Temperature, Max. =Maximum, Min.=Minimum, M. Andei = Mtito Andei

Qualitative data was collected using Household Surveys, Focus Group Discussions (FDGs) and Key Informant Interviews (KII). Secondary data was collected by reviewing literature from scientific articles and journals on green gram production and climate change to complement primary data sources. The sub-county agricultural extension officers, the area chief, farmers and farmer group leaders in the green gram value chain assisted in data collection. A mixed methods research design that was composed of quantitative and qualitative research was employed in this study.

Target Population and Sample Size Determination

The target population consisted of 29,909 small-scale farmers growing green gram in the four wards of Kibwezi East Sub County. This data was obtained from the sub-county agriculture office. Purposeful sampling was used for the identification and selection of information sources (Patton, 2002). The determination of sample size for the household survey was guided by the following equation (Krejcie, & Morgan, 1970).

$$n = \frac{X^2NP(1-P)}{d^2(N-1)+X^2P(1-P)} \quad \text{...Equation 1}$$

Where:

n = Optimal sample size

N = Target population (29,909)

P = Population proportion (0.5)

d = Degree of accuracy (0.05)

X^2 = *Chi*-square critical value at 1 degree of freedom and the desired confidence level, 95% (3.841)

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From the above computation, the sample size of 395 farmers was obtained at 95% confidence level.

Household Survey

The household survey was carried out using structured questionnaires administered in 395 households (farmers). Enumerators were identified and trained on how to effectively administer the questionnaires. Despite 395 being determined as the study sample, 400 questionnaires were distributed to minimize the risk of non- response. A response rate of 98.75% was attained. Mugenda, & Mugenda (2003) suggest that a response rate of 50% is adequate, 60% is a good response rate while 70% and higher is excellent for data analysis.

Focus Group Discussions

Focus group discussions incorporated green gram farmers, agriculture extension officers and other stakeholders in the green gram value chain from the four wards of the Sub County. The area chief and sub-county agriculture officers assisted the researcher in mobilizing the participants to attend the FDGs. Each focus group discussion had a membership of (8-12) respondents. A total of eight (8) focus groups were held, two in each ward. A focus group discussion guide was prepared based on; past and present climatic conditions, indicators of climate change, traditional weather forecasting methods, extreme weather events that have happened in the past, Climate change adaptation strategies undertaken during production and effects of government and other agencies interventions in green gram production.

Data Processing and Analysis

The data obtained were verified and validated before analysis. The *ltm* package in R statistical software (R) was used to test the reliability of the questionnaire using the Cronbach *Alpha* coefficient (Sekaran, & Bougie, 2016). To establish the data characteristics, descriptive statistics such as frequencies, percentages, means, modes and standard deviations were computed in R using *psych* package. All variables were analyzed at a *P*-value of 0.05 (5% significance level).

Chi Square Test for Independence

Chi-Square test (X^2) was used to test the independence of various attributes. *Chi*-square test for independence is a non-parametric test that assesses the association between 2 attributes of a population. The *chi*- square computation based on the observed and expected frequencies was done using the following formula

$$X^2 = \sum \frac{(\theta - \epsilon)^2}{\epsilon}$$

Where;

θ: Observed frequency

ϵ: Expected frequency

The null hypothesis was rejected whenever the computed test statistics were greater than or equal to the critical statistic obtained from the Chi-Square distribution table or whenever the *P*-value was less than the test significance level, 5%.

RESULTS

Demographic Profile of the Target Population

Examined information included gender, age distribution, education levels, household sizes, marital status and number of dependents. The sample consisted of 55.4% female and 44.6% male respondents (Table 2). On age distribution, 36.2% of the respondents were aged between 40-49 years old, 25.1% were aged between 50-59 years and 23% were between 30-39 years old. The lowest proportion of respondents were those aged below 30 years and those above 70 years. The majority of the respondents (52.4%) attained primary school education as their highest level of education. The proportion of respondents that had achieved secondary school education level was 40.3% while

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4.3% had attained university or tertiary education. Results showed that 3.0 % of the respondents did not have formal education.

Results on dependency levels indicated that 47.6% of the families had 4-6 dependents, 32.6% had 1-3 dependents, and 15.2% had 7 and above dependents. Among the sampled households 70.1% lived in semi-permanent houses with iron sheets while 3% were living in mud-walled and grass-thatched houses. A great number of the respondents (44.8%) were using firewood, 21.5% used charcoal, 20.0% used kerosene, 10.4% used gas while 3.3% used electricity as a source of fuel for domestic use. It was established that 37% of the respondents got their water from rivers, 33.9% from wells and boreholes, 14.9% had piped water while 14.2% practiced water harvesting during the rain season. The major challenges associated with water access were long distances to water sources which was indicated by 45.6%, water scarcity indicated by 32.7% of respondents and water unsuitable for consumption at 21.8% of the respondents. The main income-generating activity was farming as identified by 44.8%, followed by 38% who run businesses whereas 17.2% had formal employment.

Table 2: Socio-demographic Characteristics of the Respondents

Variable	Categories	Responses	Percentage (%)
Gender	Female	219	55.4
	Male	176	44.6
Age of the respondent in years	70 and above	10	2.5
	60-69	33	8.4
	50-59	99	25.1
	40-49	143	36.2
	30-39	91	23.0
	Less than 30	19	4.8
Level of education	Primary	207	52.4
	Secondary	159	40.3
	University	17	4.3
	No formal education	12	3.0
Marital status	Married	198	50.1
	Single	76	19.2
	Windowed	70	17.7
	Separated	35	8.9
	Divorced	16	4.1
Number of dependents	None	18	4.6
	1-3	129	32.6
	4-6	188	47.6
	7 and above	60	15.2
Housing type	Semi-permanent	277	70.1
	Permanent	60	15.2
	Grass thatched and mud walled	46	11.6
	Mud walled and grass thatched	12	3.0
Source of fuel	Firewood	177	44.8
	Charcoal	85	21.5
	Kerosene	79	20.0
	Gas	41	10.4
	Electricity	13	3.3
Water sources	River	146	37.0
	Well, /borehole	134	33.9
	Tap/Piped	59	14.9
	Rain	56	14.2

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Variable	Categories	Responses	Percentage (%)
Challenges of accessing water	Long distance	180	45.6
	Scarcity	129	32.7
	Dirty water	86	21.8
Source of household income	Farming	177	44.8
	Business	150	38.0
	Employment	68	17.2

Summary of the descriptive statistics is presented in Table 3. Results showed that the respondents attributes were well spread, a characteristic that signified the reliability of the results. The respondents' characteristics showed skewness and kurtosis that was both positive and negative with a standard error ranging from 0.03 to 0.06.

Table 3: Descriptive Statistics of the Social-demographic Characteristics

	N	SD	Median	Skew	Kurtosis	SE
Gender	394	0.55	2.00	-0.52	-0.78	0.03
Age	394	1.12	3.00	0.14	0.13	0.06
Education level	394	0.78	1.00	1.85	5.11	0.04
Marital status	394	0.60	2.00	0.62	3.05	0.03
Dependents	394	0.76	3.00	-0.47	1.37	0.04
House-type	394	0.57	3.00	-0.91	0.86	0.03
Use firewood	394	0.16	1.00	3.52	35.52	0.01
Use of piped water	394	0.50	2.00	-0.37	-1.71	0.03
Challenge Accessing Water	394	0.50	2.00	-0.23	-1.80	0.03
Income source	394	0.55	1.00	3.77	14.87	0.03

Household Food Security Status

Sixty-six percent of the respondents were consuming a mixture of maize and beans *(Githeri)* (Figure 1) as their main meal. Those who consumed rice constituted 21% of the respondents while 10% prioritized *ugali* (cooked maize flour dough).

Figure 1: Type of Food Consumed

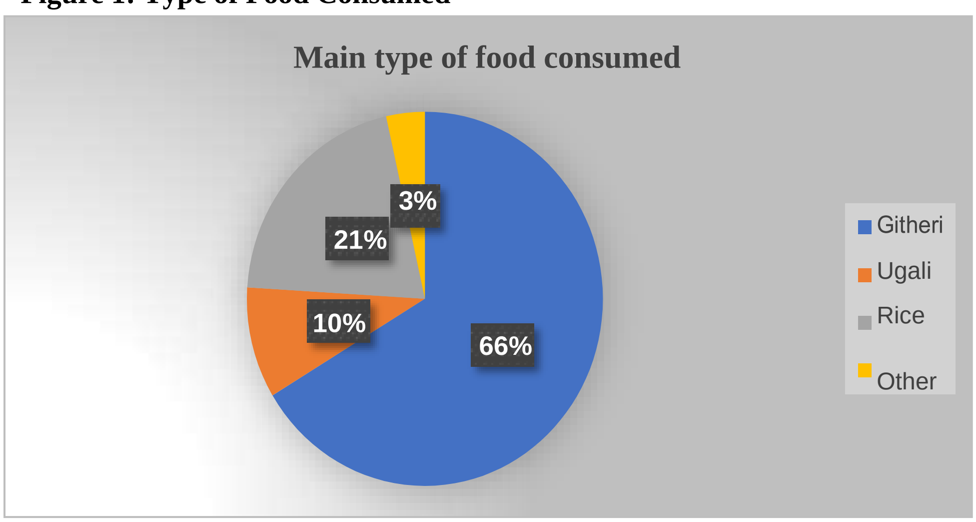

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Figure 2: Frequency of Green Gram Consumption

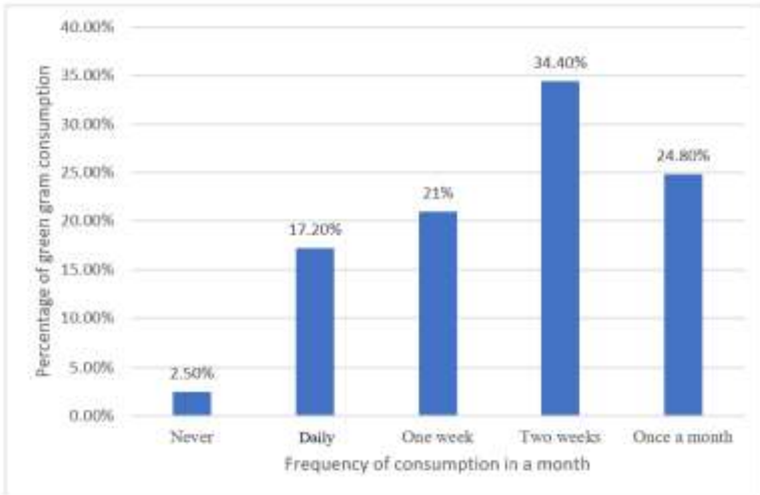

Figure 2, shows that 34.4% of the respondents consumed green grams at intervals greater than two months while, 34.4% consumed it after every two weeks, Of the respondents, 21% consumed green grams every week, 17.2% every other day and 2.5% of the respondents had never consumed it at all. Results revealed that 55.7% of the respondents lacked major staple foods like Maize (Table 4). Lack of major staple foods was attributed to lack of money by 44.6%, erratic and low rainfall amounts by 36.20% and poor yields by 14.90% of the respondents. The major crops grown in the location by the respondents were maize (45.1%) followed by green grams at 27.6%, beans at 22.0% and millet at 5.8% (Table 4).

Table 4: Household Food (In) Security Status

Variable	Categories	Responses	Percent (%)
Lack of major stable food	Yes	220	55.7
	No	175	44.3
Reasons for lack of food	Lack of money	176	44.6
	Rain Failure	143	36.2
	Poor yield	59	14.9
	Inadequate land	17	4.3
Food produced	Maize	178	45.1
	Green grams	109	27.6
	Beans	87	22.0
	Millet	23	5.8

Social Safety Nets

Results showed that 57.7% of the respondents belonged to a social group. Among the respondents, 31.1% belonged to women groups while 25.3% belonged to farmers associations (Figure 3).

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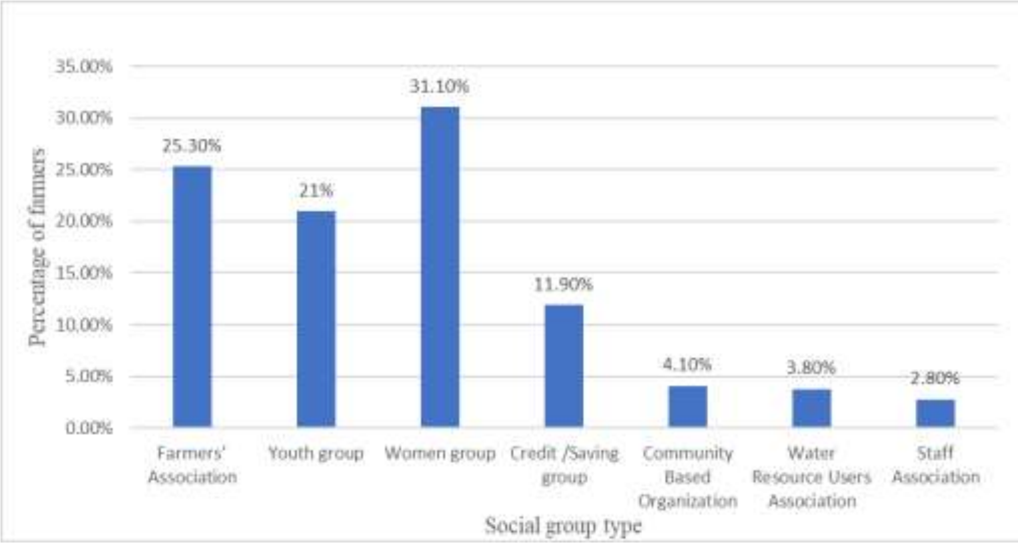
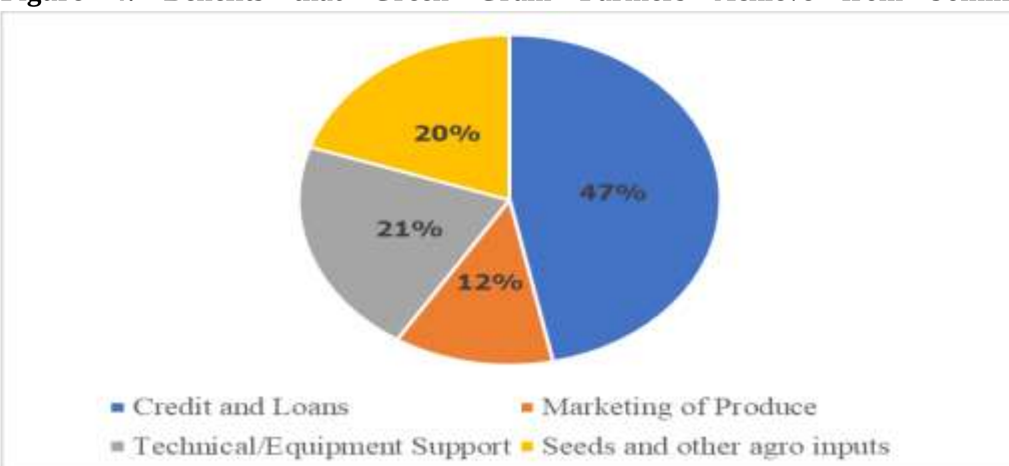
Figure 3: Group Type Engaged by Green Gram Farmers



The respondents cited some advantages of joining social groups whereby 47% had received loans and credit facilities, 12 % had received agricultural technical support, 20 % had received seeds and other agro inputs while 12 % benefited through market linkages (Figure 4).

Figure 4: Benefits that Green Gram Farmers Achieve from Joining Social Groups



Land Ownership and Use

All the interviewed respondents (100%) owned a piece of land but in different sizes whereby 42.5% owned between 2-4 acres, 29.4% owned 5-7 acres 23.0% owned less than 2 acres and only 5.1% owned 7 acres and above (Table 5). The type of land ownership was ancestral at 41.8%, 32.7% was privately owned,14.9 % was leased, and 10.6 % was communal land. The land use system was varied whereby 50.4% of the respondents used their land for crop production, 31.9% was used as grazing fields and 11.1 % was used for agroforestry. Of the respondents, 86.3% were growing green grams whereby 58.5% reported that the performance of green grams was moderate. Among farmers, only 51.9% had cultivated green grams for more than 5 years

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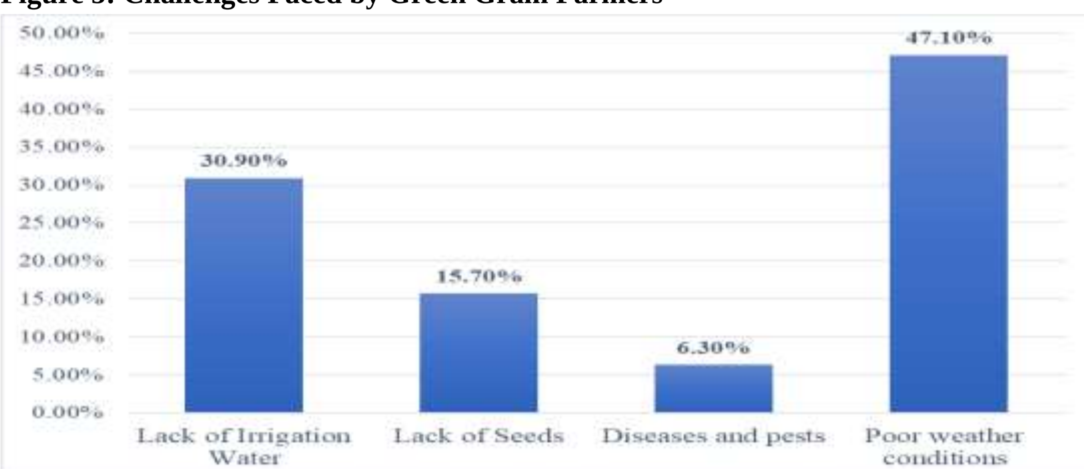
Table 5: Information Gathered from Farmers on Land Ownership and Use

Variable	Categories	Responses	Percentage (%)
Land ownership	Yes	395	0.0
	No	0	0.0
Size of land	7 and above	20	5.1
	5-7	116	29.4
	2-4	168	42.5
	Less than 2 acres	91	23.0
Type of land ownership	Ancestral land	165	41.8
	Private property with title deed	129	32.7
	Leasehold	59	14.9
	Communal land	42	10.6
Major land use	Crop production	199	50.4
	Grazing land	126	31.9
	Agroforestry	44	11.1
	Other	26	6.6
Grow Green Grams	Yes	341	86.3
	No	54	13.7
Performance of Green Grams	Moderate	231	58.5
	Poor	123	31.1
	Good	41	10.4
Period of growing Green Grams	5 and above	205	51.9
	3-4 years	134	33.9
	1-2 years	56	14.2

Farmers in the area were experiencing several challenges during production of green gram. The major challenges were poor weather conditions cited by 47.1%, lack of water for irrigation 30.9%, lack of certified seeds 15.7% and an increase in crop pests by 6.3 % (Figure 5).

Figure 5: Challenges Faced by Green Gram Farmers



Perceptions on Climate Change

In the study area, 82.3% of the respondents cited that they had observed changes in climate conditions over time (Table 5). Prolonged drought conditions which were indicated by 91% of the respondents and the influx of crop pests in green

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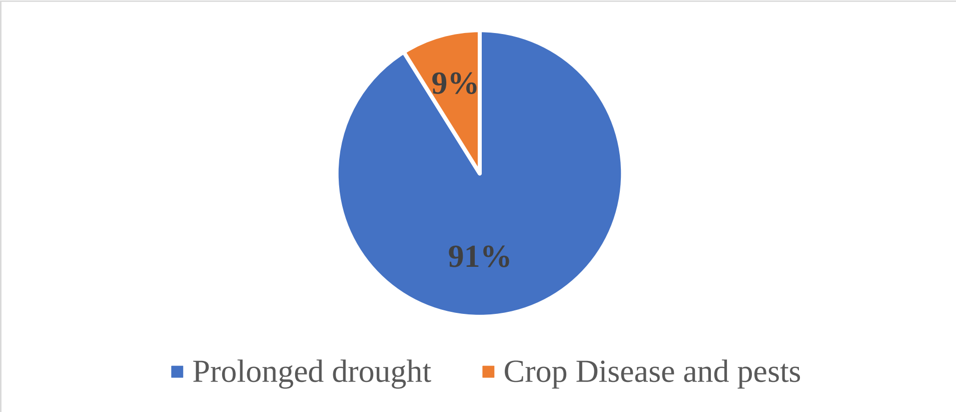
gram production cited by 9% were most cited and were attributed more to climate change (Figure 6).

Table 5: Perceptions on Climate Change

Observed climate change	Frequency	Percent
Yes	325	82.3
No	70	17.7
Total	395	100.0

Figure 6. Climate change events affecting farming activities



The farmers in the study area had employed several adaptation measures to cope with the change in climate conditions as presented in (Table 6). Results showed that, to a large extent 53.2% of the respondents had changed their green gram varieties from the traditional to improved varieties. As an adaptation measure, 35.7% of the respondents started to practice early planting and 31.3% had started to use integrated pest management (IPM) practices to curb the influx of crop pests.

Table 6. Adaptation Measures Used by Farmers to Cope with the Change in Climate

Scale	1		2		3		4		5		Total	
Variables	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
a) Changed the green gram variety	35.0	8.9	16.0	4.1	37	9.4	97	24.6	210	53.2	395	100
b) Started to practice mulching	12.0	5.3	127.0	32.2	51	12.9	180	45.6	16	4.1	395	100
c)Sought assistance from the department of agriculture	90.0	22.8	67	17	215	54.4	12	3	11	1.8	395	100
d) Started to irrigate crops	168.0	42.5	158	40	28	7.1	16	4.1	25	6.3	395	100
e) Started to plant earlier	40.0	10.1	33	8.4	25	6.3	156	39.5	141	35.7	395	100
f) Used integrated pest management practices	35.0	8.9	34	8.6	109	27.6	94	23.8	123	31.3	385	100
Mean Responses	64	16.2	73	18.5	78	19.8	93	23.5	87	22.5	385	100

F=Number of farmers, Scale of 1-5 where: 1=Never, 2= Less extent, 3=Moderate extent, 4= Large extent, 5= Very large extent.

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The *Chi*-Square results (Table 7) established that there was a significant correlation ($P<0.05$) between adaptation measures used by farmers to cope with the change in climate and green gram production.

Table 7: *Chi*-Square Tests on Adaptation Measures

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	590.154[a]	8	.000
Likelihood Ratio	499.095	8	.000
Linear-by-Linear association	9.381	1	.002
N of Valid Cases	395		

a. 3 cells (20.0%) have an expected count of less than 5. The minimum expected count is 2.59.

In order to cope with climate change and build resilience to its effects, several interventions by the relevant stakeholders were employed. These were technological, agronomic, infrastructural, affordable inputs, Market linkages and capacity building. Table 8 presents the results as per the responses from the farmers on the level of interventions carried out. Of the respondents, 37% of them strongly agreed that the county government had instituted measures to help in coping with the adverse effects of climate change. The government had assisted in the provision of free or subsidized farm inputs such as fertilizers and chemicals while 28.4% of the respondents indicated that agricultural extension services were not adequate. Similarly, 46.1% of the respondents agreed that there were interventions by the government to assist them in securing good market prices for their farm produce. Regarding infrastructure, 38% of the respondents indicated that the government had not put the proper infrastructure in place such as roads and conducive marketplaces to help farmers transport and sell their farm produce. Approximately 29.1% indicated that there were no reliable and safe storage facilities for their farm produce

Table 8: Government Interventions and Policies in Green Gram Production

Scale	1		2		3		4		5		Total	
Variables	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
F1. Capacity building to enhance adaptation climate change	29	7.3	38	9.6	55	13.9	127	32.2	146	37.0	**395**	**100.0**
F2. The government offers free or subsidized farm inputs	43	10.9	78	19.7	26	6.6	118	29.9	130	32.9	**395**	**100.0**
F3. Provision of Agriculture Extension services	108	27.3	112	28.4	38	9.6	69	17.5	68	17.2	**395**	**100.0**
F4. Negotiations of good market prices for their farm produce	12	3.0	22	5.6	44	11.1	182	46.1	135	34.2	**395**	**100.0**
F5. Development of proper infrastructure such as roads and market sheds	150	38.0	104	26.3	44	11.1	46	11.6	51	12.9	**395**	**100.0**
F6. Promotion crop irrigation in the location	34	8.6	99	25.1	143	36.2	79	20.0	40	10.1	**395**	**100.0**
F7. Provision of reliable and safe storage facilities	104	26.5	115	29.1	41	10.4	96	10.4	39	9.9	**395**	**100.0**
Mean Responses	**69**	**17.5**	**81**	**20.5**	**56**	**14.2**	**102**	**25.8**	**87**	**22.0**	**395**	**100.0**

F=Number of farmers, Scale of 1-5, where 1= Strongly disagree, 2= Disagree, 3= Neutral, 4= Agree and 5= Strongly agree.

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The *Chi*-square test shows that there was a significant association (P<0.05) between government interventions, policies and green gram production (Table 9).

Table 9. *Chi*-Square Tests on Government Interventions and Policies in Green Gram Production

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1159.048[a]	16	.000
Likelihood Ratio	965.367	16	.000
Linear-by-Linear association	337.891	1	.000
Number of Valid Cases	395		

a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is 2.86.

DISCUSSION

Socio-Demographic Characteristics

Descriptive statistics revealed a good representation of the genders with the data an indication that the sample was representative. A ratio of 1:2 in either gender is considered representative (Kothari, 2004). Most farmers were aged between 40 and 50 years. Youthful farmers can manage their farms better than older ones because they are strong and educated however there is low participation from youth and men in green gram farming in Makueni county (GoK, 2021). Farmers experience is important in knowledge of climate change and farming systems evolution (Kalele *et al*., 2021). Risk averseness increases with age (Negash, 2007). Previous studies have identified social characteristics such as age, gender, education and wealth status to be associated with vulnerability (Eriksen *et al*., 2005). For increased green gram production, there is need to encourage more youth to be involved in green gram farming.

A higher proportion of the farmers had achieved primary school education as the highest level attained followed by secondary school. Farmer level of education can influence levels of crop performance and the adaptation strategies employed against climate change. Education levels among respondents have an indication about their knowledge and skills in the field of interest. It also gives an indication of the development and civilization of the community within the location of study. The higher the level of education, the better the farming and farm management skills. Looking at the low levels of adult farmers in the study area, the capacity of the farmers in Kibwezi East needs to be increased through establishment of agricultural training centers and on farm demonstration plots and other on farm training activities on strategies to increase green gram production in the changing climate conditions. Empowered farmers are also able to research and gather information about resilient crop varieties and better solutions for the challenges faced. They also have better knowledge on how to use farm inputs and are likely to interpret information (Mucheru-Muna *et al*., 2021). Trained farmers have high influence in the implementation and adoption of water harvesting techniques, especially if it's done in a language that the all understand well. (Mango *et al*., 2017).

Most households had a mean family size of 4 members. The proportion of households engaged in agricultural activities in Makueni county decreased from 97% in 2005 to 79% in 2019 (GoK, 2021). In the study area, majority of the respondents lived in either permanent or semi-permanent houses, which was an indication of the level of income. The respondents (44.8%) indicated that their major source of income was farming. Farmers with higher incomes participated more in crop production as compared to those with low incomes (Ogeto *et al*., 2013). The dependency ratio within a household and the level of income determined the ability of the household to live better and be able to construct a permanent house. Most farmers used firewood and charcoal as sources of fuel. Destruction of forests for charcoal and firewood harvesting contributes to deforestation land use change, and degradation

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resulting into the negative effects of climate change. Affordable renewable sources of energy are recommended like solar because in the study location, temperatures are very high. Residents of Kibwezi east subcounty sources most of their water for household use from rivers as indicated by 37% of the respondents. A great proportion harvested and stored rainwater but would still travel long distances to find water once they exhaust their stock. There was no available water for irrigation except to those farmers near rivers. Majority of the farmers relied on more than one source of water. Some of the rivers in this region are seasonal. Water being a basic need for household use and irrigation, sustainable water supply needs to be considered in this area.

Household Food Security Status

About 55% of the respondents indicated that they did not have adequate supply of maize in their diet. When maize is not available, it is regarded as a situation of food insecurity or hunger since 66% of the respondent's preferred mixture of maize and beans as their main diet. A proportion of the population consumed *ugali* or rice and green grams. Many farmers about 45.1% grew maize in their farms during the major rainy seasons. Green gram was planted by 27.6 % of the respondents. Maize crop failed due to unreliable rainfall patterns leaving the households without food. Green grams can yield a big harvest even with little rainfall amounts as opposed to maize but it is only grown by 27.6% of the respondents. Lack of sustainable food sources was associated with low incomes by 44.6% of the respondents and with rainfall failure by 36.2% of the respondents. Unreliability in rainfall is expected to affect food prices and reduce disposable incomes (GoK, 2021). The dependency burden in the households ranged between 41% to 44.1%. Farmers should be sensitized on the benefits of green gram as a nutritive and affordable food source. From the results, 21%-34.4% of the respondents consumed green grams in a span of 2 weeks to 1 month. As a food crop, green gram is a good source of many essential nutrients, its tolerated well by children and causes less flatulence than other legumes. Green gram is more affordable compared to other protein sources (Nair *et al*., 2013). Farmers should also be encouraged to increase the consumption of green gram, to manage micro nutrient deficiencies (Nair *et al*,2013).

Social Safety Nets

It was evident that 57.7% of the respondents were members of farmer social networks and common interest groups. These included women groups (31.10%), youth groups (21%) and farmer associations (25.3%). The social safety nets helped to provide, access to credit and loans, markets linkages, technical and equipment support, seeds and other agro-inputs. In Makueni county,10.7% of farming households are organized into agricultural groups (GoK, 2021).

Land Ownership and Use

About 42.5% of the respondents owned a land size of 2-4 acres while 29.4% owned 5-7 acres. The common types of land ownership were ancestral at 41.8% and private at 32.5%. From the results, agroforestry was not practiced and it was indicated that 50.4% respondents used their land for crop production, while 31.9% was used as grazing fields for their livestock. There is need for farmers to be trained on agroforestry and also to be encourage to practice it with the intention of adapting to the effects of climate change. The results showed that 86.3% of the respondents had grown green grams for a long time whereby 51.9% of them had grown the crop for more than 5 years however, 58.5% of them said the performance of the crop was not near optimal. Therefore, proper interventions and strategies need to be instituted to increase the yields. Key challenges included poor weather conditions, lack of water for irrigation, lack of seeds and other inputs and diseases and pests.

Perceptions on Climate Change

Majority of the respondents at least 82.3 % in the study region had observed and experienced climate

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change. It was perceived that climate change had affected crop production mostly through prolonged droughts and increased incidences of crop pests. Similar research has showed that drought and crop pests are the most prevalent problems facing farmers (Mrema *et al*., 2017). In other studies, farmers identified declining rainfall amounts and increased variability in the distribution of rainfall across and within seasons to be a cause of poor yields (Bryan *et al*., 2011; Bryan *et al*., 2013). High temperatures coupled with low rainfall conditions and prolonged drought events had led to increased vulnerability of farming systems in the ASAL areas (Gichangi, & Gatheru, 2018; Kalele, 2021).

Majority of the farmers had changed their green gram variety from the indigenous/traditional low yielding varieties and had adopted some high yielding and drought tolerant varieties. However more farmers need to be trained and encouraged to adopt the resilient and improved varieties to increase yields. Some farmers had started to practice early planting. This is important because crops are able to utilize the available water from rainfall falling early in the season leading to early maturity and as a drought escaping strategy. The adoption of Integrated pest management (IPM) practices as a pest control strategy helps to manage emerging populations of pests in green grams in a more environmentally friendly manner and leads to judicious use of pesticides as well as reducing the cost of production. Local adaptation options are important in building resilience to climate change effects. In addition to the farmers' innovative measures, the respondents anticipated complementary government interventions to enhance their resilience to climate change effects. Indeed, 37% of the respondents felt that the government had instituted measures to help them overcome adverse effects of climate change which was less than 50 of the population. Only 32.9% of the farmers had benefitted from subsidized and free farm inputs from the government and other actors which was not regular. Agricultural extension services were not adequately provided to the farmers to guide them on climate smart agriculture practices as indicated by 28.4% of the study participants. Improvement of agricultural extension services by the respective agencies would help to equip farmers with skills to enable them adapt to climate change.

There was an initiative by the government to ensure good market prices for their farm produce. The county government had completed the construction of a grain and pulses value addition factory at Makindu town to dry, clean, sort, grade and package pulses for the market. However, 38% of the respondents stated that were no adequate water sources for irrigation and no reliable storage facilities to help the farmers adapt to climate change effects. Farmers who carried out irrigation had three times more income compared to those that relied solely on rainfed farming (Mintesinot, 2002). This shows the importance of crop irrigation in increasing yields or sustaining and supplementing crops during periods of little rainfall. However, farmers faced challenges such as lack of improved planting materials, high cost of seeds, irrigation technologies and other strategies to adapt to the changing climate (Mugambi, 2017). The effects of climate change were being experienced in this area and there were many challenges being experienced and to be addressed. The high temperatures as expressed by 71% of the respondents lead to inadequate soil moisture, increase in diseases and pests and low productivity.

CONCLUSIONS AND RECOMMENDATIONS

Previous studies identified age, gender, education and income levels to be associated with vulnerability (Eriksen *et al*., 2005). These determinants direct the manner in which people are able to cope with, reduce exposure to and recovery from adverse or opportunities due to the effects of climate change. High temperatures and erratic rainfall affect the green gram value chain. The adaptation levels were still low and more needed to be done. This calls for farmers to identify what they call food in the areas where they live, focus on those

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crops that are already adaptable and power them with science and innovative strategies to make them more productive. Specific strategies for adaptation to be designed to each location and situation. Coordination of joint working groups and involvement of multi-stakeholder partnerships will be required to enhance adaptation and resilience to climate change effects, bridge that gaps and increase yields.

REFERENCES

Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. Agronomy for Sustainable Development, 35 (3), 869–890.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. Journal of Environmental Management, 114, 26–35.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2011). Coping with climate change and variability and adapting to climate change in Kenya: Household and community strategies and determinants. Adaptation of Smallholder Agriculture to Climate Change in Kenya. International Food Policy Research Institute (IFPRI), Washington, DC, 3.

Chauhan, Y.S., Williams, R. (2018). Physiological and Agronomic Strategies to Increase Mungbean Yield in Climatically Variable Environments of Northern Australia. Agronomy. 2018;8(6):83

Demissie, T., Bolt, J., Duku, C., Groot, A., & Recha, J. W. M. (2019). Green grams Kenya: Climate change risks and opportunities.

Eriksen, S. H., Brown, K., & Kelly, P. M. (2005). The dynamics of vulnerability: Locating coping strategies in Kenya and Tanzania. Geographical Journal, 171 (4), 287–305.

Gichangi, E. M., & Gatheru, M. (2018). Farmers' awareness and perception of climate change and the various adaptation measures they employ in the semi-arid eastern Kenya. Climate Change, 4 (14), 112–122.

Gichangi. E., Gatheru. M., Njiru.E., Mungube. E., Wambua. J., Wamuongo. J. (2015). Assessment of climate variability and change in semi-arid eastern Kenya. Climatic Change. 130. 10.1007/s10584-015-1341-2.

Government of Kenya (GoK). (2021). Annual development plan for Makueni County 2022-2023.

GoK. (2013). Government of Kenya (GoK). (2013). Makueni County First County Integrated Development Plan 2013- 2017. Government of Kenya, Nairobi. – Google Search. https://www .devolutionhub.or.ke/resource/makueni- count y-first- county-integrated-development-plan-2013-2017

Hatfield, J.L., Pruege, J.H. (2015). Temperature extremes: Effect on plant growth and development Weather and Climate Extremes, Volume 10, Part A,2015, Pages 4-10, ISSN 2212- 0947, https://doi.org/10.1016/j.wace.201 5.08.001

Jincy, M., Prasad, V., Jeyakumar, P., Senthil, A., & Manikandan, N. (2021). Evaluation of green gram genotypes for drought tolerance by PEG (polyethylene glycol) induced drought stress at seedling stage. Legume Research-An International Journal, 44 (6), 684–691.

Kalele, D. N. (2021). Climate-smart Agriculture Options for Enhanced Resilience and Food Security: A Case Study of Yatta, Machakos County, Kenya [PhD Thesis]. University of Nairobi.

Article DOI : https://doi.org/10.37284/ajccrs.3.1.2336

Kangai. R., Chitechi., Waswa. B., Ngare. I., Adiel. R., Koske. J. (2021). Determinants of climate change adaptation and perceptions among small-scale farmers of Embu County, Eastern Kenya. African Journal of Environmental Science and Technology. 15. 167-178. 10.5897/AJEST2020.2943

Kenya Agricultural Livestock and Research Organization (KALRO). (2016). The Kenya Cereals Enhancement Programme (KCEP). KALRO-KCEP Green Grams Production Training and Extension Manual.

Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30 (3), 607–610.

MCIDP. (2013). Makueni County Integrated Development Plan 2013-2017. Government of Makueni County. https://makueni.go.ke/download/makueni-county-integrated-development-plan-2013-2017/

Mintesinot, B. (2002). Assessment and optimization of traditional irrigation of Vertisols in Northern Ethiopia: A case study at Gumselasa Microdam using Maize as an Indicator Crop [PhD Thesis]. Ghent University.

Mrema, E., Shimelis, H., Laing, M., & Bucheyeki, T. (2017). Farmers' perceptions of sorghum production constraints and Striga control practices in semi-arid areas of Tanzania. International Journal of Pest Management, 63 (2), 146– 156. https://doi.org/10.1080/09670874.2016.1238115

Mugambi, M. D. M. (2017). Climate change perceptions and coping strategies among the marginalized and resource poor households in Tharaka south, Kenya.

Muia V. K., Opere A. O., Ndunda E., Amwata D. A. (2024) Rainfall and Temperature Trend Analysis using Mann-Kendall and Sen's Slope Estimator Test in Makueni County, Kenya, J. Mater. Environ. Sci., 15(3), 349-367.

Man, C., & Thiede, B. (2021). Beyond Yields: Mapping the Many Impacts of Climate on Food Security. https://www.csis.org/analysis/beyond-yields-mapping-many-impacts-climate-food-security

Mango, N., Makate, C., Tamene, L., Mponela, P., & Ndengu, G. (2017). Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. International Soil and Water Conservation Research, 5 (2), 122–129.

MoALF. (2017). Climate Risk Profile for Makueni County. Kenya County Climate Risk Profile Series [Report]. https://cgspace.cgiar.org/handle/10568/80457

MoALF, K. (2015). Economic Review of Agriculture [ERA] 2015. https://books.google.co.ke/books?id=wplfnQAACAAJ

Mucheru-Muna, M. W., Ada, M. A., Mugwe, J. N., Mairura, F. S., Mugi-Ngenga, E., Zingore, S., & Mutegi, J. K. (2021). Socio-economic predictors, soil fertility knowledge domains and strategies for sustainable maize intensification in Embu County, Kenya. Heliyon, 7 (2), e06345. https://doi.org/10.1016/j.heliyon.2021.e06345

Muchomba, M. K., Muindi, E. M., & Mulinge, J. M. (2023). Overview of Green Gram (Vigna radiata L.) Crop, Its Economic Importance, Ecological Requirements and Production Constraints in Kenya. Journal of Agriculture and Ecology Research International, 24 (2), 1–11.

Article DOI : https://doi.org/10.37284/ajccrs.3.1.2336

Mugenda, O. M., & Mugenda, A. G. (2003). Research methods: Quantitative & qualitative approaches (Vol. 2). Acts press Nairobi.

Nair, R. M., Yang, R.-Y., Easdown, W. J., Thavarajah, D., Thavarajah, P., Hughes, J. d'A, & Keatinge, J. D. H. (2013). Biofortification of Mungbean (Vigna radiata) as a whole food to enhance human health. Journal of the Science of Food and Agriculture, 93 (8), 1805–1813.

Nair R.M., Schafleitner, R., Kenyon, L., Srinivasan, R., Easdown, W., Ebert, R.W., Hanson, P. (2012). Genetic improvement of mungbean. SABRAO J. Breed. Genet., 44: 177-190

Negash, R. (2007). Determinants of Adopting of Improved Haricot Bean Production Package in Alaba Special Woreda, Southern, Ethiopia, s.l.: s.n.

Nyandiko, N., Wakhungu, J., Otengi, S. (2015). Effects of climate variability on maize yield in the arid and semi-arid lands of lower Eastern Kenya. Agriculture & Food Security. 4. 10.1186/s40066-015-0028-2.

Ogeto, R. M., Cheruiyot, E., Mshenga, P., & Onyari, C. N. (2013). Sorghum production for food security: A socioeconomic analysis of sorghum production in Nakuru County, Kenya.

Palombi, L., & Sessa, R. (2013). Climate-smart agriculture: Sourcebook. Food and Agriculture Organization of the United Nations (FAO).

Patton, M. Q. (2002). Qualitative research and evaluation methods. Thousand Oaks. Cal.: Sage Publications, 4. https://www.worldcat.org/title/qualitative-research-and-evaluation-methods/oclc/47844738

Sekaran, U. & Bougie, R. (2016). Research Methods for Business: A Skill-Building Approach. 7th Edition, Wiley & Sons, West Sussex.

Sita, K., Sehgal, A., Hanumantha., R. B., Nair, R. M., Vara Prasad, P. V., Kumar, S., et al. (2017). Food legumes and rising temperatures: effects, adaptive functional mechanisms specific to reproductive growth stage and strategies to improve heat tolerance. *Front.* Plant Sci. 8, 1658. doi: 10.3389/fpls.2017.01658

SNV, (2018). CRAFT project (2018- 2022): Green gram, Kenya: Climate change Risks and opportunities.

Wambua, J. M., Ngigi, M., & Lutta, M. (2017). Yields of green grams and pigeon peas under smallholder conditions in Machakos County, Kenya. East African Agricultural and Forestry Journal, 82 (2–4), 91–117.

World Bank & CIAT. (2015). Climate-smart agriculture in Kenya. CSA Country Profiles for Africa, Asia, and Latin America and the Caribbean Series. The World Bank Group Washington, DC.

World Bank. (2021). World Bank Climate Change Knowledge Portal Climate Risk Country Profiles. https://climateknowledgeportal.worldbank.org/

World Bank. (2001). World Development Report 2000/2001. New York: Oxford University Press. https://doi.org/10.1596/0- 1952-1129-4