Vulnerability of Small-Scale Coffee Farmers: The Implications of Climate Variability in Kirinyaga County, Kenya.

Abstract: Coffee farming constitutes a substantial source of income to a significant fraction of ménages across the globe, Kenya being one. The impact of climate variability on coffee farming is negative. Small-scale coffee farmers in Mukure ward, Kirinyaga have not adequately assumed appropriate adaptation strategies to enhance resilience against this challenge. This research sought to assess the strategies utilized by small-scale coffee farmers to adapt to climate variability, and its impacts on small-scale coffee farming in Mukure ward. The purpose of the research was to evaluate climate variability, how it relates with coffee farming and to determine adaptation strategies for resilience against climate variability by small-scale coffee farmers in Mukure ward. The study area was Mukure ward within Kirinyaga County with a total population of 30,534. Applying Yamane's formula gave a sample size of 400 farmers. These were randomly sampled in the study area. Primary data was collected using questionnaires, conducting interviews among selected respondents and field observations. Data on temperature and precipitation trends was accessed from the local Kenya Meteorological Department offices while data on coffee farming was provided by Kirinyaga County Government. The raw data from the field was analyzed using Statistical Package for Social Science (SPSS) and spreadsheets that then generated tables, comparative graphs and frequencies. The findings from this study found out that small-scale coffee farmers in Mukure Ward experienced climate variability in the period 1987-2017. The findings also established a positive linkage between temperature variation and coffee yields in Mukure. In the months when the temperatures were high, the coffee yields were lower while months that experienced high precipitation saw higher yields. The most commonly applied strategies among the small-scale coffee farmers were use of new and improved coffee varieties, use of traditional coffee shades, strengthening local farmer groups and diversification in farming. The study concluded that small-scale coffee farmers in Mukure ward were facing climate variability, and had devised different adaptation mechanisms which were on the other hand faced by myriad of challenges. Going by the findings of the study, with the fluctuations in temperature and rainfall patterns, there is an absolute need to create awareness among small scale-coffee farmers on climate variability, weather forecast and appropriate adaptation strategies.

Key words: Climate Variability; Adaptation Strategies; Vulnerability

Introduction: For the past thirty to forty years, climate variability has been witnessed in all terrestrial parts of the globe and indeed enthused people's perceptions and slants (Iscaro, 2014). From as early as the early-1980s, variation in precipitation and temperature patterns have been recorded and associated with natural stimuluses of a place's climate (Killeen and Harper, 2016). Surveys indicate that variations in weather patterns occur at faster paces than was the case fifty or so years ago, leading to irreversible alterations in major environmental sceneries and biomes (Kasterine *et al*., 2010).

World over, its known that societies that are solely dependent on natural resources on a habitual basis are severely affected by impacts of climate variability, and they are mostly distressed by extreme weather events such as drought, flooding and other lifestyle strains like diseases, inter-group conflicts and increased population pressure (Enomoto *et al.,* 2011). Changes in weather patterns therefore could influence productivity, and therefore have an orientation on people's livelihoods ((Iscaro, 2014).

Coffee has distinctively remained a major trade product across the globe, and within discrete farms; it is second to petroleum in the set of the legitimate supplies in many countries (Iscaro, 2014). This information is in conformism with separate studies previously conducted by Davis *et al*. (2012) who stated that coffee ranked as second most transacted product in all continents. World's best known coffee producer is Brazil with Vietnam and Colombia swiftly following (DaMatta *et al*., 2008).

The situation in Brazil, world's number one producer of Robusta and Arabica coffee, changes in rainfall and temperature levels are likely to affect coffee farming substantively. In the state of Sao Paulo for instance, an increase in temperatures by 1^{0}C is likely to result in a 25% decline in coffee yields by the year 2050 (Davis *et al.,* 2012). In Southeast Brazil, climate variability has been blamed for more than 20% of decline in coffee yields in the last three decades (Eakin *et al.*, 2005).

In Africa, countries like Ivory Coast, Ethiopia and Malawi largely to a large extent depend on coffee production for national budgeting, and general sustenance of a fundamental fraction of the population. According to DaMatta *et al*. (2008), a good number of the African coffee-producing nations reap as much as US$ 100 billion from international coffee trade. Arabica coffee originated and was diversified in Ethiopia, and the country is ranked the first in Africa in coffee production ((Leksmono *et al.,* 2006). Ethiopia's national economy is 34% dependent on coffee production with small-scale coffee farming supporting more than 15 million locals.

In Kenya, coffee has been identified as one of the main cash crops post colonialism era (Davis *et al.,* 2012). There are different regions that are known for coffee production in Kenya. In Central region, counties that are identified with the practice are Kirinyaga, Murang'a, Nyeri and Kiambu and they account for more than half of the total national harvest (Davis *et al.*, 2012). In Embu, the crop is commonly grown in the area bordering Mt. Kenya where soils are mainly volcanic. Other zones that produce coffee are Rift Valley, Nyanza and Kakamega.

The average production of coffee in the growing zones in Kenya is 280kg/ha, yields that rank very lowly globally (Asghar *et al.,* 2019). The low productivity has partly been blamed on increasing temperatures globally that has facilitated infestation of coffee berry borer (*Hypothenemus hampei)* in areas that were previously considered cool and where the existence of the insect was unheard of. Irregular rainfall patterns during the long and short rains have also resulted in stress on coffee bushes, a situation that has affected 70% of overall farming practices dependent on rain.

Methodology:

Study Area

The research was conducted in Mukure Ward, Kirinyaga County which is found at the foot of Mt. Kenya. It is located between 0°31'40.1''S and 37°13'38.1''E in Kirinyaga County, Kenya. Mukure Ward has an altitude that ranges between 1158 M and 5380 M above sea level (GoK, 2019). It is about 110Km from Kenya's capital, Nairobi. Mukure Ward extends to Mt. Kenya

Forest in the northern end, borders Kiine Ward to the west, Mutira Ward to the East and Mwerua Ward to the south eastern side, all in Kirinyaga County (GOK, 2019).

Physical and Topographic Features

The terrain is generally gently sloping along the borders with Mt. Kenya, while the lower ends are basically flat. The area bordering the mountain is forested, and is defined by steep slopes with rivers cutting along them (GOK, 2019).

There are several rivers and streams emanating from the forest. Thiba river, Nyamindi, Rupingazi, Ragati, River Sagana as well as Rwamuthambi River define the main sources of water in the expansive county (GOK, 2009). They all drain to Tana River. These rivers are mostly used in small-scale and commercial farming. The main types of soils are the volcanic soils on the Mt. Kenya slopes and red soils where the terrain is gently sloping (Mwenda & Kibutu, 2012).

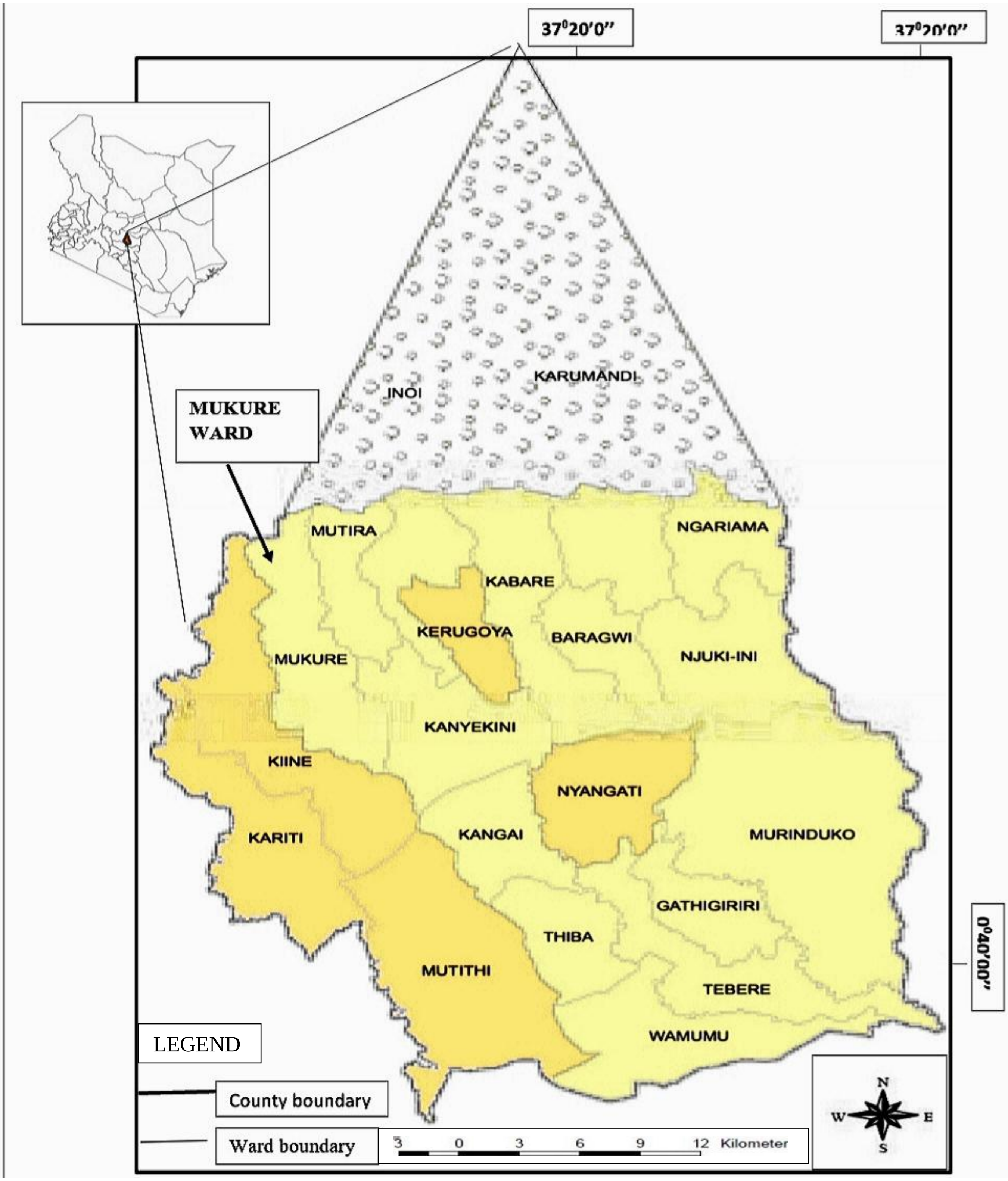

Figure 1: Map of Study Area

(Source: GoK 2019)

Ecological Conditions

Mukure Ward is identified with assorted ecological precincts. There is a zone perceived as lowland area, a midland precinct and the highlands, and every area ropes their exclusive ecosystems (Murphy & Chirchir, 2017). The forest is tenanted by an extensive selection of biota and birds. It is common to come across people grazing livestock within the forest. The ward falls under the general agro-ecological zone of Mt. Kenya's windward side that is characterized by wet and chilly zones closer to the mountain and relatively dry and less humid areas that extend to Kiine Ward area (Mwenda & Kibutu, 2012). Most of the agro-ecological zones of Mukure Ward are agriculturally productive. The very cold and wet zone is covered by mountain vegetation with a section of the same being used for tea production.

Climatic Conditions

Mukure Ward is positioned on a high elevation with equitably calm climate. It has a tropical climate with two main rainy seasons within a year. Temperature ranges from a low of 12^0C to a high of 30^0C (GOK, 2009). The rains are mostly influenced by the proximity of the ward to the equator, and its windward location from Mt Kenya. Long rains are experienced between March and May while the short rains season falls between October and December. Mukure Ward has an annual precipitation of 1200mm with an equatorial rainfall pattern (Mwenda & Kibutu, 2012).

Vegetation

The apex of Mukure Ward falls within Mt. Kenya Forest. There are indigenous and exotic tree species within the forest and a few spread across the ward. The areas of the mountain slopes considered very wet have thick trees blended with bamboo. The belt that follows has montane forests although a fraction of it has been cleared by locals to pave way for tea farming. For a long time, residents of Mukure Ward have planted cash crops such as tea and coffee, majorly on small scale basis while those residing in the low lands plant cereal crops. It is also common to find maize, beans and banana farming across Mukure Ward.

Research Design

The study utilized descriptive research model in collection of raw data by way of interrogating and administering questionnaires to a sample of individuals. Data collected was both qualitative and quantitative. Descriptive research entails observation as well as reporting of the behavior of specific subject without interfering with it at that time (Mugenda and Mugenda, 1999).

Target Population

Kirinyaga County population based on the 2019 Kenya Population and Housing Census had 610,411 persons with an annual growth rate of 1.5%. Going by the figures, it is projected that the population will hit 625,157 by 2030 (KBS, 2010). The study focused on Mukure Ward whose population was 30,534 (GoK, 2019).

Sample Size and Sampling Procedure

The sample size was determined using Yamane's (1973) formula since it maintains a very high confidence interval, and therefore high exactness.

$$n = \frac{N}{[1 + N^{*}(e)^{2}]}$$

Where n = sample size, N= size of the entire population and e=is the acceptable sampling error. Usually, 95% confidence level with P=0.5 are assumed when using Yamane's formula. Applying the formula, the resultant sample size was 395, but the study took advantage of a larger sample and made it 400;

$n = 30,534 / [1+30,534*(0.05)^2]$

$n = 30,534 / [1+76.335]$

n= 394.83

The research applied multi-stage sampling technique that ensured clusters, systemic as well as purposive sampling. Cluster sampling was necessary because it capitalized on natural groupings of households that depict resembling characteristics. Some villages within Mukure with high coffee yields from small-scale coffee farmers were purposely selected with the guidance of key informants from the agriculture department and opinion leaders in the study area. Key institutions involved in coffee production, agriculture in general and coffee marketing within the county were identified and chosen through purposive sampling. Purposive sampling was also used in seeking expert opinions among members of staff in the selected institutions.

Data Collection Methods and Instruments

Questionnaires (both structured and semi-structured) were applied for purposes of collecting data in this study. Data from Embu meteorological center (under which meteorological data of Mukure Ward is held) within the study area was also sought. Interviews were administered to key informants. Photography was also applied as a means of documenting evidence. In addition to this, Participatory Rural Appraisal (PRA) was used to collect information on farmers' awareness of climate variability, vulnerability prompted by climate variability and their adaptation mechanisms. Historic reference to life forms were collected from reliable people within Mukure Ward. The main intention of this approach was to establish occasions and processes of climate variability in the interviewee's life trajectories and expound further on them.

Life experiences were gathered from respondents within the age bracket of sixty-five and eighty-five years who had resided in the area of study for a substantive period of time. When selecting the respondents, household heads were engaged to bring forth their experiences, knowledge and opinions. In-depth approach that gave respondents opportunities to elaborate in detail their perception on climate variability, the experiences they had witnessed, their vulnerabilities, the adjustments they had to do in their growing journey and each person's challenges in the adaptation journey were prioritized.

Data Analysis

Data was analyzed using the statistical package for social sciences (SPSS) version 21 using descriptive and inferential statistics such as ranges, percentages, charts and bar charts as well as Chi-square and Pearson Correlation when testing significance and relationships between variables (non-parametric statistic instruments). SPSS and Excel spreadsheets were as such used to analyze data collected using the structured questionnaires. Data was then organized, structured and processed and presented using pie charts, graph comparisons and percentages after getting a broad overview of the variables that can be tested quantitatively (Ganti, 2020).

Qualitative data was scrutinized using content analysis. Observations from the field, interactions with respondents, and other forms of data captured on site were categorized, summarized and structured in tables and spreadsheets.

For purposes of establishing the impact of independent variables of precipitation amounts and temperature levels on coffee production (dependent variable), regression analysis was used. Linear correlation coefficient (*R)* was used to quantify the level of association between variables (coffee yields and climate variability) as outlined by Sharon (2009).

Results:

This study targeted of 400 samples and all questionnaires were filled. The study established that 56% of people interviewed were 45 years and above. The respondents who were in the age bracket 45-65 years comprised 39.8% while those above 65 years represented 16.2% of the sample size (Table 1). In Mukure Ward, there are more young people engaged in farming, particularly coffee farming. This could be ascribed to the ever-increasing rates of unemployment in the country, which, going by a report by Krishnamurthy & Dejan, (2009) was put at 40% in the year 2009. The findings have a slight variation with the 2019 KNBS census which indicated that persons above 65 years in Mukure Ward comprised 6% of the population while those aged between 15 and 64 years comprised 61% whereas 33% were in the 15 to 34 years bracket (GoK, 2019). It therefore means that many of the small-scale coffee farmers are above the youthful age, and have experience in coffee farming.

Table 1: Percentage of Respondents by Age

Age Bracket	Frequency	Percentage (%)
29 and below	69	17.2
30-44	107	26.8
45-65	159	39.8
Above 65	65	16.2
Total	**400**	**100**

4.3.2 Gender of Respondents

The study established that 84% of small-scale coffee farmers in Mukure Ward were men while only 16% were ladies (Fig 2). It therefore means that small-scale coffee farming is mostly practiced by men in the study area. Gender may regulate the small-scale farmers vulnerability to climate variability, choice of adaptation mechanisms and the challenges the farmers face on their farms.

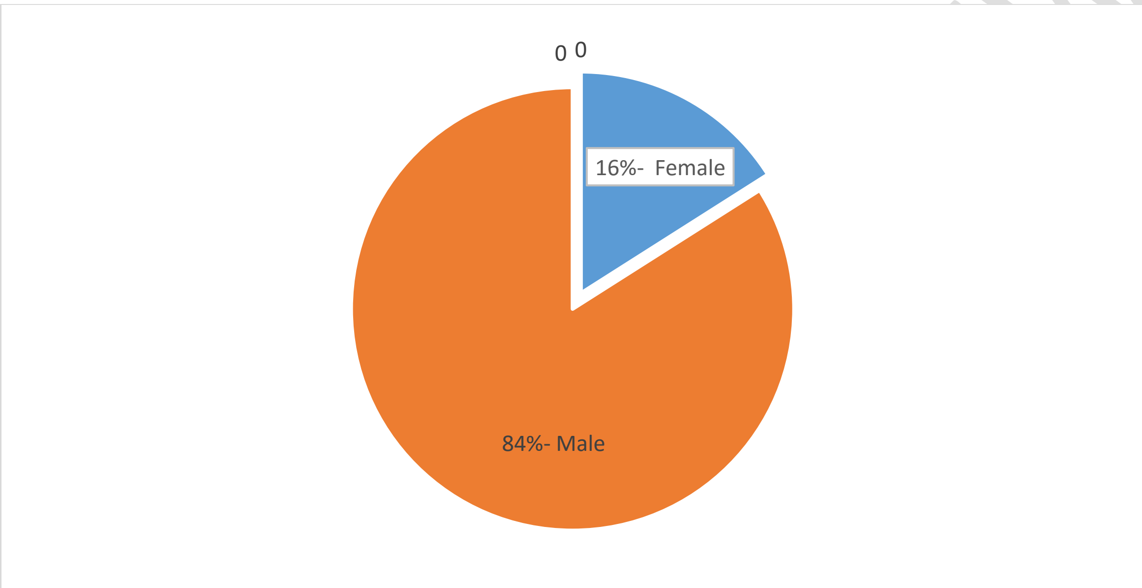

Figure 2: Gender Distribution of the Respondents in Mukure Ward

Impacts of climate variability is greater among women as compared to their male counterparts (Kristine, 2019). This is because women have been found to produce up to 30% lesser coffee yields than men world over owing to their limited access to education, land ownership and general exclusion to decision making opportunities (FAO, 2011).

4.3.3 Level of Education of Respondents

The study found out that more than 50% of the respondents had attained post-secondary education level. Those that had gone up to secondary level represented 35.75%, while those that had university degrees were 14% (Fig 3). Going by data from Kenya National Bureau of

Statistics data, only 14% of residents in Kirinyaga County didn't have any formal education while 28% have a secondary level (GoK, 2019). The variation could be ascribed to the point that small-scale coffee farmers were economically advantaged over the average residents in Kirinyaga County, and were as such able to cater for education fees. Even though many respondents did not have university education, majority had basic education, and could therefore understand disseminated information. The small fraction of 5.5% that hadn't attained formal education would still get information from the literate fraction.

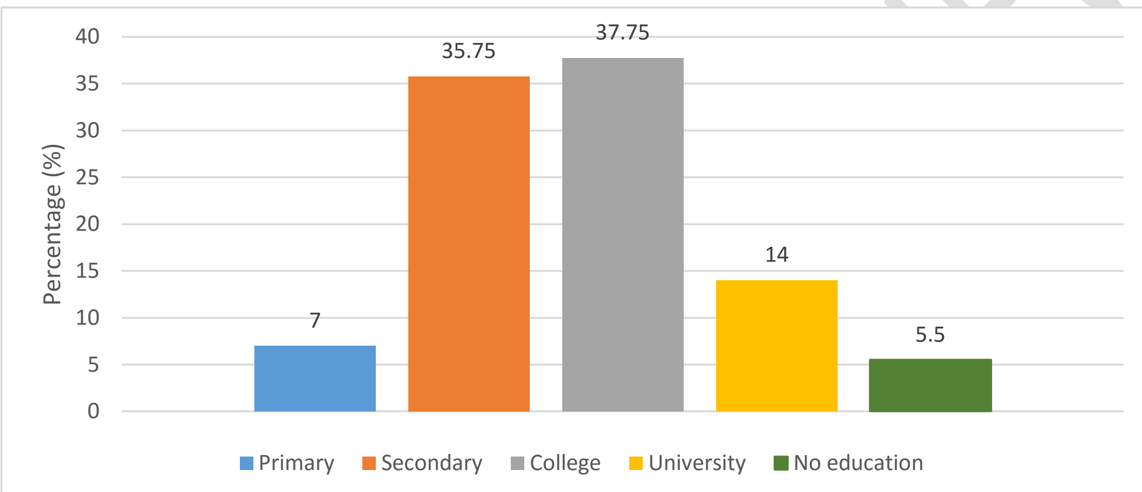

Figure 3: Respondents' Education Attained

Acquisition of education may influence coffee farming productivity in a direct way since it dictates the farming methods by altering farmers' attitudes, practices and routine. Small-scale coffee farmers' level of education is as such critical in farming in the economic perspective or within a swiftly evolving technology (Martin, 2006). In addition, a population that has not acquired education is less likely to comprehend and appreciate information on climate and therefore make adjust appropriately to changes (Kane *et al.,* 2000).

4.3.4 Farmers' Marital Status

The findings from the research depict that majority (79%) of respondents were espoused (Table 2). According to the KNBS statistics, the proportion of people married, both in monogamous and polygamous settings in Kirinyaga County is 39.6% while the widowed and separated represent 3% and 2.4% respectively (GoK, 2019).

Table 2: Marital Status of Respondents in Mukure Ward

Marital status	**Frequency**	**Percentage (%)**
Married	316	79
Divorcee	16	4
Widow	20	5
Widower	12	3
Single	36	9
Total	**400**	**100**

According to Holvoet (2016), a woman’s marital status is critical in determining their choice and decision on various adaptation strategies to climate variability, and the same doesn’t apply to men This was a clear indication that most of the small-scale coffee farmers made joint decisions, and could have diverse resources that they pool together to attend to climate variability-related risks and were as such less vulnerable. Single ladies and widows who have ventured in farming have little access to resources, and are disadvantaged in making decisions within their coffee cooperatives (Ncube *et al.*, 2013).

4.3.5 Duration Respondents have Practiced Coffee Farming

The research found out that majority (52.7%) of the interviewees had practiced coffee farming for a period between eleven and twenty years. They were followed by the group that had practiced coffee farming between twenty-one and forty years at 32% (Table 3). It is therefore a clear indication that majority of the farmers interviwed had practiced coffee farming for a substantive duration of time.

Table 3: Number of Years Respondents have Practiced Coffee Farming in Mukure Ward

Duration (Years)	Farmers	%
10 years and below	16	4.1
11-20	211	52.7
21- 40	128	32
41 and over	45	11.2
Total	**400**	**100**

According to Krishnamurthy and Dejan (2009), the age of farmers is a representation of their experience and is considered a determining factor in agricultural adaptation. Farmers who had 41 years and over in experience are likely to display resistance towards on-farm adaptation strategies, diversification in income generating activities and livelihood adjustment. This is because farmers of advanced age are more attached to traditional farming practices emotionally and may often resist technological switch. According to Kasterine *et al.*, (2010) young farmers are more receptive to knowledge-intensive adaptation alternatives like new crop varieties, insurance and diversification in income-generating alternatives. The young farmers are known to be better risk-takers while their old counterparts exhibit more risk-averse tendencies (Onang'o and Orodho, 2016).

Effects of climate variability in Kenya, like drought are cyclical, with major ones being felt after a decade and trivial ones coming every 3-4 years (UNDP, 2012). This means that many of the respondents in Mukure Ward have experienced effects of climate variability since they are in an area susceptible to climate variability (FEWSNET, 2010). Mt Kenya region, the coffee growing zone under which Mukure Ward falls is believed to have started growing Arabica coffee in the 1960s (Davis *et al.,* 2012). The proportion of the population that has grown coffee over 41 years has therefore been the most experienced in the field, and has experienced changes in coffee growing, flowering, yields and diversification in the ward.

4.3.6 Coffee Varieties and Number of Stems on Farm

The research revealed that majority (48.4%) of the small-scale coffee farmers had more than one coffee variety on their farm (Table 4). Those that specialized in SL28 coffee variety were 38%, followed by Batian at 7% and Ruiru 11 variety at 6.6%. According to William *et al.* (2020), diversification in crop varieties within the same locality serves to distribute survival risks since each of the crop strives to exist under its unique environmental conditions. Diversification coffee varieties has also been found to have the agronomical advantages of pest management because it breaks life cycles of predominant pests and diseases, minimizing weeds on the farm and regulates evaporation (Murphy and Chirchir, 2017). These findings are echoed by a report by Davis *et al.* (2012) who established that large coffee estates specializing in one variety in Uganda were more likely to be affected by new pests and diseases than small-scale farms with a variety of new and old coffee varieties.

Table 4: Coffee Varieties grown in Mukure Ward

Coffee Varieties	Farmers	%
More than 1 Variety	194	48.4
SL28	152	38
Batian	28	7
Ruiru 11	26	6.6

Total	400	100

Majority (75%) of small-scale coffee farmers in Mukure ward had between 1 and 300 stems of coffee while a small fraction had more than 400 stems (Figure 4). The farmers have small parcels of land that can accommodate coffee farming as well as other land uses.

33% of the small-scale coffee farmers in Mukure Ward had 101 to 200 coffee stems on their farms while those with stem numbers between 201 and 300 comprised 22%. There were less than 5% of farmers with more than 500 coffee stems. The least number of stems in a farm was 4, where the farmer had uprooted some coffee stems and replaced them with banana tubers. In other instances, farmers who had small numbers of coffee stems blamed prolonged dry weather. One farmer said "*The rainfall patterns have been changing. Young seedlings have been drying every time we replace old coffee varieties. We are unable to consistently water the stems hence the low survival rate on the farms.*"

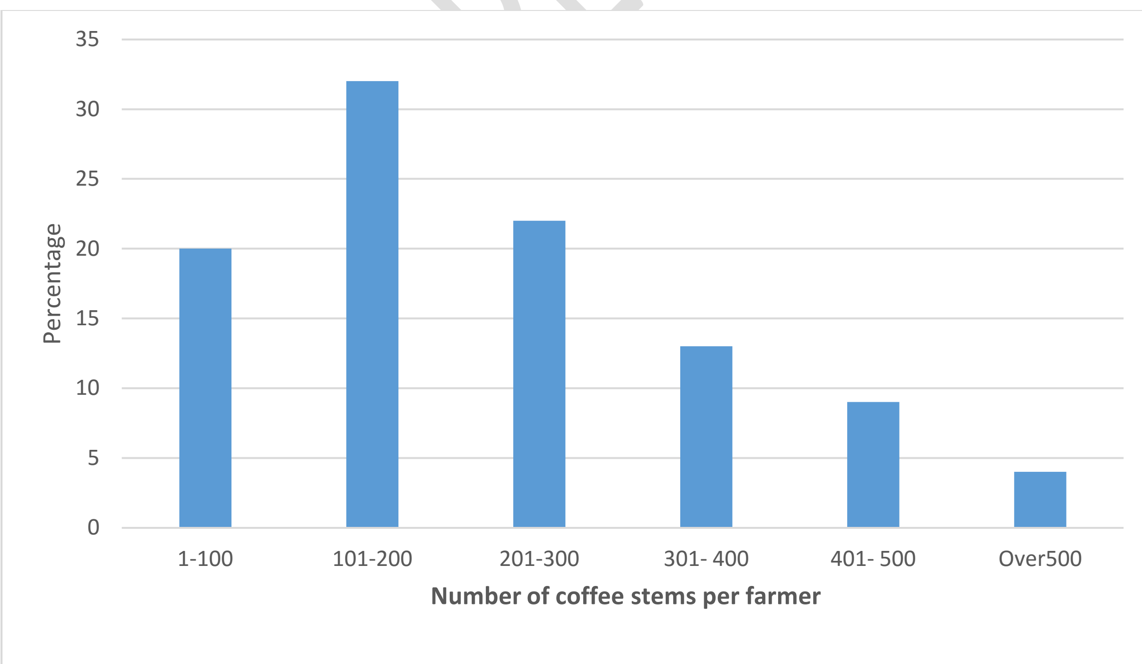

Figure 4.: Number of Coffee Stems per farmer in Mukure Ward

According to Philpot *et al.* (2020), finances and resources at the disposal of farmers dictate land ownership, and the possessions therein.

4.3.7 Size of Farm Owned by Coffee Farmers

A large fraction (62%) of the respondents possessed parcels of land smaller or equal to 1 acre (Table 5). The survey showed that many people had small parcels of land, and only a small percentage of the population owned large pieces of land. Respondents indicated that they had inherited small parcels of land, and that the value of land was too high for them to afford more/ extra sizes. One respondent said "*we inherited small parcels of land, and we have to utilize that for coffee farming and other farm practices that we desire. Land prices are exorbitant, and where they are affordable, there are ownership wrangles involved.*"

Table 5: Size of Farm owned by Respondents in Mukure Ward

Number of acres	**Frequency**	**Percentage (%)**
≤ 1	248	62
Above 1 up to 2	80	20
Above 2 up to 3	36	9
Above 3 up to 4	20	5
More than 4	16	4
Total	**400**	**100**

Going by the findings by Jayne *et al.* (2003), the regular sizes of land owned by a majority of individuals in Kenya is less than 7 acres. There is insignificant variance in farm size ownership by either gender (whether headed by a man or a lady) (x^2=2.501, df=3, p=0.5).

A breakdown on land ownership based on gender indicated that there existed insignificant difference between men and ladies in Mukure Ward (Table 6). Respondents indicated that there were as many men owning land as there were women. One respondent said: "There *are no restrictions as to who, between men and women should own land. When a spouse dies, it is automatic that land ownership reverts to the surviving spouse, unless there are pre-existing legal obstructions well-known in the community."*

Table 6: Acreage, age of respondents (n=400)

Acres	**Gender**				**Total**	
	Male		**Female**			
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
≤ 1	128	32	120	30	248	62
Above 1 up to 2	32	8	48	12	80	20
Above 2 up to 3	16	4	20	5	36	9
Above 3 up to 4	12	3	8	2	20	5
More than 4	8	2	8	2	16	4
Total	**196**	**49**	**204**	**51**	**400**	**100**

In addition, a report by FAO (2012) demonstrates that in substantive number of nations in African continent, the typical acreage owned by individuals is classified within the fragmentation of land holdings. The report further pointed out that average acreage in Asia continent declined in the period beginning 1970 and extending through the 1980s by 17%. In India, the size of land owned by an individual on average decreased from 0.64 to 0.58 hectares while that in the Philippines reduced from 3.6 to 2.6 hectares in the same period. As a way to fill the void left by the ever-shrinking size in acreage in the country, different line ministries in government, non-government organizations and partners have continued to encourage intensification of land use by use of techniques like irrigation.

4.4 Rainfall and Temperature Trends in Mukure Ward

4.4.1 Rainfall Trends

Annual rainfall in Mukure Ward has not been consistent. Data from Kenya Meteorological Department on rainfall between 1987 and 2017 depicted fluctuations between a low of 400 mm total annual in 1991 and a high of 1580 mm in 2016 (Fig 5).

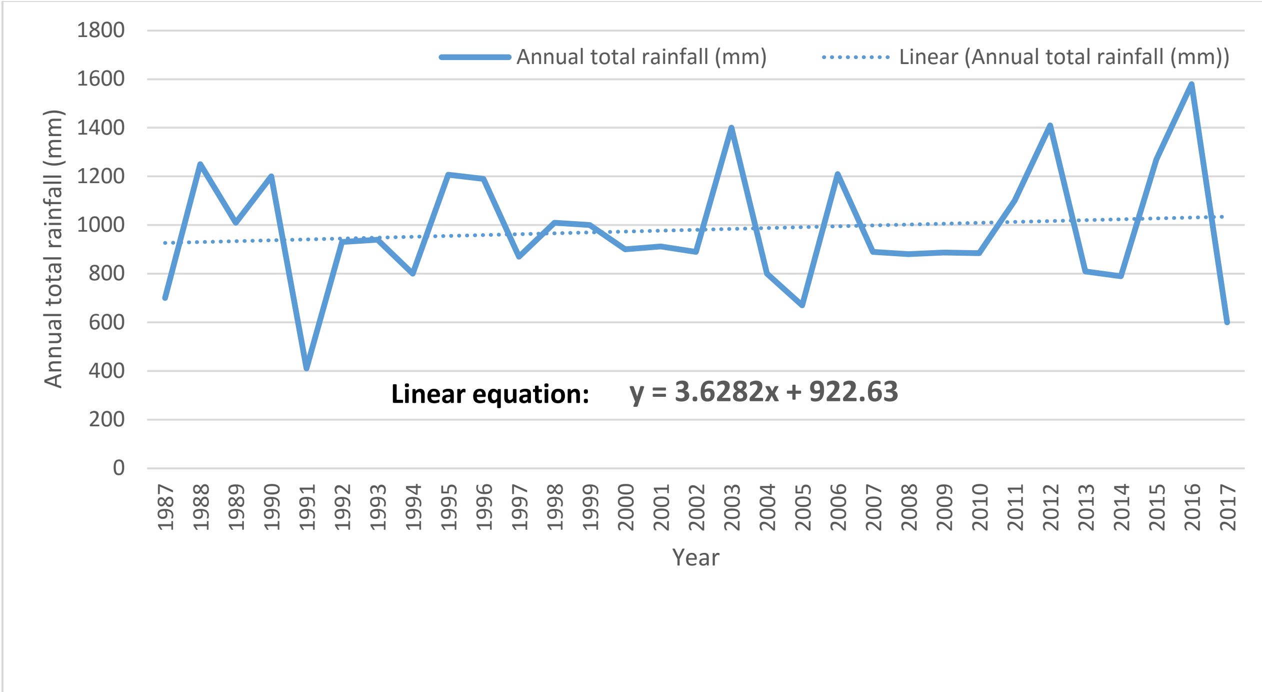

Figure 5: Yearly Total Rainfall (mm) in Mukure Ward (1987-2017)

Source: Embu Meteorological Station

4.4.2 Coefficient of Variation Calculation

Coefficient of variation was used in the research to measure the variability between rainfall (mm) amounts and time (years). The calculated coefficient of variation for rainfall was 25.49%, which is the relative size of standard deviation as a fraction of the mean. The value is greater than 1, therefore represents 25.49% degree of relative variability. It therefore means that rainfall amounts varied by 25.49% from the mean over the 30-year study period.

N: 31

M: 980.61

SS: 1936791.35

$\sigma 2 = SS/N = 1936791.35/31 = 62477.14$

$\sigma = \sqrt{\sigma 2} = \sqrt{62477.14} = 249.95$

$CV = (\sigma/M) * 100 = (249.95/980.61) * 100 = 25.49$

Coefficient of Variation= 25.4896%

The linear regression depicts a constant increase in amounts of rainfall over the period of study.

The average monthly rainfall over the study period were inconsistent, and they varied from month to another (Fig 6). It is notable that the months of January and February recorded the lowest amounts of rainfall in the study area. July and August are notably the moths that received high amounts of rainfall, the long rains. The months that follow, that's May, June and July were relatively wet as can be observed from the graph. Short rains were recorded between the months of October and extend to the end of the year (December). November is notably the wettest month during the short rains.

According to Kristine (2019), farmers across the globe are known to study rainfall trends, and adjust their planting seasons to tally with onset of wet months. These verdicts are in line with investigations by Ngigi (2009) which found out that farmers in Kirinyaga plant seasonal crops in October and July, the onsets of wet months.

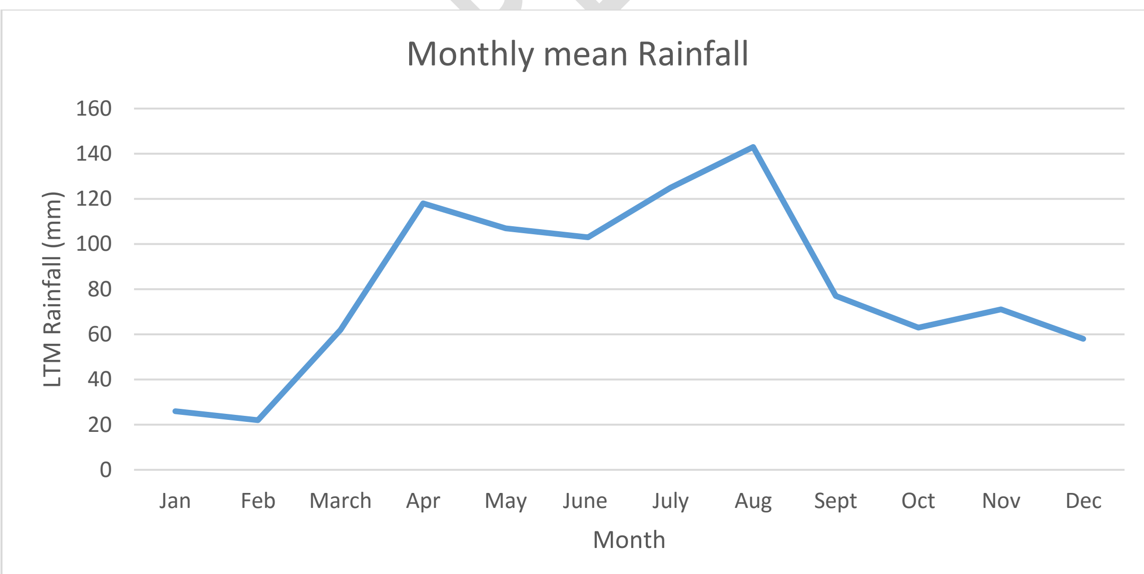

Figure 6: Long-Term Monthly Mean Rain in Mukure Ward (1987-2017)

Source: Embu Meteorological Station

The linear trend line for total annual rainfall and average monthly rainfall graphs indicates a gradual increase in amounts of rainfall received in Mukure Ward between 1987 and 2017. The findings are in conformity with research data from the Ministry of Agriculture, Cooperatives, Fisheries and Livestock (2019) that indicated that the annual average rainfall in Kirinyaga ranges between 700mm and 1400 mm. The short rains have been increasing since 1985, and the trend could continue until the year 2040 going by developed climate models based on daily precipitation of this season which is signaled by extremely wet days (Murphy and Chirchir, 2017). This is in conformity with studies by IPCC (2007) which indicated that rainfall fluctuates from time-to-time, and its spatiotemporal. These findings also corroborate those of Davis *et al. (*2012), which concluded that levels of rainfall in an area, spatial coverage as well as rainfall reliability depend on location and specific time.

4.4.7 Temperature Trends

The mean average temperatures of Mukure Ward are 18.6^{0}C. There was a steady surge in temperatures between 1987 and 2017. The highest mean temperatures were recorded in 2002-18.5^{0}C while the lowest temperatures were 17.3^{0}C recorded in 1998. As clearly observed in Fig 7 below, there was an overall increasing trend in the linear graph as portrayed by the positive slope in the trend equation.

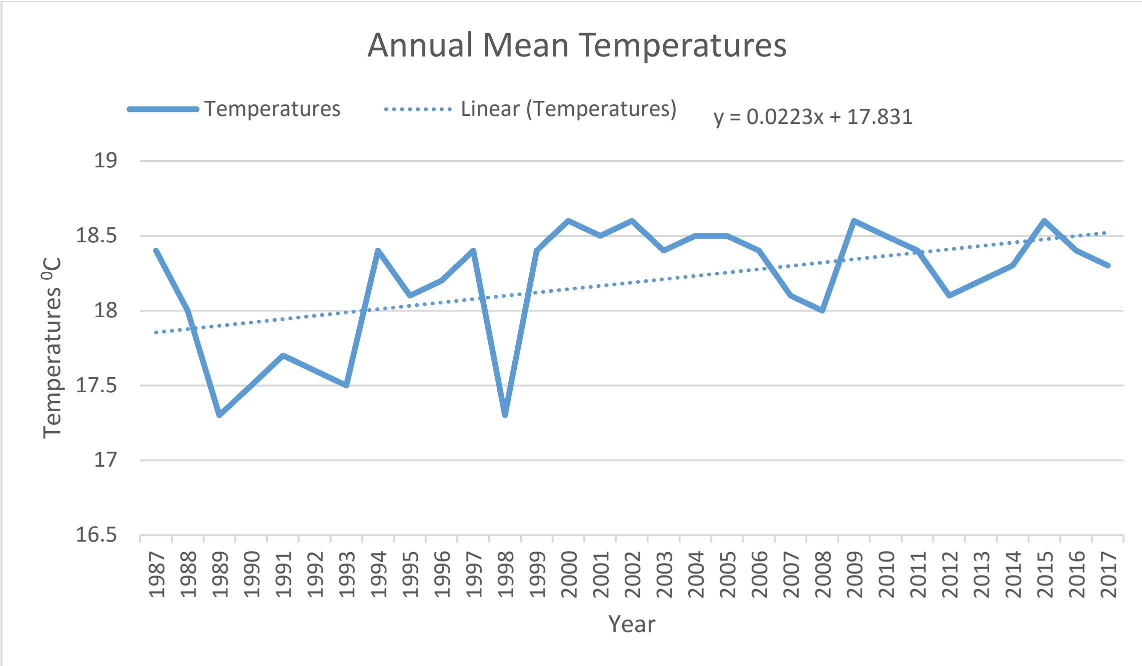

Figure 7: Annual Mean Temperature Trends in Mukure Ward (1987-2017)

Source: Embu Meteorological Station

4.4.8 Coefficient of Variation

Coefficient of variation was used in the research to measure the variability between temperatures (^{0}C) amounts and time (years). The calculated coefficient of variation for temperature was 2.13%, which is the relative size of standard deviation as a fraction of the mean. The value is greater than 1, and is therefore represents 2.13% degree of relative variability. It therefore means that rainfall amounts varied by 2.13% from the mean over the 30-year study period.

N: 31

M: 18.19

SS: 4.65

σ2 = SS⁄N =4.65/31=0.15

σ=√σ2 =√0.15=0.39

CV = (σ/M) *100 = (0.39/18.19) *100 = 2.13

Coefficient of Variation= 2.13%

There existed a general positive and regular increase in temperatures and a notable crowning being recorded at spans of 3-5 years. The overall variation in temperatures (highest- lowest) was 1.3^0C which translated to 0.043^0C every year. These results agree with data from IPCC (2001) which established that temperature levels within the East African region will rise by a margin of 0.4^0C for the period under study. The IPCC report of 2007 further stated that many parts of Africa will experience climate variation differently, and the scenario has applied to Mukure Ward.

According to Raiyera *et al.* (2009) the registered fluctuations in the temperature levels coincide with the different years that extreme weather has been registered in the world like the infamous global La Nina-linked drought of 2001. In the years 1991-1992, 2004-2006 and 2009-2010, severe drought were witnessed while intense rainfall was recorded in the year 1998 and intense frost happening in 2012 (KIPPRA, 2013).

4.5 Vulnerability of Coffee Farmers to Climate Variability

Several indicators were utilized as representatives of small-scale coffee farmers' sensitivity, adaptive capacity and exposure to effects of climate variability in Mukure Ward.

4.5.1 Farm Categories

Small-scale coffee farmers in Mukure Ward fall into three discrete farm typologies as was identified by their main sources of livelihood and investment on capital. Majority (70%) of the farmers fall under the *farm-income-founded* fraction (Figure 8). The small-scale coffee farmers in this category mainly draw their finances for day-to-day survival from farming, with occasional off-farm engagements, and they have the largest portions of land under coffee. The other group of small-scale coffee farmers comprising of 24% can be classified under *marginal and off-farm* *founded typology*. Farmers under this group have off-farm income generating activities, and rarely depend on coffee payouts. They are employed in government-and non-government institutions while others run own businesses. The third category of farm typology is the *irrigation-dependent* group, that comprises of 6% of small-scale coffee farmers under this study. Small-scale coffee farmers in this category have invested in irrigation for their coffee stems and other crops, their parcels of land are slightly larger and they use more farm inputs in the crop production process. Their financial gains from farm practices are higher.

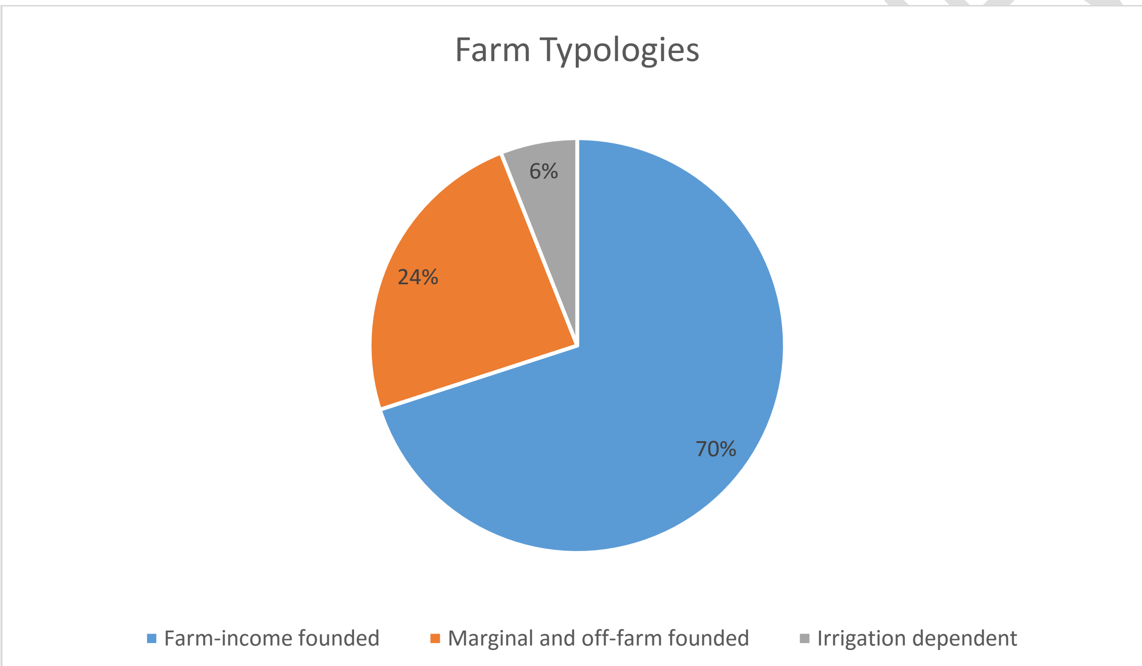

Figure 8: Small-Scale Coffee Farm Typologies in Mukure Ward

4.5.2 Exposure: Farmers Experience with Drought and Impacts of Climate Variability

Majority (48%) of the respondents had hardly experienced extreme weather conditions for the duration they had lived in Mukure Ward while 34% of the respondents had no information about drought occurrence in the region. According to this survey, 14.4% of the respondents' experience drought occasionally (Table 7). More than 30% of the respondents in Mukure Ward indicated that they didn't have any information on drought occurrence.

One of the respondents said: "*I was born here some 43 years ago. I have not experienced many extreme weather conditions like the infamous drought of 1984. Though I was young then (1984), my interactions with neighbors indicate that none of the recent incidences of drought match that of 1984. It literally left Mukure Ward's economy paralyzed.*"

Table 7: Respondents Experience with Drought

Frequency of drought	Number of respondents	Percentage (%)
Hardly experienced drought	192	48
No information on drought occurrence	136	34
Moderately to recurrent	4	1.1
Sometimes	58	14.4
Recurrent	10	2.5
Total	**400**	**100**

According to William *et al.* (2020), national drought affects more than 15% of Kenya's population, and may extend for a period of two or three consecutive seasons. It may happen once in a decade. Regional drought is experienced by less than 15% of Kenya's population, and may last for a single or two growing seasons. On the other side, local drought may occur once annually in one part of the country more so in the marginal eastern foreland plateau (Asghar *et al.,* 2019). In the local drought context, there is usually recorded rainfall variability associated with crop failure at the local level or even extreme food shortage at the times of harvest (Nazari *et al.,* 2017). William *et al.,* (2020) established that in places where experience with drought is minimal, there are low chances that the farmers in those places will conceptualize it as an occurrence.

According to Jayne *et al.* (2003), an analysis of sensitivity of individual ménages reveals the available choices for handling dire effects of climate variability. In Kenya, the sensitivity of small-scale coffee farmers to drought, crop failure and dwindling coffee yields could be attributed to loss of moisture and stress on soils. To tackle the challenge, it would be advisable to replenish the soils with moisture through intensive irrigation while at the same time looking into the options of agriculture insurance. Baumuller (2001) suggested crop insurance for coffee farmers in Sub-Saharan Africa to cushion farmers from losses that emanate from crop failure in areas where rain-fed agriculture is the norm.

Small-scale coffee farmers in Mukure Ward indicated that they had experienced effects of climate variability in different ways. Majority (42%) of the interviewed individuals indicated that they had lost assets while 19% said that they had at one point lost their crop due to climate variability (Fig 9).

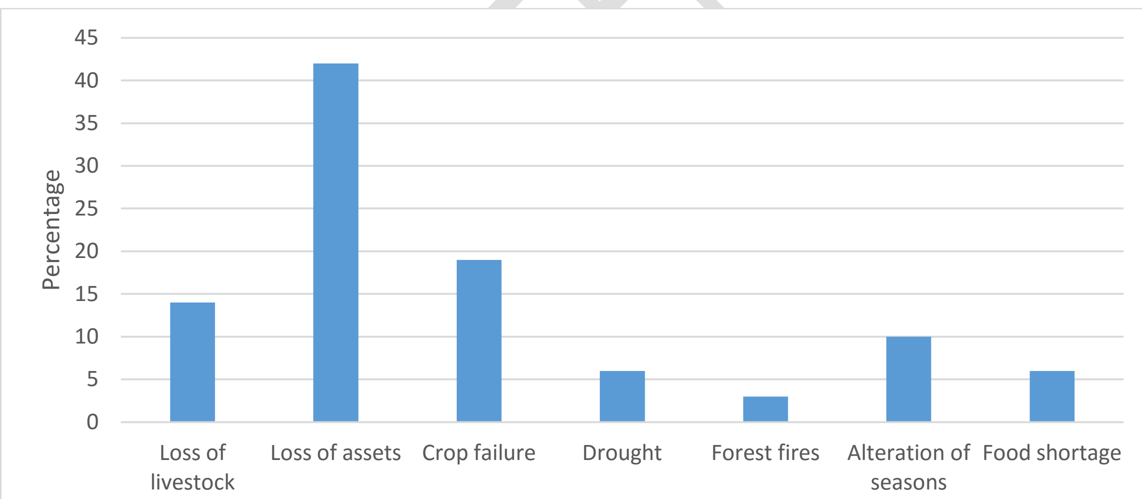

Figure 9: Impacts Attributed to Climate Variability in Mukure Ward

A society's experience with climate variability is essential in tackling emanating effects. People's exposure to climate variability increases when they lack the understanding of the changes that their environment is undergoing. Jayne *et al.*, (2003) argued that climate variability was more likely to be noted as a major phenomenon among farmers who practice irrigation all-year round.

The unique agro-ecological zone under which Mukure Ward falls results in unique exposure to drought amongst small-scale coffee farmers. This variance can be attributed to different farmers' socio-economic characteristics, differences in physical characteristics of the area and unique lifestyles of residents. There is need to intensify efforts to educate farmers on climate variability, especially those that rely more on irrigation, and those that rarely depend on farming for survival in Mukure Ward so as to improve overall adaptation capacity of the community.

4.5.3 Sensitivity: Coffee Production, Pests and Diseases

Majority (90%) of farmers in Mukure Ward indicated that average coffee production had decreased in the last 10 years (Table 8).

Table 8: Respondents View of Coffee Production Trends in the last 10 years

Trends in Coffee Yields	Frequency	Percentage
Yields have increased	16	4
Yields have reduced	360	90
Yields have remained the same	24	6
Total	**400**	**100**

Communities that rely mainly on cultivation stand high chances of being affected by variation in environmental conditions of the area (Nazari *et al.*, 2017). The economy of small-scale coffee farmers in Mukure Ward is dependent on farming systems and is therefore tied to the environmental sensitivity to the ecosystem. Respondents indicated that crop failure is common, a scenario that has exacerbated crop production over time. Rainfall amounts have been increasing over time, but coffee yields have been decreasing. This is due to increase in rainfall intensity over short spans, often resulting in flooding, soil erosion and damage of coffee bushes as opposed to even distribution of rainfall amounts throughout the year (Ngigi, 2009). The small percentage (4%) that registered increase in coffee yields was as a result of intensive application of adaptation strategies to counter impacts of climate variability (Nzeadibe *et al.*, 2011).

Majority (73%) of small-scale coffee farmers in Mukure Ward depend on rain to water coffee stems throughout the year. 13% of the respondents use piped water to water coffee stems during drought while 9% pump water from rivers and use it for irrigation. 5% of the respondents use water from wells to water their stems (Fig 10).

One of the respondents said: "*I have only used piped water once to irrigate young coffee stems a few months after their planting. Since then, I rely on rainfall even in times of drought.*"

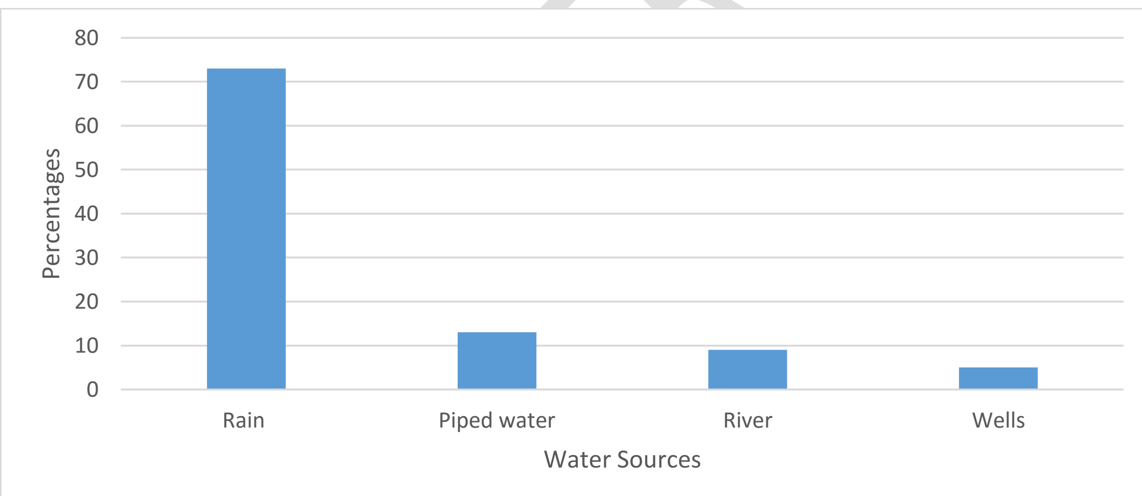

Figure 10: Sources of Water for Coffee Farming in Mukure Ward

The unpredictable and erratic rainfall pattern in Mukure Ward, especially in the main growing period has negatively affected coffee production. Farmers who practice crop irrigation throughout the year are less sensitive to drought than farmers who rely on rain fed agriculture. An area's rainfall variability in space and time has made it complicated for farmers to tell when to expect rains, and this spatiotemporal precipitation scenario is highly attributed to crop failure (Kristine, 2019).

Farmers in Mukure Ward reported that they have been experiencing new berry diseases unlike in the past (Plate 1). One of the farmers said: "*We have been fighting different variants of the sooty mould over the years. It is strange that it is persistent in all seasons, and it develops resistance to new pesticides each time they are introduced.*"

Plate 1: A Coffee Berry infested by Sooty Mould (*Capnodium spp.)*Disease

Crop diseases are fast spreading fast in many parts of the world (Kane and Shogren, 2000). The crop diseases that have been found to be predominant in East Africa are coffee berry disease (*Colletotrichum kahawae*), sooty mould (*Capnodium spp.)* and brown eye spot (*Cercospora coffeicola).* Small-scale coffee farmers in Kenya own small parcels of land, and are as such the farmers who are bound to be highly hit by spread of coffee pests and diseases (Kasterine *et al.*, 2010). Spread in pests is influenced by changing environmental conditions in the favor of destructive pests further escalating the risk of farmers to effects of drought.

Kasterine *et al.*, (2010) found out that Antestia bugs that are mostly found in the dry season lead to rotting of coffee beans, cause blackening of buds and cause change in the color of the berry pulp thereby compromising coffee quality and quantity. Attack on coffee berries by pests often result in "zebra beans"- a result of coffee berries' attack by pests leading to poor taste and overall appeal. It has been attributed to low market prices globally (Morton, 2007).

4.5.4 Adaptive Capacity: Wealth, Technology, Access to Infrastructure and Diversification in Income Sources

Majority (66%) of the respondents indicated that it took them a maximum of 20 minutes to get to the nearest market while 23% mentioned that it took them 21 to 40 minutes to access the facility (Table 9). Only 5% of the respondents took more than an hour to get to the market.

Table 9: Time taken by Respondents to reach Nearest Market

Distance to nearest market	Frequency	Percentage
1-20 minutes	264	66
21-40 minutes	92	23
41 minutes- 1 hour	24	6
More than 1 hour	20	5
Total	**400**	**100**

Majority (62%) of the people interviewed indicated that they had access to transportation means while 38% struggled to afford decent transport for themselves and their goods (Fig 11).

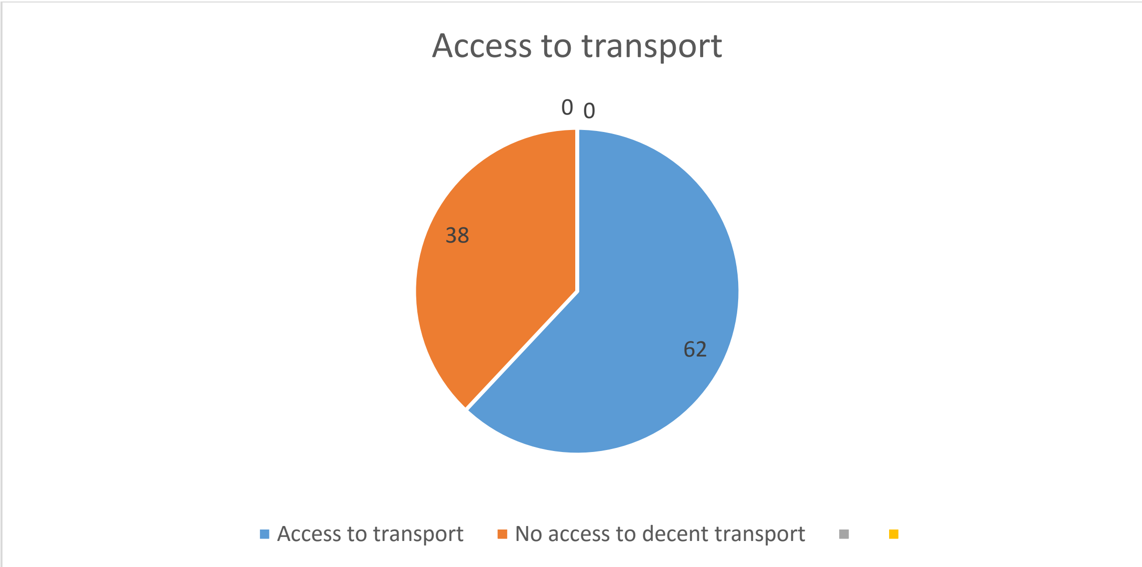

Figure 11: Respondents' Access to Transport

A substantive fraction of respondents (72%) had access to electricity while 28% weren't connected to electricity mains (Fig 12).

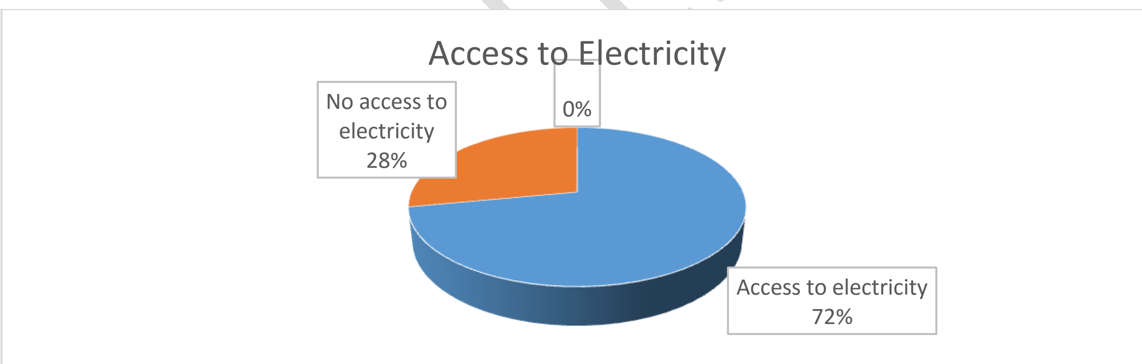

Figure 12: Respondents' Access to Electricity

Access to transport, markets and connectivity to electricity mains are directly linked to the quality of life of the small-scale coffee farmers, and the productivity of the families concerned (Pathak *et al.*, 2012). For instance, connectivity to electricity could diversify the family's income by way of micro-processing and trading. According to Nazari *et al* (2017), efficient access to electricity for lighting can enhance school-going children's learning capacity since they can easily do assignments at night while other members of the family follow news on TV sets and access information on weather and local market trends, or make extra income from services that require electricity.

Small-scale coffee farmers were not well-experienced in use of local technology such as water pumps and electric incubation units. Out of the 400 interviewees, only 32, representing 8% of the farmers had experience in using irrigation technologies such as water pumps, sprinklers and drip irrigation systems and application of appropriate farm inputs (Fig 13).

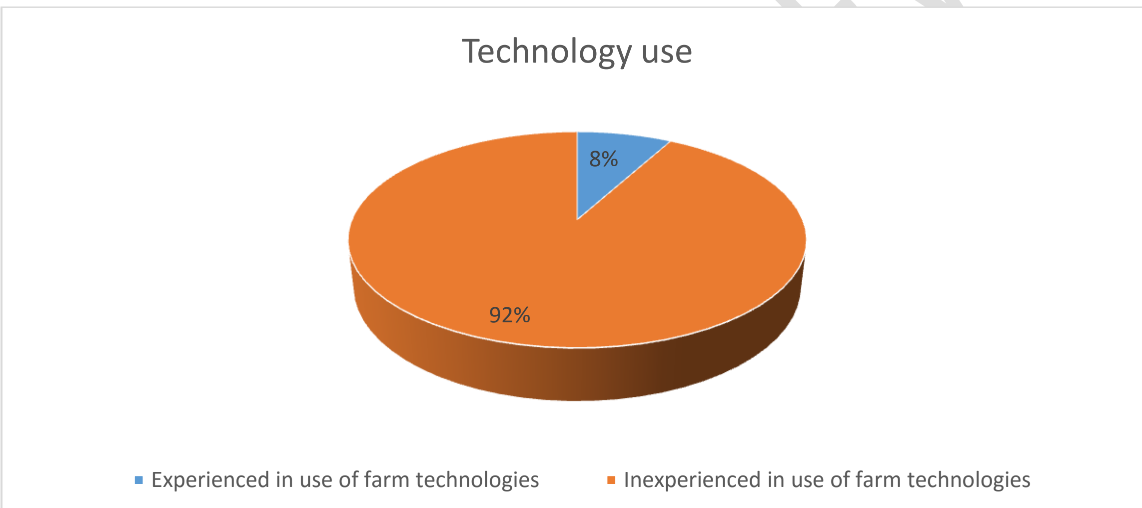

Figure 13: Respondents' Experience in use of Farm Technology

Access to agricultural technology could influence the overall productivity on the farms, and therefore the income of farmers. Adaptive capacity development initiatives by different stakeholders can focus on improved access and utilization of rural technologies in Mukure Ward (Nazari *et al.*, 2017).

Majority (48%) of the small-scale coffee farmers in Mukure ward sought external assistance to manage their farms through engagement of casuals, staff on monthly pay (19%), or seasonal employees (9%) (Fig 14). There are some farmers whose parcels of land were managed by their own family members on a day-to-day-basis. The figure below illustrates this

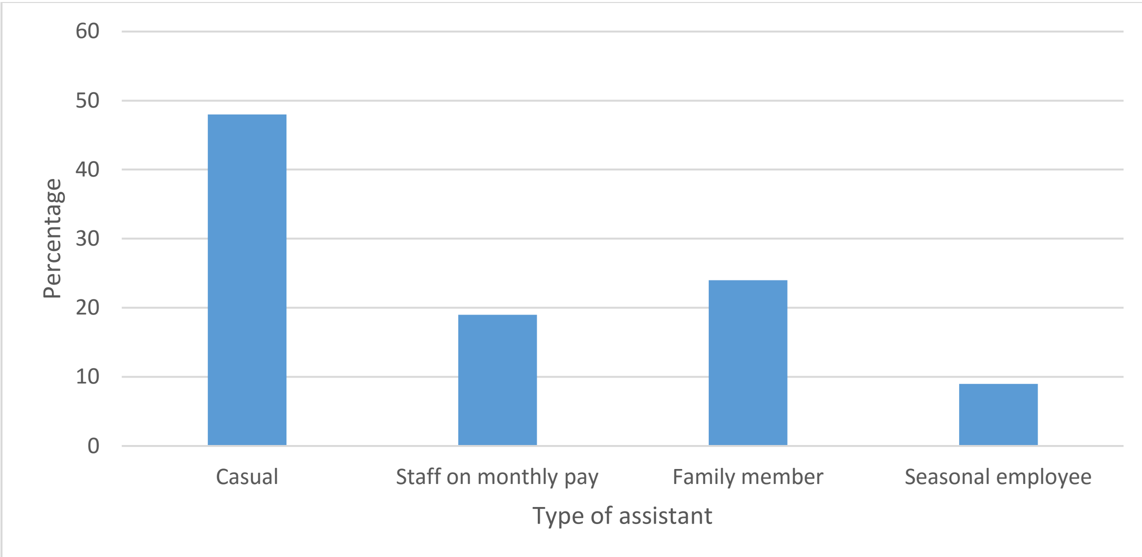

Figure 14: Mode of Management used by Small Scale Coffee Farmers

The farmers cited lack adequate financial resources to deploy professional coffee managers on a permanent employment basis. This is so because the earnings they reap from their farms can in most cases cater for their daily expenditures and casual laborers on need basis.

Wealth is an important attribute in a community that mainly relies on agricultural practices for livelihood. For example, it’s not easy for small-scale farmers to meet financial obligations if they don’t have livestock and crops on land, which significantly count as wealth among local farmers (Ncube *et al.*, 2003). Farmers in Mukure ward have small parcels of land that restrain them from diversification, and expanding farm practices. This attribute exposes farmers as highly vulnerable to effects of drought. Lack of experience in technology coupled with limited diversification on their farms limits the farmers’ future prosperity and restricts the farmers adaptive capacity in tackling effects of drought.

Diversification in income-generating activities is a major determinant of adaptive capacity among small-scale coffee farmers in Mukure Ward. Assessment of respondents' engagement in alternative ventures other than farming, access to water for irrigation, and therefore involvement in irrigation ventures revealed that 22% were employed, 92% practiced mixed cropping on their farms while those that had livestock on the same parcel of land comprised 73% (Table 10).

Table 10: Respondents' Diversification in Income-generating Activities

Income generating activity	**Frequency**	**Percentage**
Employed by government/ private entity	89	22
Practice of mixed cropping	366	92
Keeping livestock on farm	291	73
Own private business	125	31

The factors considered showed that small-scale coffee farmers were less vulnerable to climate variability since they had diversified in livelihoods. This, consequentially meant that the households adaptive capacity to impacts of drought were high. According to FAO (2011), income diversification ensures that farmers have more livelihood opportunities, a necessary component in the rural small-scale coffee farmers development of resilience. Farmers who have more opportunities can easily switch from one engagement to another, giving space to better response to effects of effects of climate variability, as well as improved life resilience.

Residents accessed information from different sources. Majority (33%) got the information through radio broadcast while 23% accessed it via Television programs (Table 11).

Table 11: Main Sources of Information on Weather and Climate

Institution	Respondents	%
Radio	135	33.2
TV	92	23
Chiefs Barazas	80	20
NGOs	72	18
Coffee Marketers	8	2
Agricultural experts and teachers	21	3.8
Total	**400**	**100**

Access to information in a large way influences the level of adaptive capacity (William *et al.*, 2020). In Mukure Ward, building resilience of small-scale coffee farmers calls for strengthening of different social networks that exist between farmers, such as the coffee unions and farmers' associations. This is of course not to mean that the influence from radio and television broadcasts is underrated. Social networks have been found to be very effective in spreading information in rural set-ups in the era of cell-phones and in set-ups where farmers subscribe to farmers' associations like water-users association (Davis *et al.,* 2012). The role of local leadership, especially the administrators and coffee marketers must not be ignored if dissemination of information is to be effectively done.

Respondents seek help from government bodies, non-government institutions, close allies and immediate family members to recover after losses due to extreme weather. According to the respondents, family members were ranked highly (43%), followed by friends (19%) (Figure 4.15). Other sources of help were government institutions, charitable organizations and non-government institutions (16%). The respondents indicated that the help came in form of information on better farming methods (38%), external assistance (37%), water projects (18%). There were other forms of assistance like provision of planting seeds and food items.

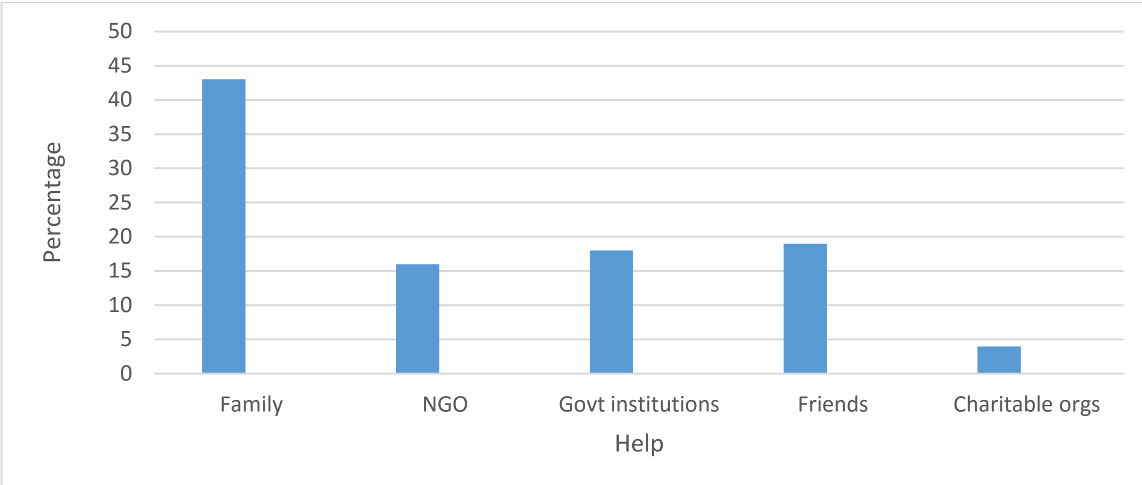

Figure 15: Source of Help in Times of Extreme Weather

Respondents indicated that they sought different types of help after losses due to extreme weather. They included better farming methods, water projects and food items (Figure 16).

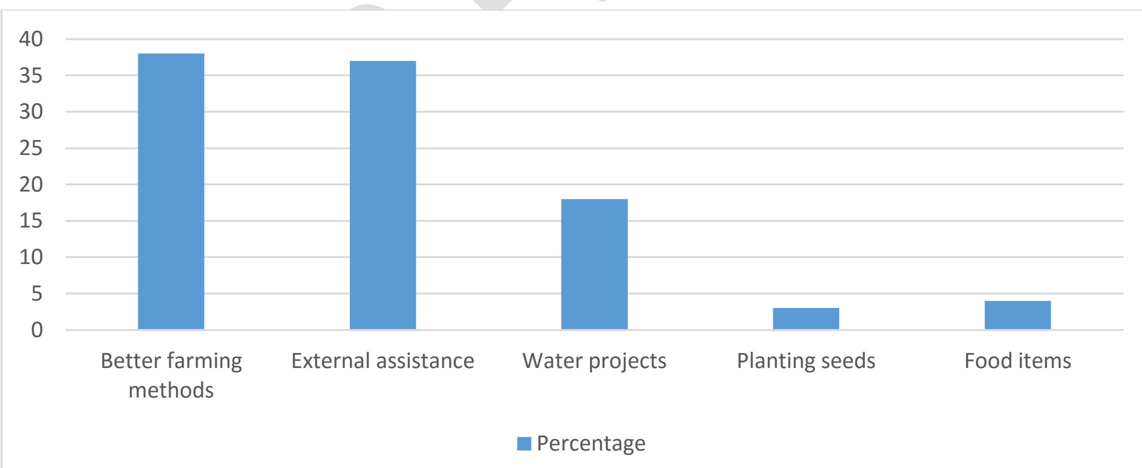

Figure 16: Type of Help Offered

Majority (77%) of the respondents indicated that they had access to loans from different financial institutions to enhance their small-scale coffee farming activities (Fig 17).

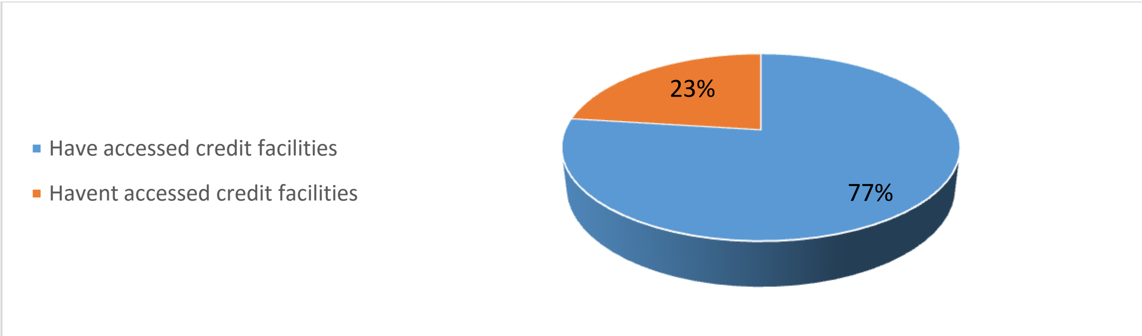

Figure 17: Access to Credit by Small-scale Coffee Farmers

Respondents who could not secure advance payments or loans at times of extreme weather conditions indicated that their credit worthiness had been compromised by other uncleared loans (44%), failure to meet minimum conditions set by banks (32%) and lack of collateral commensurate to credit sought. According to William, *et al.*, (2020), access to credit facilities has an impact on farmers' threats to impacts of weather extremes. Individuals who can access financial loans with ease stand lesser chances of suffering from climate variability threats than those who can hardly access the facility.

Respondents indicated that they experienced challenges while trying to access credit facilities. The challenges ranged from cases of previously defaulted loans (44%) to unmatched collateral that couldn't guarantee them financial credit (29%) (Fig 18).

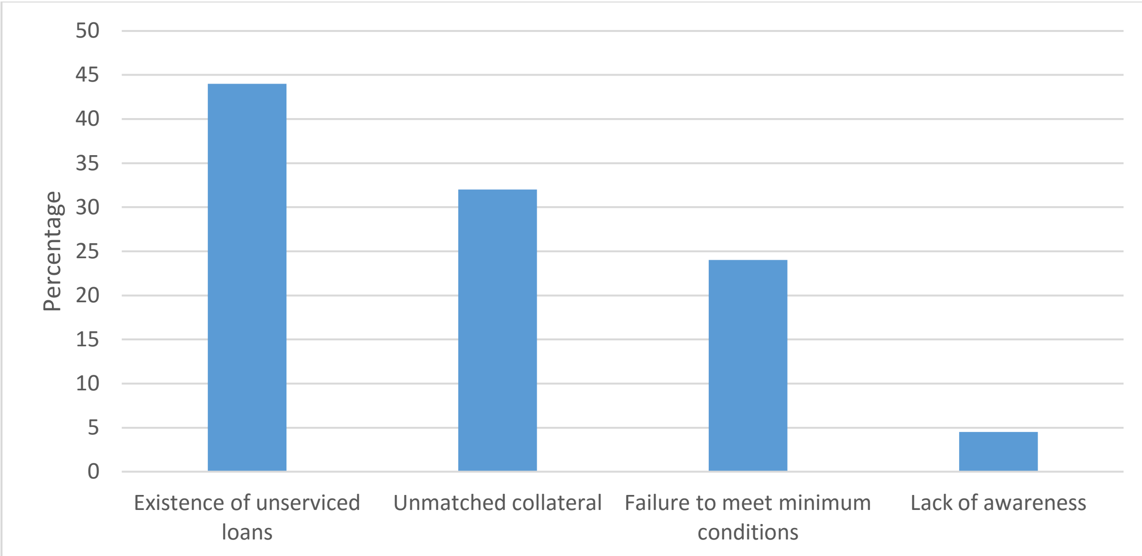

Figure 18: Reasons for denial of Credit Facilities by Financial Institutions

Adaptive capacity is determined by apposite functionality of a society's sociodemographic characteristics, availability of local infrastructure and their socio system. Improvement of the adaptive capacity calls for improvement of farmers' experience with local technology, diversification in income-generating activities and encouraging farmers to develop a saving culture.

Discussion

Small-scale coffee farmers in Mukure Ward were found to be highly exposed to climate variability effects. The farmers were exposed to drought risks and effects of prolonged climate variability. In the aspect of sensitivity, they were found to be sensitive to drought since only a small fraction practiced irrigation throughout the year. Small-scale coffee farmers in Mukure Ward however had a good adaptive capacity, that made them cope with effects of exposure as well as sensitivity. Farmers who practiced irrigation in general were less susceptible to climate variability effects as likened with their counterparts who rely on rain-fed agriculture since the former's adaptive capacity is higher.

In order to minimize exposure and sensitivity of Mukure Ward's small-scale coffee farmers, it would imperative that they consider growing crop varieties that withstand moisture stress and integrated with existing coffee stems. It will also be necessary to adequately manage the sensitivity of the environment that tolerates presence of certain pests and diseases in coffee. Chemicals and farm inputs used must be utilized within specified time spans and in rightful amounts. Use of agricultural insurance should be considered, especially where drought is inevitable. Use of rural technologies should be within the farmers' reach, and utilization of irrigation where rain-fed agriculture has been the case encouraged. Finally, farmer-tailored technologies for Mukure Ward should be developed if exposure and sensitivity is to be addressed.

Conclusion

The study concluded that small-scale coffee farmers were highly exposed to climate variability effects. The farmers were exposed to drought risks and effects of prolonged climate variability. In the aspect of sensitivity, they were found to be sensitive to drought since only a small fraction practiced irrigation throughout the year. Small-scale coffee farmers in Mukure Ward however had a good adaptive capacity, that made them cope with effects of exposure as well as sensitivity. Farmers who practiced irrigation in general were less vulnerable to climate variability effects as likened to their counterparts who rely on rain-fed agriculture since the former's adaptive capacity is higher.

REFERENCES

Adzawla, W. & Baumuller, H. (2001). Effects of Livelihood Diversification on Gendered Climate Vulnerability in Northern Ghana. Environment, Development and Sustainability

Agbogidi, O.M, (2011). Global Climate Change: A Threat to Food Security and Environmental Conservation. British Journal of Environment & Climate Change, 1(3), 74-89

Al-Balushi, S. M., Al-Musawi, A. S., Ambusaidi, A. K., & Al-Hajri, F. H. (2017). The effectiveness of interacting with scientific animations in chemistry using mobile devices on grade 12 students' spatial ability and scientific reasoning skills. *Journal of Science Education and Technology*, *26*(1), 70-81.

Alim, N., Linda, W., Gunawan, F., & Saad, M. S. M. (2019). The effectiveness of Google classroom as an instructional media: A case of state islamic institute of Kendari, Indonesia. *Humanities & Social Sciences Reviews*, *7*(2), 240-246.

Asghar, M. Z., Rahman, F., Kundi, F. M., & Ahmad, S. (2019). Development of stock market trend prediction system using multiple regression. *Computational and mathematical organization theory*, *25*(3), 271-301.

Baker, P.S. and Haggar, J. (2007). Global Warming: The Impact of Global Coffee. *Specialty Coffee Association of America Conference Handout,* Long Beach, 14 pp

Brown, M. E., and Funk, C.C (2008). Food Security under Climate Change. Science 319:580–581.

DaMatta FM (2006). Ecophysiological Constraints on the Production of Shaded and Unshaded Coffee: A Review. Field Crop Res 86:99–114.

Damatta FM, Ronchi CP, Maestri M, Barros RS (2008). Ecophysiology of Coffee Growth and Production. Braz. J. Plant Physiol.19:485–510.

Daoud, J. I. (2017, December). Multicollinearity and Regression Analysis. In *Journal of Physics*: Conference Series (Vol. 949, No. 1, p. 012009). IOP Publishing.

Davis AP, Gole TW, Baena S, Moat J (2012). The Impact of Climate Change on Indigenous Arabica Coffee (Coffea arabica): Predicting Future Trends and Identifying Priorities. PLoS One 7(11):e47981.

Dutta, R. (2014). Climate Change and its Impact on Tea in Northeast India. *Journal of Water and Climate Change, 5*(4), 625-632

Eakin, H. and Wehbe, M.B. (2005). Linking Local Vulnerability to System Sustainability in a Resilient Framework: Two Cases from Latin America. La Jolla, C A. pp 19

Enomoto R (2011). Climate-friendly and Productive farming Guide for Coffee smallholders in Africa.

FAO. (2012). "Towards the future we want, end hunger and make the transition to sustainable Agricultural and food systems". Rome.

FAO. (2011e). "FAO's Framework Programme on Climate Change Adaptation". Rome

FEWS-NET, 2010. Food Security in East Africa. *Retrieved June 2020.*

Ganti, A. (2020). Correlation coefficient. Corp. Finance. Account, 9, 145-152.

Gbetibou, G. A. (2009). Understanding farmers' perceptions and adaptations to climate change and variability: The Case of the Limpopo Basin, South Africa (IFPRI Discussion Paper). Washington DC: International Food Policy Research Institute.

Gelman, A., Goodrich, B., Gabry, J., & Vehtari, A. (2019). R-squared for Bayesian Regression Models. The American Statistician.

GIZ. (2010). Climate change adaptation and mitigation in the Kenyan coffee sector. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany.

Government of Kenya. (2009). Statistical Analysis of TourismTrends Globally and Locally, Ministry of Tourism and Wildlife, Republic of Kenya. accessible http://www.tourism.go.ke/ministry.nsf/doc/Tourism_Trends_OCT2006_Revised.pdf/$file/ Tourism_Trends_OCT2006.

Hartmann, D. L., A. M. G. Klein Tank, M. Rusticucci, L. V. Alexander, S. Bronnimann, Y. Charabi, et al. (2013). Observations: atmosphere and surface. Pp. 159–254

Holvoet, N. (2016). Intersections of Gender and Marital Status in Accessing Climate Change Adaptation: Evidence from Rural Tanzania. MacMillan Publishers, Nairobi

Iscaro, J (2014). The Impact of climate change on coffee production in Colombia and Ethiopia. Global Majority E-Journal, 5(1):33-43

Jaramillo, J., E. Muchugu, F. E. Vega, A. Davis, C. Borgemeister, and A. Chabi-Olaye. (2011). Some Like it Hot: The Influence and Implications of Climate Change on Coffee Berry Borer (*Hypothenemus hampei*) and Coffee Production in East Africa.

Jayne, T.S., Yamano, T., Weber, M., Tschirley, D., Benfica, R., Chapoto, A., and B. Zulu (2003). Smallholder income and land distribution in Africa. Implications for poverty reduction strategies. *Food Policy* 28 (3) pp253-275

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi- structured interview guide. Journal of advanced nursing, 72(12), 2954-2965.

Kane, S.M. and J.F. Shogren, (2000). Linking Adaptation and Mitigation in Climate Change Policy. *Climate Change*, 45 (1), 75-102

Kasterine A, Scholer M, Hilten JH (2010). Climate Change and the Coffee Industry. Abstract for trade information services. International Trade Centre, Palais des Nations, 1211 Geneva 10, Switzerland.

Kenya Bureau of Statistics, 2010. 2009Kenya Population and Housing Census, Nairobi

Killeen JT, Harper G (2016). Coffee in the 21st century. Will Climate Change and Increased Demand Lead to New Deforestation?

Kraus, L., Wechsung, I., & Möller, S. (2017). Psychological needs as motivators for security and privacy actions on smartphones. Journal of Information Security and Applications, 34, 34-45.

Krishnamurthy, S. and Dejan, V. (2009). *The Global Public Relations Handbook Revised Edition,* 329. (Taylor & Francis: 2009). Routledge Publishers. New York. ISBN 13:978-203-88937-4(ebk).

Kristine, A. (2019). How Climate Change Impacts Women Farmers- And What We're Doing about It. Oxford University Press, New York

Lin, B. B., Perfecto, I., and Vandermeer, J. (2008). Synergies Between Agricultural Intensification and Climate Change could Create Surprising Vulnerabilities for Crops. *Bioscience* 58: 847-855

Marginson, S. (2016). High participation systems of higher education. The Journal of Higher Education, 87(2), 243-271.

Martin, R. & Sunley, P. (2006). Path Dependence and Regional Economic Evolution. *Journal of Economic Geography* 6 (4), 395-437

Momanyi, S., Mutai, N. & Bii, J. (2012). Attracting Young People to Farming. Agfax. Reporting Science in Africa.

Morton JF (2007). The Impact of Climate Change on Smallholders and Subsistence Agriculture. National Academy of Sciences, Washington, DC

Mugenda, O. M., and Mugenda, A. G. (1999). Research Methods: Quantitative and Qualitative. Nairobi: ACTS Press.

Murphy,D. and Chirchir, D. (2017). Kenya County Integrated Development Plans (CIDPs) 2013-2017: Review of Climate Change Mainstreaming. StARCK+ Technical Assistance to Government of Kenya

Mwenda, A. and Kibutu, T. (2012). Implications of the New Constitution on Environmental Management in Kenya. Law, Environment and Development Journal, 1(1)

Nazari, S. Pezeshki, H., Sedighi, H. & Azadi, H. (2017). Vulnerability of Wheat Farmers: Towards A Conceptual Framework. PP. 517-532

Ncube, M., Madubula, N., Ngwenya, H., Zinyengere, N., Zhou, L., Francis, J. & Madzivhandila, T. (2013). Climate Change, Household Vulnerability and Smart Agriculture: The Case of two South African Provinces. *Disaster Risk Studies*, pp. 6-8

Ngigi, S.N. (2009). Climate Change Adaptation Strategies: Water Resources Management Options for Smallholder Farming Systems in Sub-Saharan Africa. *The MDG Centre, East and South Saharan Africa.* The Earth Institute at Columbia University

Nzeadibe, T.C., Egbule, C. L., Chukwuone, N. A & Agu, V. C. (2011). Farmers' Pereption of Climate Change Governance and Adaptation Constraints in Niger Delta Region of Nigeria. Published by the African Technology Policy Studies Network Nairobi, Kenya

Onang'o, O. T., & Orodho, J. A. (2016). Effects of level of adequacy of higher education loans on participation rates of students in distance degree programmes at Kenyatta University, Kenya. Research on Humanities and Social Sciences, 6(8), 66-73.

Philpot, S. M., Arendt W. J, Armbrecht, I.,Bichier, P., Dietsch, T. V., Gordon, C., Greenberg, R. (2008). Biodiversity Loss in Latin American Coffee Landscapes: Review of the Evidence on Ants, Birds and Trees. *Conservation Biology*. 22: 1093-1105.

Poerbonegoro, G. A., & Setiawan, M. (2017). The Phenomena of Organizational Structure Change as Change Factor of Financial Consultant's Motivation.

Sappleton, N., & Lourenço, F. (2016). Email subject lines and response rates to invitations to participate in a web survey and a face-to-face interview: the sound of silence. International Journal of Social Research Methodology, 19(5), 611-622.

Sharon L. Lohr (2009). Sampling: Design and Analysis. Second Edition. Arizona State University. USA

UNDP, 2012. *Factoring Weather and climate information and products into disaster management policy: A contribution to strategies for disaster reduction in Kenya,* Nairobi, Kenya.

URT. (2003). Initial national communication under the United Nations Framework Convention on Climate Change (UNFCCC). United Republic of Tanzania, Vice President's Office, Dar es Salaam, Tanzania.

William, A., Azumah, B., Anani, P., Donkoh, S. (2020). Analysis of Farm Households' Percieved Climate Change Impacts, Vulnerability and Resilience in Ghana. *Scientific African Journal*

Wintgens JN (ed) (2009) Coffee: Growing, Processing, Sustainable Production - A Guidebook for Growers, Processors, Traders, and Researchers, 2nd edn. Wiley-VCH, Weinheim