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Climate related challenges faced by smallholder farmers in Kimira Oluch Smallholder IrrigationProject in Homabay County, Kenya

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Abstract:
Climate change is global problem with profound negative impacts on Agriculture. The Agricultural sector in Kenya directly contributes 26% of the GDP, creates 70% of informal jobs in rural areas and forms 65% of total exports making it a critical sector of the economy. Many projects therefore aim to address the negative impacts of climate change through improving the adaptive capacity of farmers. Adaptation and Mitigation are the two main approaches used to address the negative impacts of climate change. The purpose of this study was to determine climate related challenges faced by smallholder farmers in Kimira Oluch Smallholder Irrigation Project in Homabay County, Kenya.
The study used descriptive survey design for the collection of quantitative and qualitative data for results triangulation and in-depth understanding. Study population consisted of 3000 farmers while sample size of 353 was determine using n= N/ [1+N (e)2] and a 95% level of confidence. Data was analyzed using descriptive statistics. From the results, 90% of the respondents indicated droughts affect their farming practices while 58% indicated floods and 86% high temperatures. The study concludes that changes in climatic patterns results into droughts, floods and high temperatures. This makes irrigation agriculture critical for success of farmers. The researcher recommends that scholars should conduct research on factors influencing adaptive capacity of smallholder farmers to climate change. Moreover, case studies other than smallholder farmers' projects should be used to verify the findings for further generalization.
Key Word: Climate Change; Adaptation; Mitigation

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I. Introduction

The increased emission of greenhouse gases due to human activities has led to rapid global climate change of increased temperatures and erratic rainfall patterns resulting into extreme droughts, floods and increased incidence of pests and diseases that negatively affects livestock and crop production leading to food insecurity[i,ii]. Consequently, nearly 690 million people or 8.9% of the global population are hungry which is up by nearly 60 million in five years and the situation will be exacerbated as the world will need to produce 70% more food by 2050 to feed an estimated 9 billion people[iii]. Even though, Agriculture constitutes approximately 30% of the annual Gross Domestic Product of Africa, 80% of its population remains vulnerable as they depend on rain-fed agriculture for food and livelihood needs[iv]. Countries in Africa, including Kenya,continues to experience decreasing rainfall and increasing temperature trends which requires farmers to adapt to climate change to increase productivity, income and food security[v]The current study therefore aims to determine climate related challenges faced by smallholder farmers in Kimira Oluch Smallholder Irrigation Project in Homabay County, Kenya.

II. Material and Methods

The design adopted for this research is descriptive survey carried out on smallholder farmers in Kimira Oluch Smallholder Irrigation Project (KOSFIP).
Study Design: Descriptive survey
Study Location: The study was conducted in Homabay County, Kenya.
Study Duration: January 2022 to December 2022.
Sample size: A total of 353 respondents out of a population size of 3,000.

Sample size calculation: The sample size was calculated using the formula n= N/ [1+N (e)2] with 95% confidencelevel where n= 3,000/(1+3,000(0.05)2. The 353 respondents give the number of lowest acceptable respondents that was required for maintaining confidence level of 95% and 0.05% sampling error.

Subjects & selection method: The study population was drawn from 3,000 smallholder farmers recruited and registered by KOSFIP Project. The 353 respondents were distributed across the following five (5) administrative unit where Kimira and Oluch Scheme lies. These were Kochia, Kagan, Kibiri, Central Karachuonyo and Kendu Bay Towndistributed as follows:

S/No.	Administration unit	No. of Households	Sample size calculation
1	Central Karachuonyo	6,755	(6,755/30,354) x 353 = 79
2	Kochia	6,498	(6,498/30,354) x 353 = 75
3.	Kibiri Ward	4,655	(4,655/30,354) x 353 = 54
4.	Kagan	8,104	(8,104/30,354) x 353 = 94
5	Kendu Bay Town	4,342	(4,342/30,354) x 353 = 51
	TOTAL	30,354	353

Inclusion criteria:

1. Smallholder farmer registered under KOSFIP Project
2. Located within Kimira and Oluch Scheme
3. Active within the 5 administrative unit
4. Either sex
5. Aged ≥ 18 years,

Procedure methodology

After ethical approval was obtained from National Commission for Science, Technology and Innovation (NACOSTI) with reference no. NACOSTI/P/19/32778/28776 a well-designed questionnaire was used to collect the data from the respondents. The Questionnaire was divided into 2 sections, (A-B), where by section A tackled demographic information while Section B: climate related challenges faced by smallholder farmers.

Statistical analysis

The method used for data analysis was descriptive statistic of frequency and percentages, with the aid of SPSS since the data that were collected were based on questions generated from both the quantitative and qualitative information. This method helped in establishing climate related problems faced by the smallholder farmers in Homabay.

III. Result

The climate related challenges were measured in terms of drought, flood, rainfall variability and extreme temperatures which negatively affects crop production. An understanding of the crops grown and the conditions under which they are grown including rain fed and irrigation agriculture were analyzedfurther.

Drought

Drought as a component of climate related challenge was referenced in terms of the time taken before receiving rainfall and the severity in relation to agricultural sustainability. The responses on the severity of droughts are shown in Table no. 1 below:

Table no. 1*:* Drought Severity

Statement Item	Drought Severity		
How often do you experience the following climate related challenges due to changes in rainfall patterns	Frequently (57%)	Moderately (33%)	Less frequently (10%)

The results in Table no. 1 indicate that the area experiences severe drought at 57%, moderate drought at 33% and mild drought at 10%.

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Rainfall Variability

Rainfall variability as a component of climate related challenge was referenced in terms of the time taken before receiving rainfall, rainfall duration and quantity received. The responses on the rainfall variability are shown in Figure no. 1.

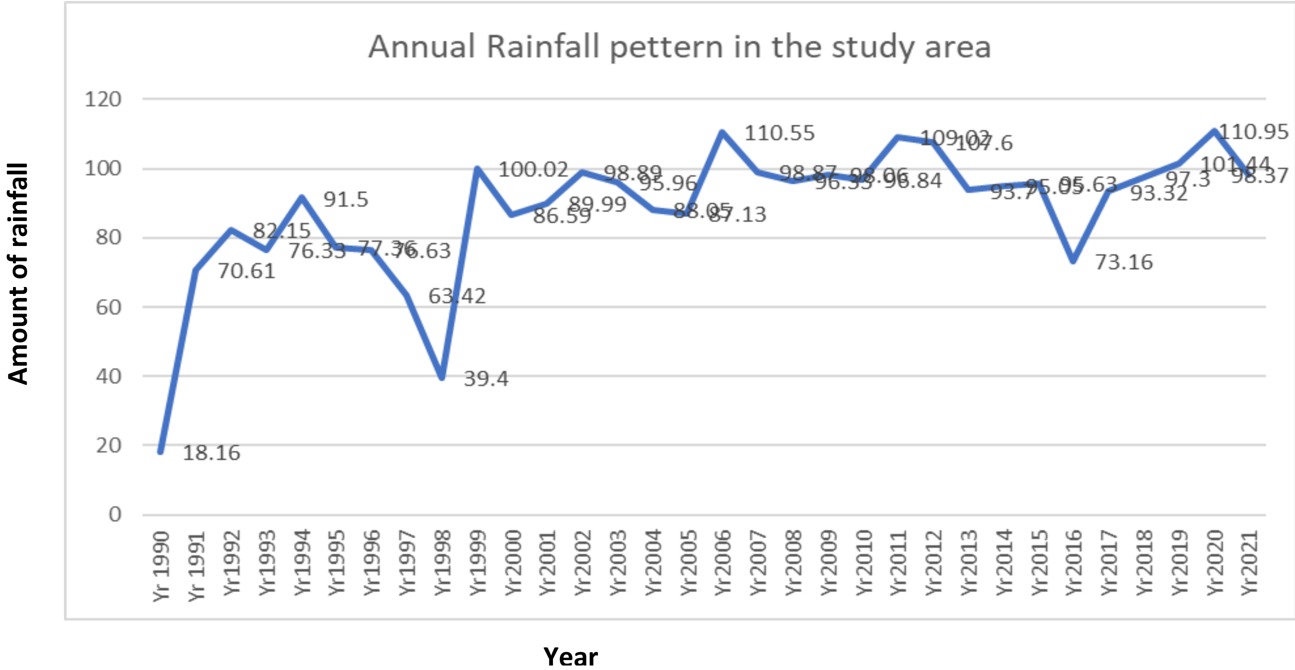

Figure no.1: Rainfall Pattern in the Study Area

The results in figure no. 1 shows that the annual average rainfall for the period do not go beyond 110.95mm which is below the amounts of rainfall required to grow some of the traditional crops like maize that requires rainfall averages of between 600mm to 1000mm for high yields. The severe rains were experienced in 1990, 1997 and 1998 that led to extreme droughts. The little amount of received rainfall causes drought, thus, making irrigation agriculture critical. The study further reviewed annual rainfall pattern for 2021 which is illustrated in Figure no. 2 below.

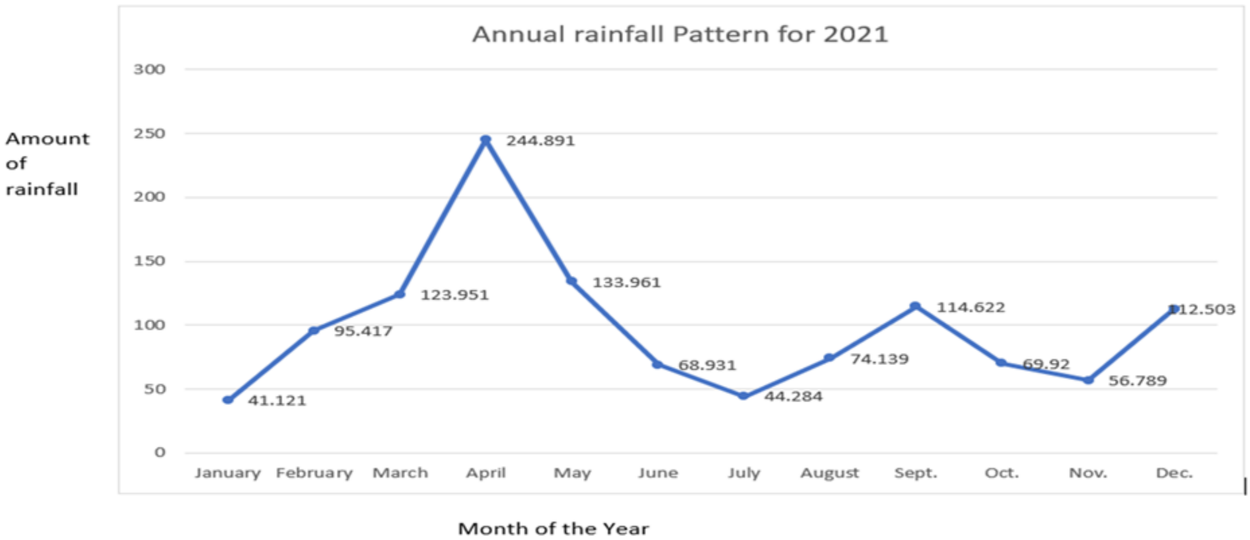

Figure no. 2: Annual rainfall pattern for 2021 (Source: Meteorological Department, 2022)

An in-depth look into the rainfall pattern in 2021 represented in figure no. 2 shows that April which is the planting season received 244.891ml of rainfall while September which is considered the second season of harvesting also receiving 114.622ml of rainfall. This was even below the required amounts of rainfall for crops like maize which require between 600mm and 1000mm for high yields. Worse still, the heavy rains in the planting seasons are followed by sharp recession which causes crops to dry prematurely leading to low or zero yields. These changes in climatic conditions can only be mitigated through irrigation agriculture, planting hybrid crop varieties and changing planting patterns.

Further, the study sought to establish annual rainfall patterns for planting and harvesting. The results were analyzed and presented in percentages as shown in Table no. 2.

Table no. 2: Rainfall Patterns for planting and harvesting in a year

Statement Item		**Month of the year**												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Onset of rains for planting	When do rains for planting season begin in a normal year	0%	14%	64%	1%	0%	0%	0%	10%	11%	0%	0%	0%	**100%**
	When do rains for planting season begin when they are early	32 %	57%	0%	0%	0%	0%	7%	4%	0%	0%	0%	0%	**100%**
	When do rains for planting season begin when they are late	0%	0%	12%	78%	0%	0%	0%	0%	0%	10%	0%	0%	**100%**
End of rains	When do rains for planting season stop in a normal year	0%	0%	0%	0%	11%	78%	0%	0%	0%	11%	0%	0%	**100%**
	When do rains for planting season stop when they are early	0%	0%	0%	12%	77%	0%	0%	0%	11%	0%	0%	0%	**100%**
	When do rains for planting season stop when they are late	0%	0%	0%	0%	0%	15%	76%	0%	0%	0%	0%	9%	**100%**

The results in Table no. 2 indicate that rains for planting and harvesting usually takes a span of 3 months but on a worse state, 2 months. A normal rain for first planting season begins in February and intensifies into March then subsides thereafter stopping in May through June. In the second planting season the rains begin in August spreading to September and stop in October. An early rain for the first planting season begins in January through February and ends in April through May. In the second planting season the rains begin in July through August and stops in September. Late rain for the first planting season begins in March through April and ends in June through July. In the second planting season the rains begin in October and stops in December. This finding is similar to data from the meteorological department showing a normal rainfall pattern in a year with April receiving the highest amount followed by a recession and September also receiving increased rainfall amounts followed by receding amounts.

Table no. 3:*Types of crops and conditions under which they are grown*

Statement Items	**Crops**							
	Maize	Beans	Rice	Sukum a wiki	Tomatoes	Arrow roots	Bananas	Sugarcane
What crops do you grow	248 (100%)	221 (89%)	129 (52%)	146 (59%)	102 (41%)	64 (26%)	114 (46%)	50 (20%)
Which crops do you grow under rain fed agriculture	248 (100%)	248 (100%)	50 (8%)	171 (69%)	184 (74%)	82 (33%)	52 (21%)	151 (61%)
Which crop do you grow under irrigation agriculture	176 (71%)	188 (76%)	248 (100%)	221 (89%)	226 (91%)	228 (92%)	226 (91%)	213 (86%)

The results in Table no. 3 indicated that farmers universally grow maize "100%" while the other crops are grown in varying proportions such as beans (52%), rice (52%), sukumawiki (59%), tomatoes (41%), arrow roots

(26%), bananas (46%) and sugarcane (20%). Majority of smallholder farmers still consider the traditional maize and beans farming as the best bet in the ever-changing climatic conditions while rice and sukumawiki were averagely grown. Further, majority of the farmers exercise crop diversification other than the universally grown maize. The diversification provides a good buffer of food security and reduces the risk of total failure on single crop farming. Concerning the conditions under which each of the cropswere grown, results shows that the crops were grown under both rain fed and irrigation agriculture. All farmers growing rice uses irrigation agriculture while majority of the farmers growing arrow roots (92%), tomatoes (91%), bananas (91%), sukumawiki (89%) and sugarcane (86%) have adopted irrigation agriculture at most seasons. However, irrigation agriculture is not purely done in isolation as farmers indicated that during rainy seasons they equally grow the crops. This is captured by 100% of farmers universally agreeing that they grow maize and beans during rainy seasons with others (71%) exercising the same using irrigation agriculture during dry season. Further, only few rice farmers (8%) grow the crop with rain fed agriculture and this can be attributed to the fact that those areas are swampy during those seasons providing a required condition for rice farming.

The study sought to establish whether farmers experienced delay in planting time. The results were analyzed and presented using percentages as presented in Table no 4.

Table no. 4: Delay in planting time

Statement Item	**Response**	
Do you experience delay in planting time	Yes (32%)	No (68%)

The results in Table no. 4 indicate that 68% of Smallholder farmers did not experience delay in planting time while minority (32%) experienced delay in planting time because majority of the farmers no longer rely on rain fed agriculture since the inception of KOSFIP project.

The study sought to establish farmer's coping mechanism to delayed onset of rainfall for planting. Results were analyzed and presented qualitatively as presented in Table no. 5.

Table no. 5: Farmers Coping Mechanism to Delay in Planting Time

Statement Items	**Crops**							
	Maize	Beans	Rice	Sukuma wiki	Tomatoes	Arrow roots	Bananas	Sugarcane
What happens to each crop when the onset of rains is delayed	Late plating (29%)	Late planting (26%)	Nothing	Nothing	Nothing	Nothing	Nothing	Nothing
What is your coping mechanism when the onset of the rains is delayed	Irrigation agriculture, Plant early maturing and drought resistant variety	Irrigation agricultur e Plant early maturing variety	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture

The results in Table no. 5 indicate that when the onset rainfall for planting is delayed crops such as maize, beans, sukumawiki and tomatoes tend to wilt. As mitigation, farmers exercise irrigation agriculture by allowing water flowing throw irrigation canals to be diverted to the farms through auxiliary tunnels. Farmers equally plant drought resistant varieties of maize that yields faster under weather vagaries.

The study sought to establish the farmer's coping mechanism to periods of too high and prolonged rainfall. The results were analyzed and presented using qualitative data as presented in Table no. 6.

Table no. 6: ***Farmers Coping Mechanisms to Period of Too High and prolonged Rainfall***

Statement Items	**Crops**							
	Maize	Beans	Rice	Sukuma wiki	Tomatoes	Arrow roots	Bananas	Sugarcane
What happens to each crop when the rainfall amounts are too high and the season is	Water logging loss of crop. Crop decay	Waterlogging and loss of crop	Bumper harvest	Water logging and loss of crop	Disease infection	Early maturity	Early maturity	Early maturity

prolonged								
What is your coping mechanism when the rainfall amounts are too high and the season is prolonged	Planting alternative crop varieties that require a lot of rainfall	Planting alternative crop varieties that require a lot of rainfall	Opening/ Closing canals to allow excess water to flow down stream	Spraying with chemicals	Spray with chemicals	Opening/ Closing canals to allow excess water to flow down stream	Opening/ Closing canals to allow excess water to flow down stream	Opening/ Closing canals to allow excess water to flow down stream

The study sought to establish the farmer's coping mechanism to periods of rains stopping too early. Results were analyzed and presented using qualitative data as presented in Table no. 7.

Table no. 7: ***Farmers Coping Mechanism to Period of Rains Stopping too early***

Statement Items	**Crops**							
	Maize	Beans	Rice	Sukuma wiki	Tomatoes	Arrow roots	Bananas	Sugarcane
What happens to each crop when the rains stop too early	Wilting	Wilting	Nothing	Nothing	Nothing	Nothing	Nothing	Nothing
What is your coping mechanism when the rains stop too early	Irrigation agriculture	Irrigation agricultur e	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture	Irrigation agriculture

The results in Table no. 7 indicate that when rains stop too early, some crops like maize, beans, sukumawiki and tomatoes experience wilting and dry up which requires farmers to grow quick yielding and drought resistant hybrid varieties or adopt irrigation agriculture. However for crops that are either grown in marshy grounds or fully under irrigated agriculture like arrow roots, bananas and sugarcane the short rains to not amount to much negative effect.

Floods

Floods as a component of climate related challenge was referenced in terms of the periods of occurrences, effect on crops grown and trends in the study area. The responses on the frequency of occurrences of floods are shown in Table no. 8.

Table no. 8:Flood Frequency

Statement Item	**Floods**		
How often do you experience the following climate related challenges due to changes in rainfall patterns	Frequently (27%)	Moderately (31%)	Less frequently (42%)

The results in Table 4.18 indicate that changes in rainfall patterns results into severe flood at 27%, moderate flood at 31% and mild flood at 42%.

Extreme Temperatures

Extreme temperature component of climate related challenge was referenced in terms of the farmer vulnerability to extreme temperature, effect to crops grown and trends in the area under investigation. The responses on the frequency of occurrences of extreme temperatures are shown in Table no. 9.

Table no. 9: Extreme Temperature

Statement Item	Extremely High temperature change		
How often do you experience the following climate related challenges due to changes in rainfall patterns	Frequently (59%)	Moderately (27%)	Less frequently (14%)

The results in Table no. 9 indicate that the area experiences extreme high temperature change at 59%, moderate high temperature change at 27% and mild temperature change at 14%.

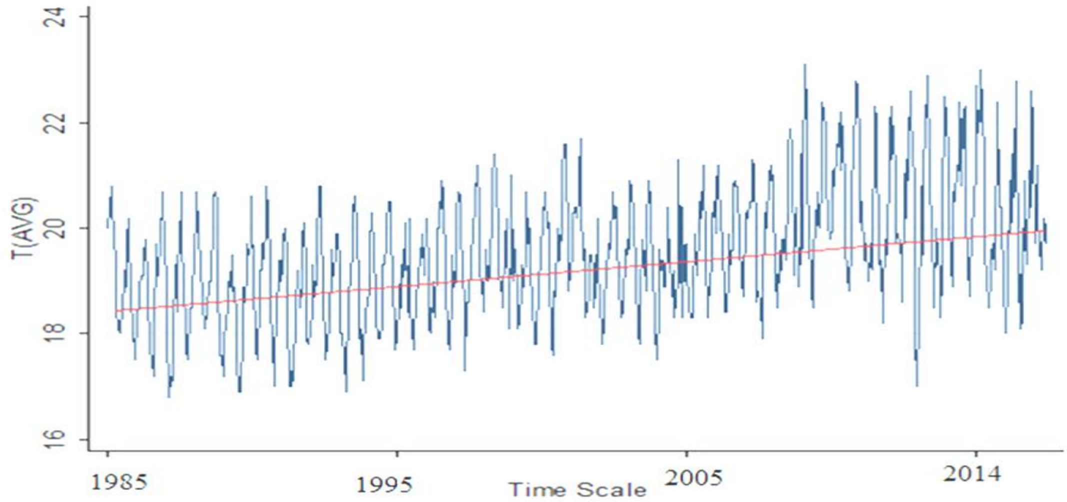

Figure no. 4: Variation of average temperature spanning 1985-2014

High temperature changes results into dehydration which affects the quality of the crops produced. Generally, climate related challenges decreases farm productivity, thus requiring the use of irrigation agriculture, cropping system and stakeholder engagement in order to reverse the negatives.

Discussion

The droughts are caused by reduced rainfall amounts. Droughts lead to delayed or failed planting besides reducing crop productivity and food insecurity. Worse off are plants like arrow roots and rice that require high rainfall amounts for high productivity. This makes irrigation agriculture critical for success of farmers so that during droughts water can be spread into the farms through canals

Droughts did not have significant effects on farming practices on farms where irrigation agriculture is done since water was available throughout the year. As a secondary precaution, farmers usually use fast yielding and drought resistant hybrid crop varieties especially maize seeds. This shows that the smallholder farmers' projects have become resilient to changes in climate conditions thus securing food security to the populace. However, farms which solely depend on rain-fed agriculture experience wilting and drying up of crops leading to poor or absolutely zero harvest.

An in-depth look into the rainfall pattern in 2021 represented in study area shows that April which is the planting season received 244.891ml of rainfall while September which is considered the second season of harvesting also receiving 114.622ml of rainfall. This was even below the required amounts of rainfall for crops like maize which require between 600mm and 1000mm for high yields. Worse still, the heavy rains in the planting seasons are followed by sharp recession which causes crops to dry prematurely leading to low or zero yields. These changes in climatic conditions can only be mitigated through irrigation agriculture, planting hybrid crop varieties and changing planting patterns.

Rainfall patterns influence the type of crops grown at different seasons of the year. When the rainfall is too high it leads to flooding while when it's little or delays it results into drought that affects the crop production. The types of crops therefore grown by the smallholder farmers under KOSFIP project included maize, beans, rice, sukumawiki, tomatoes, arrowroots, bananas and sugarcane. The conditions under which each of the crops is grown included rain fed and irrigation agriculture.

The inadequate rainfall in the study area results into frequent droughts which necessitated the initiation of irrigation agriculture to bridge the gap for crop production continuity. For example, maize production requires an average rainfall amounts between 600mm to 1000mm but the rainfall amounts received in the area under study ranges between 12.503mm to 244.891mm in the peak. This implies that even during the rainy season of planting, the rainfall amounts fall below the recommended amounts which call for complementation of the traditional rain-fed agriculture for maize with irrigation agriculture besides use of hybrid varieties for optimum production. Rice farming was fully done under agriculture since the rains were not adequate for the growing period. Equally, due to little rainfall, crops such as tomatoes, bananas, sukumawiki and sugarcane do well under irrigation agriculture. Little rainfall causes drying up and low productivity of crops. On the other hand, too much rainfall causes flooding leading to water logging. Water technologies and management are particularly critical for adaptation for smallholder farmers, who are primarily dependent on rain fed agriculture.

Further, too high and prolonged rainfall results into water logging and decay of crops such as maize, beans, sukumawiki and tomatoes since the soil experiences water log due to the clay cotton soil characteristics of the area which has poor permeability. However, crops that require a lot of water such as arrow roots, bananas and sugarcane experience early maturity. For the rice farmers there is little noticeable change since the crop requires water throughout its lifespan. The high and prolonged rainfalls are occasionally experienced during April and September planting seasons resulting into water logging and crop loss. To cope with the situation, farmers that experience decay of crops tend to adopt a hybrid variety that requires high rainfall or altogether plant alternative crop varieties that can withstand huge rainfall quantities. For the other crops that do not experience negative effects of too high rainfall amounts, opening of canals for water to flow downstream act as a better coping mechanism.

Flooding that is majorly experienced during rainy planting seasons of April and September leads to crop and soil erosion, disease spread that causes wilting and low or zero yields. However, arrow roots and rice farming are not affected by flooding since the crops require a lot of water for high yield. The other crop types like maize, beans, sukumawiki and tomatoes cannot survive flooding. On areas that experience flooding, farmers usually shift to crops that require a lot of water such as arrow roots, rice, sugarcane and bananas. Farm flooding's results into wilting, pest and disease infections of crops such as maize, beans, sukumawiki and tomatoes.

The high temperature causes high evaporation rate on the soil and surface water besides plants water loss through transpiration leading to drying up of crops and low yield to those that survive. This makes irrigation agriculture critical for success of farmers so that during extreme high temperatures water can be spread into the farms to compensate for that lost during transpiration.

The decreasing rainfall and increasing temperature trends in Africa therefore requires farmers to adapt to climate change to increase productivity, income and food security.

IV. Conclusion

The study concludes that changes in rainfall patterns results into droughts, floods and high temperatures. This makes irrigation agriculture critical for success of farmers so that during droughts water can be spread into the farms through canals while during floods canals can be emptied downstream.

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