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The Effect of Rainfall Duration on Maize, Beans and African Nightshade Production in Nyando Sub-County of Kisumu County, Kenya

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Abstract:- At the backdrop of the on-going variability in rainfall, this research used a quasi-longitudinal research design to assess the effect of rainfall duration on beans, maize and African nightshade production in Nyando sub-County, Kisumu County, Kenya. Primary data were obtained from questionnaires, interview schedules for key informants, photography, and observation checklist. Secondary data were obtained from Kisumu County's Meteorological Department and Ministry of Agriculture. Data were analyzed at descriptive and regression levels. The analytical results showed that longer rainfall duration positively affected maize crop production ($t = 18.82$, $p < .001$) while it negatively affected both beans ($t = -6.04$, $p < .001$) and the African nightshade ($t = -8.05$, $p < .001$) yields. The research recommends that farmers should put emphasis on maize production during long rain seasons with minimal production of both beans and African nightshade for output maximization. More beans and African nightshade than maize should be grown in short rains durations to curb climate-related loses.

Key Words:- *Rainfall Duration; Maize; Beans; African Nightshade; Nyando*

I. INTRODUCTION

Rainfall variability is a major concern to most farmers globally due to its detrimental impacts on agricultural activities (Dinar, 2008). There have been many incidences of changes in rainfall amounts, seasonality, and trends. As reported by Nedumaran (2015), the yields by various crops depend on the reliability of rainfall that determines the soil water levels. Globally, many countries have experienced changes in farming activities due to many cases of rainfall variability (Dinar, 2008). One of the major parameters of rainfall variability that concerns many geographers is rainfall duration which is a measure of how rainfall is concentrated on land during the rainy season. Other parameters include the timing and magnitude of rainfall (Shackleton et.al, 2009). These aspects of rainfall variability have affected crop production thus leading to food insecurity in different parts of the world. The data provided by United Nation Framework Convention on Climate Change (UNFCCC) shows that trends, seasonality and amounts of rainfall have changed in different parts of the world thus affecting crop production (2010).

Kenya as a developing nation has endured countless instances of climate change such as prolonged droughts, floods, heatwaves at the coast and ice recession seen at the top of Mount Kenya (Ondieki & Kitheka, 2019). According to Ogola et al. (2007), the past decades witnessed a massive decline in rainfall amounts in areas that were perceived to experience high rainfall. This reduction of rainfall affected several crops. For instance, there was a reduction in total wheat produced in 2016 and 2017 from 215,900 to 156,900 tons. Seasonal rainfall changes between 2008 and 2010 had a serious impact on the production of Irish potatoes in Nyamira, Baringo, Nandi and Laikipia counties. Most farmers had to look for alternative crops that were drought resistant due to the changes in rainfall amount.

Nyando sub-County for a long time was considered as the food basket to Kisumu County, especially in the production of food crops such as maize, beans and vegetables, specifically the African nightshade (Ogola et al., 2007). There were other crops such as beans, cowpeas, tomatoes that were also grown in the area for a long time. These crops were fully dependent on rainfall for their survival as the area experienced high and reliable annual rainfall in the past years. However, changes in rainfall duration have made food crop production difficult in the sub-County. As Leal et al. (2015) assert, crops such as maize, beans and African nightshade require reliable rainfall for their success. Conversely, the change in rainfall patterns such as seasonal and monthly variability of rainfall can reduce the quantity and quality of such crops.

As a food crop-producing region, many households have benefited from the farming activities such as enhancing household food security, increasing income and many others. However, the situation is fast changing in recent years as most farms go uncultivated for months due to rainfall variability thus leading to reduced food security in the area. Even though the many studies conducted in the area focused on the effect of rainfall variability on various food crop production, there is still a need to examine the effect of rainfall variability on the production of maize, beans, and African nightshade. This study assessed the effect of rainfall duration on maize, beans and African nightshade production in Nyando sub-County, Kisumu County, Kenya. The findings of the study avail the much-needed information for farmers thus creating awareness on how they can restore the crop production levels witnessed in the past years. Further, the information gotten from this research acts as a policy guideline to the county government

in realizing food security within the sub-County and the entire county at large.

II. REVIEW OF RELATED LITERATURE

Rainfall variability effect has been greatly felt in the agricultural sector, particularly on rain-fed crops. The changes witnessed in the duration of rainfall experienced in different parts of the world have had a dire impact on crop farming. According to Krol & Bronstert (2007), rainfall reduction witnessed in Brazil between 2005 and 2015 had serious consequences on rainfall sensitive crops like beans. Within six of the ten years, there was a significant reduction of rainfall of close to 838mm which led to a substantial decrease of maize growing within Itaporanga Municipality. A study by Karnataka (2007) also shows that seasonal change in rainfall amount in India led to a 20% decline of the area under beans cultivation and a 23% reduction of total yield between 2006 and 2013.

Limited technological advancement in Africa has forced many countries to rely on rain-fed agriculture in the production of various crops. As such, many households in Africa are fast becoming more food insecure due to the changes in rainfall patterns. A report published by the World Meteorological Organization (WMO) (2008), show that there is an annual decrease of about 2mm of rainfall in most parts of Africa. From 2006 to date, rainfall in Angola declined by 24% per decade thus minimizing the production of many rain-fed crops (Kgathi et al., 2006). For instance, there was a substantial reduction of beans production in the Southern Province of Angola by 11% due to the changes in rainfall amounts. As such, many households resorted to the production of drought-resistant crops and irrigation farming which is quite expensive to most farmers. On the other hand, changes in rainfall amounts in the Democratic Republic of Congo (DRC) affected the production of maize and the common bean (Phaseolus vulgaris). According to Katungi et al. (2009), the historical drought experienced in 2017 in DRC led to a 40% drop in common bean production especially in the valley of Ruzizi, the valley of Rutshuru and in Southern Katanga. Moreover, there have been other incidences of drought during the African nightshade growing period over the years which have lowered the quantity of production. This situation increases household food insecurity since these crops are largely consumed by the people of Congo.

Common bean, maize and African nightshade are famous among East African households due to their nutritional value. Majority of farmers rely on rainfall for growing these crops even though there are few cases where new farming techniques have been adopted. As one of the major producers of beans in East Africa, Uganda has experienced a change in their production due to climate variability leading to a change in rainfall patterns. According to Kgathi et al. (2006), a drop in the quantity of beans produced in 2018 is attributed to the changes in rainfall patterns. Since beans are largely grown in Uganda, any slight change in their production affects many households thus causing increased food insecurity. Tanzania is also known as a major maize producer within the East African communities. However, many incidences of reduced rainfall amounts have led to a slip in maize production in the country. A study conducted in Hai District, Kilimanjaro concluded that reduction of rainfall between the years 2000 and 2005 led to a massive decline in food crop production such as maize, beans and vegetables (Kgathi et.al., 2006).

A study by Arunga et al. (2012) shows that Kenyans currently consume an average of 755,000 metric tons of beans against total amount produced of about 600,000 metric tons. This shows that beans are one of the staple crops among many households in Kenya. However, changes in rainfall trend in Kenya have led to a drop in beans production in different parts of the country, more so rosecoco and yellow beans (Arunga et al., 2012). The unreliability of rainfall in these regions further affects the quantity of African nightshade and maize produced. Nyando area has been affected by changes in rainfall amounts in the last decades which have led to a major drop in the quantity of crops produced and increased food insecurity among many households (Owino, 2008).

III. DATA AND METHODS

- *Location, Climate and Soils of the Study Area*

Nyando sub-County lies between longitude 33° 20’ to 35° 20' East and latitude 0° 20' to 0° 50' South. The sub-county is sandwiched between the Nandi Hills of Rift Valley and the Nyabondo Plateau of Upper Nyakach. It is approximately 163 km2 with a population of 122,376 persons (KNBS, 2019). The sub-County is located within a hot climatic region with unpredictable weather patterns. The area experiences mean annual temperatures of about 22°C. Despite the high temperatures throughout the year, the region experiences a mean annual rainfall of 1000mm. However, these rainfall amounts have kept on changing in the recent decades (Mogaka, 2006). It is dominated by the black cotton soils that have a distinct feature of developing cracks during dry seasons. However, at the onset of rains, the cracks close thus hindering infiltration and resulting in floods in most parts of the area. The black cotton soil is ideal for growing of maize, beans, and African nightshade due to its high capacity of water retention.

- *Research Design*

This research used a quasi-longitudinal research design to get the qualitative and quantitative data on rainfall from the meteorological department and data on food crop production from household heads. Primary data on food crop production and yields was obtained from household heads' questionnaires, interview schedules for key informants, photography, and observation checklist. Secondary data was obtained from publications, Kisumu County’s Meteorological Department and Ministry of Agriculture. The unit of data analysis was the household.

ISSN No:-2456-2165

➢ *Study Population and Sampling*

The target population was 384 households. It was arrived at using a formula cited in Mugenda & Mugenda (2003):

$n = \frac{(Z)^2 * (p) * (1-p)}{c^2}$, where: n = sample size; z = 1.96; p = sample proportion (0.5); and c = degree of accuracy (0.05).

$$\text{Hence n} = \frac{(1.96)^2 * 0.5 * (1-0.5)}{(0.05)^2} = 384$$

Systematic random sampling was used in selecting the 384 respondents from the farming households in the study area. Purposive sampling was used to provide key informants that included officers from the Ministry of Agriculture (MOA) who provided data on crops grown in the area for the 10 last years and from the Kenya Meteorological Department (KMD) who provided significant data on the rainfall amounts for the last ten years.

➢ *Data Analysis*

Quantitative data on food crop yields was analyzed using descriptive statistics of frequency charts, percentages, and standard deviation. Documented data on rainfall duration from the Kisumu Meteorological Department was analyzed by regression analysis. These data were processed using Statistical Package for Social Science (SPSS Version 22). Qualitative data on types of food crops was analyzed by creating categories, themes, and patterns in order to help in evaluating the usefulness of the information in answering research questions.

➢ *Ethical Considerations*

The study sought research permission from the Maseno University Ethics Review Committee, Nyando sub-County offices, Kisumu Meteorological Department, Kisumu County Ministry of Agriculture, and the local administration. Written informed consent was obtained from the respondents after a brief introduction of the study. Participation in the study was on a voluntary basis. Confidentiality, privacy, and anonymity of the participants was maintained to ensure that they were protected.

IV. RESULTS AND DISCUSSION

➢ *Demographic Characteristics and Food Crop Farming Experience of the Respondents*

Data on gender distribution, age, marital status and farming experience of the respondents was as presented in Table 1.

Table 1 Gender Distribution, Age, Marital Status and Farming Experience of the Respondents

Variable	Count	Percentage
Gender		
Male	145	38
Female	237	62
Intersex	2	<1
Age of household head		
20-35	46	12
36-45	85	22
46-55	238	62
>55	15	4
Marital status		
Single	40	10.4
Married	167	43.4
Divorced/separated	57	14.8
Widowed	120	31.4
Household size		
1-2	20	5.2
3-4	262	68.2
5-6	70	18
>6	34	8.8
Time of farming experience in years		
≥15	13	39.4
11-15	14	42.4
5-10	4	12.1
0-5	2	6.1

Source: Field Data (2022)

Out of the total number of the respondents, the study established that 145 (38%) were males, 237 (62%) were females while <1% accounted for intersex (Table 2). This indicates that the majority of the farmers who grew maize, beans and African nightshade were female household heads. This could be explained by the fact that most males are

skewed towards the production of cash crops. It therefore supports the general understanding that female household heads (62%) are more interested in food crop farming than the male household heads (38%) to provide food for their households.

The results of this study are similar to those by Arunga et al. (2012) which presented that more female respondents than males were engaged in the production of beans in rural areas of Kenya. The findings also agreed with the findings of Abukutsa (2010) that noted a majority of food crop farmers in Kajiado sub-County were women. Men were more engaged in livestock keeping which they considered valuable than food crop farming. Mati (2010) also asserted that women were generally more interested and involved in small scale food crop farming than men. As such, instances of climate variability greatly affect women because they have the burden of providing for their children.

The majority of farmers (62%) were within the 46 – 55 years' age bracket. This reveals that food crop farming is majorly done by the middle age population. The younger population normally migrates from rural to urban areas in search of formal employment in other sectors of the economy different from agriculture which is attributed to the uneducated and older generation. Also, agriculture requires farm labour, which makes it difficult for the older, lesser energetic population to practice it. The elderly (>55 years) were less involved in farming since they were less energetic: they opted to stay at home to be taken care of by the energetic respondents. Similar results were observed by Owino (2008) who noted that the younger households in Kisumu District, Kenya, shied away agricultural activities since they considered farming as an odd job. Also, the study conducted in Bungoma County by Abakutsa (2010) and another conducted by Cohen and Atieno (2010) established that the younger generation have been known avoid engaging in agricultural activities.

The study established that large number of the respondents (43.49%) were married, 14.8% were divorced and 10.4% were single. The widowed respondents constituted around 31.4% of the total population. The married respondents could have been actively involved in crop production since the couples were able to consolidate funds for better farming unlike the single respondents. The single respondents were least engaged in food crop farming since they had no burden of providing for their families. The majority of the single respondents were also of the young population who considered farming as an odd job thus decided to stay away from farming practices. The research done by Owino (2008) also agreed with the current study findings that the single spouse households' heads have been known to avoid taking agricultural practice seriously due to financial constraints and that the little income they get is directly used in buying food and not for food crop production. On widowhood, the results are identical to the finding of a study by Ooko et al (2015) which observed a higher number of widows in Kisumu County. His research found that Human Immuno-Deficiency Virus (HIV) was the major cause of high mortality rates. His findings agree with the current study that pointed out that the widowed were rarely engaged in food crop production due to the burden of taking care of the large families left behind.

The largest household size was made up of 3-4 children whom stood at 68.2 % of the sampled households. The household size made up of 1-2 children constituted 5.2%, while the household sizes of 5-6 and above 6 constituted 18% and 8.8% respectively. The results showed that the households with few children were less engaged in farming activities since the pressure of feeding them is less compared to the larger families. Most household heads with more than 3 children were actively involved in food crop production to sustain their daily needs. Also, the households that had more than 6 children were actively involved in cash crop farming compared to food crop farming. This is because cash crops like sugarcane fetch higher income that helped in meeting monetary demands like school fees brought about by large families. The results however differed from the finding of a study by Katungi et al. (2009) that noted relatively smaller household sizes. This is because Katungi et al. (2009) sampled only the educated households. He argued that higher education levels had been known to negatively impact fertility and therefore the reduced need to actively engage in food crop production.

The result on number of years that the participants had engaged in crop farming was determined as shown in Table 2. The farmers that had practiced farming within the period less than five years were the fewest because it is this period that the study area experienced great rainfall variability. The farmers that had engaged in farming for a period (≥15) were the second largest which meant that most of them opted away from food crop production when rainfall duration changed within the study area. Most household heads (42.4%) had practiced food crop farming between 11 to 15 years. This communicates the fact that "practice makes perfect". The majority of the household heads had the longest experience in food crop farming. They had studied and mastered rainfall patterns and variations over the years and understood the durations of rainfall. The knowledge on rainfall patterns in the area was vital to the farmers as it informed their cultivation practices that ultimately determined the yields of maize, beans and African nightshade. These results are similar to the findings of a survey conducted by Arunga et al. (2012) on bean growing areas in Kenya which reported more agricultural experience by farmers in the rural setups. Further, the findings are justified by Ondieki & Kitheka (2019) who established that rural agriculture was the mainstay in the rural areas and that the experience had been ancestrally passed to the current generation.

- *Mean Annual Production of Maize, Beans and African Nightshade*

The research used data from the Kisumu County Ministry of Agriculture to plot a graph on the mean annual production of the food crops under study in the last decade. The results are as presented on Figure 1.

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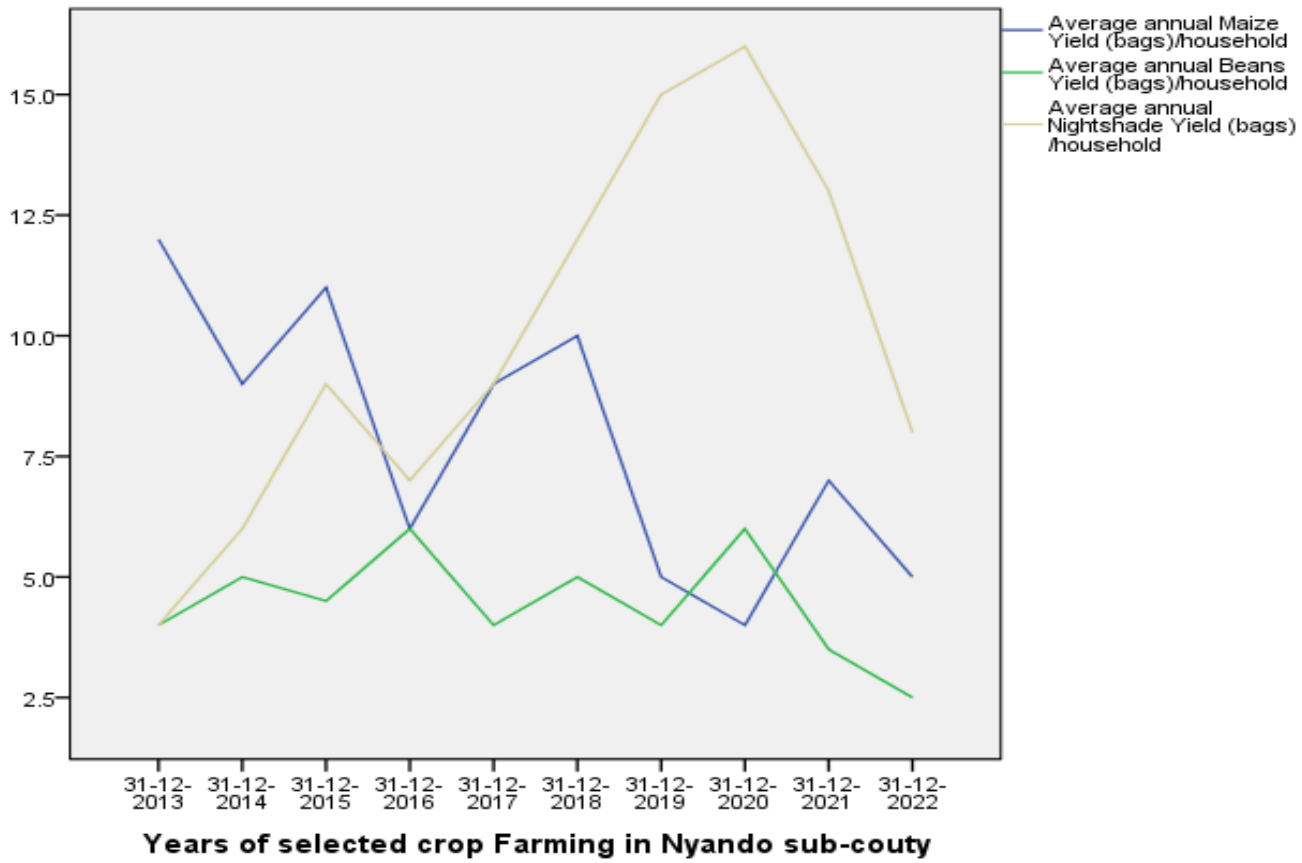

Fig 1 Mean Annual Fluctuations in Yields of Maize, Beans and African Nightshade
Source: Ministry of Agriculture (2022)

From Figure 1, we learn that maize crop production is generally on a decline despite the few positive fluctuations. The year 2020 marked the lowest maize yield in a ten-year history of its production in Nyando sub-County. The decline in maize production over the years was attributed to the changes in rainfall variability that affected different parts of the country. Prolonged droughts and unpredictable rainfall patterns affected most farmers. The results also indicated that most household were unable to have reliable maize production unlike 2013. The change in rainfall duration during the study period made farmers to opt out of food crop production since they made massive losses. One of the respondents shared her views regarding the decline in production of maize between 2017 and 2020.

"*I cannot imagine the pain that I have underwent when my only source of livelihood is no longer important. I recall my bumper harvest in the year 2017 when I harvested close to 20 bags of maize on the same farm that could not produce even 5 bags of maize in the year 2020. We have now to resort to other drought tolerant crops like sorghum even though we are not used to these crops. My children don't like it at all".*

Source: A respondent from Awasi Ward

However, most farmers could not explain that the variation in maize crop production was due to global warming that caused rainfall variability. As such, most farmers were forced to venture into drought tolerant crops farming which are not staple among the households.

Beans maintained a low yield of less than 7.5 bags per annum for the entire period with 2022 revealing the lowest yield. From the findings, bean crop was massively affected by rainfall variability leading to the reduced yields over the years. The reduction in the rainfall duration affected different varieties of beans such as *nyayo* and *rosecoco* beans. Despite the fact that beans require low rainfall compared to maize, the amount of rainfall experienced in 2022 was insufficient for optimal yield of the crop. Most bean crops withered and some were attacked by pests and diseases that thrived well in dry conditions leading to the drop in yields. Therefore, the sharp decline in bean crop production in 2022 was caused by severe and prolonged drought that ravaged most parts of the country affecting both crops and livestock.

The results further indicated that the African nightshade production showed a steady increase from 2013-2015 with a slowdown in 2016. However, it gained steadily up to 2020 before a sudden decline in between 2021 and 2022. Between the year 2016 and 2019, there was sufficient rainfall for the production of vegetables such as the African nightshade. The timely arrival of rainfall led to sufficient rains for the African nightshade that had been planted earlier. This highly contributed to the increase in the crop yields. Moreover, there was enough surface run-off that was ideal for growing of the African nightshade hence the rise in

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its production. However, the 2022 drought also affected the African nightshade just like maize and beans during the same period. The black cotton soil within the study area dried up quickly during the low rainfall seasons in 2022 which led to wilting of the vegetable and eventually leading to its drying up. It was therefore evident that change in rainfall duration affected the production of African nightshade just like other crops.

The results on maize fluctuation identified with findings by Ondieki (2019) who showed that the changes in rainfall patterns greatly affected maize production in Siaya County. He noted that most farms under maize cultivation withered at week 4 due to rainfall insufficiency. The findings of Mogaka (2006) on climate variability on resource degradation argued that most crops are weather and climate dependent, therefore, weather variability was responsible for the changes in their yields. Mati (2010) also agreed that rainfall variability had ravaged different parts of the country which has contributed to loss of vital food crops. He argued that mean average rainfall received between 2009 and 2017 was not sufficient for the production maize crop. He also asserted that reduction of rainfall during the maize growing period led to the emergence of pests that destroy the maize crop leading to the decline in production.

- *Yearly Variation of Rainfall Duration in Nyando Sub-County*

Data from Kisumu Meteorological Department (KMD) was used to plot a graph to show the annual variation in rainfall duration in Nyando sub-County. The results are as presented in Figure 2.

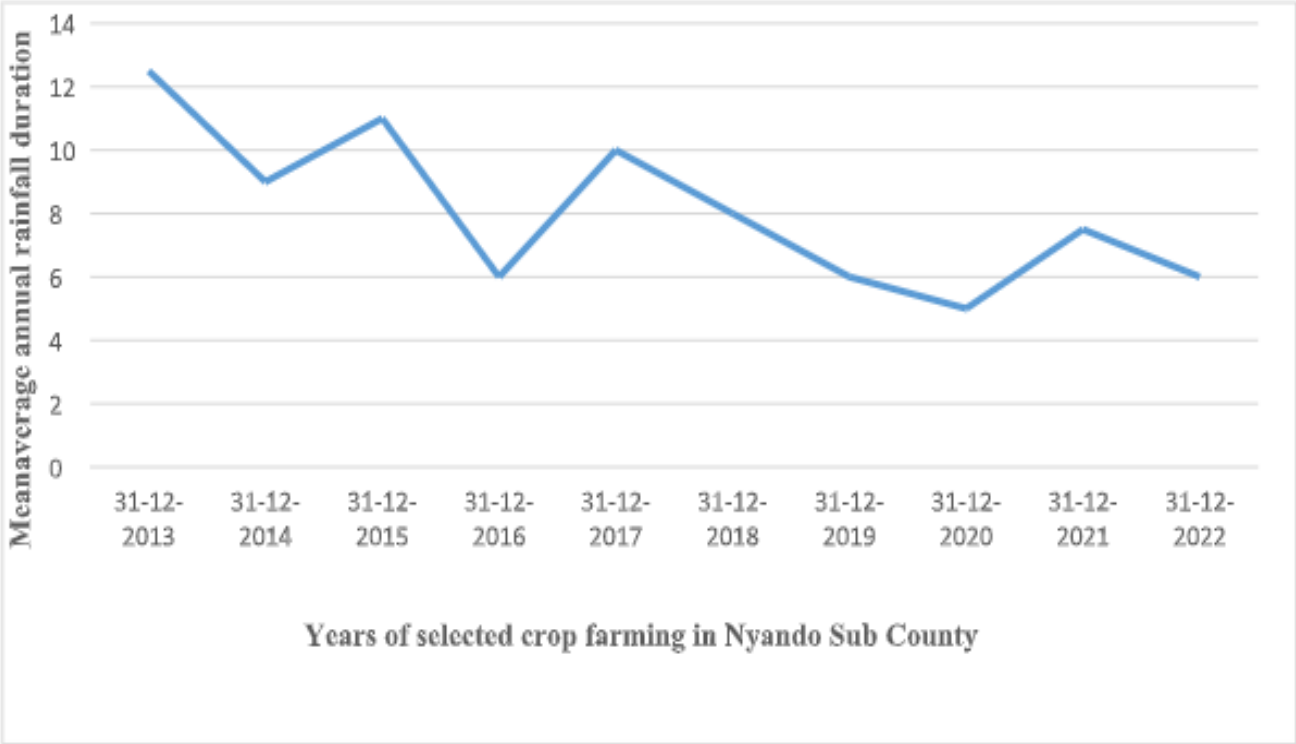

Fig 2 Yearly Variability of Rainfall Durations
Source: KMD Data (2022)

From Figure 2, it is evident that rainfall duration had been steadily declining from 2013 to 2022. Being the year that most parts of the country experienced prolonged droughts, the weekly rainfall reduced greatly in 2020 thus affecting a number of farming activities. This reduction in rainfall duration resulted in most farms drying up leading to the reduced production of maize, beans and African nightshade. The mean average annual rainfall magnitudes had been low and unpredictable in the study area. The millimeter per hour of rainfall reduced over the years which affected the production of maize, beans and African nightshade. Mati (2010) agreed that rainfall duration had varied over the years, a fact that he said affected the production of various crops. This variability in rainfall is attributed to global warming due to increase of greenhouse gases in the upper atmosphere thereby altering the hydrological cycle. The findings of Ker (2009) agreed with the current study which asserted that the change in rainfall duration had led to the reduction in the yields of crops among the farmers who relied on rain-fed agriculture.

- *Effect Of Rainfall Duration on Maize, Beans and African Nightshade Production*

This objective sought to establish the effect of duration of rainfall on the production of maize, beans and African nightshade in Nyando sub-County. Descriptive analysis was conducted to bring out the number of households that engaged in food crop production, the type of food crops grown, the acreage under each crop and the trends in the yields of the crops from 2019 and 2022. The results are presented in Table 2.

ISSN No:-2456-2165

Table 2 Duration of Rainfall on the Production of Maize, Beans and African Nightshade

Respondents engaged in crop farming	Food crops grown	Cultivation of maize, beans, and Nightshade	Average acreage	Crop yield 2019-2022	Crops by land size
N - 384 No - 22 Yes - 362	N - 384 Maize - 248 Beans - 96 Vegetables - 30 Sorghum - 10	N – 384 Yes - 159 No – 225	1.82	Maize - 25 Bags Beans - 11.5 Bags Nightshade - 320kg	Maize - 1.54 Beans - 0.87 Nightshade - 0.48

Source: Field Data (2022)

The results in Table 2 indicated that the majority of the respondents (94%) were involved in crop production within the sub-County. Maize crop was the most popular amongst the households (248) followed by beans (96) while vegetables and sorghum stood were (30) and (10) respectively. The average crop yield from 2019-2020 were: maize – 25 bags, beans - 11.5 bags and nightshades - 320 kg per household. The mean land size per household was 1.82 acres. As such, maize occupied an average of 1.54 acres, beans 0.87 acre while night shades took 0.48 acres of the households' agricultural land.

The findings therefore established that the majority of the household heads were engaged in agricultural production. This was attributed to the fact farming is the major source of income due to great unemployment in the rural areas. The household heads were engaged in the production of different crops (maize, beans, sorghum and vegetables). Maize was the most grown crop since it occupied the largest acreage (1.54). This was due to the fact that maize was staple among the households. Other crops were grown alongside maize to spread the risk of having insufficient maize harvest and to ensure continued provision of food to the households. The crop yields from 2019 to 2022 were insufficient to support the large households with the year 2022 having the peak of food shortage. Most households became food insecure and could not afford the normal meals like the previous years as most of them resorted rice consumption which was considered a 'light meal' according to most respondents. The reduced yields were attributed to changes in rainfall patterns which made it difficult for the production of such crops since farming was purely rain-fed.

The study findings agreed with those of Arunga et al. (2012) which asserted that maize and beans being staple food were preferred by most farmers in Kenya. They argued that most Kenyan households preferred eating maize in form of *ugali* or *githeri* in their at least two meals a day. This increased the production of these two crops in different parts of the country. The study of Kaguongo et al. (2013) also agreed that maize formed one of the staple foods among the Kenyan households and any change in its production massively contributed to food insecurity. Bouman (2009)'s findings also agreed with the current study that majority of African households valued maize and beans. Therefore, the changes in their production caused by climate variability increased the level of hunger among the people.

The findings in Table 3 provides the yields of maize, beans and African nightshade during the short and long rains and the perception of farmers on rainfall sufficiency in Nyando sub-County.

Table 3 Yields of Maize, Beans and African Nightshade During the Short and Long Rains and the Perception of Farmers on Rainfall Sufficiency.

Harvest during long rains	Weeks of long rain	Weeks of short rains	Harvest during short rains	Change in rainfall duration	Perception of rainfall sufficiency
Maize - 9.00 Bags/acre Beans - 4.00 Bags/acre Nightshade - 100kg/acre	10.89	6.63	Maize - 4.26 Bags/acre Beans - 4.65 Bags/acre Nightshade - 174kg/acre	Increasing - 20 Decreasing - 355 Constant - 9	Yes - 378 No - 4 Undecided - 2

Source: Field Data (2022)

From Table 3, the harvests during long rains were: Maize 9.00 bags/acre, Beans 4.00 bags/acre and African Nightshade 100kg/acre. On average, the long rain went for about 10.89 weeks for the months of March to May while the short rains last for at least 6.63 weeks for the months of October to November. The harvests for short rains were: Maize 4.26 bags/acre, Beans 4.65 bags/acre and Night shades was 174kg/acre. Further, farmers were asked about their perception on whether the rains were sufficient for the production of maize, beans and African nightshade during the long and short rains. In response, majority of the respondents (98.4%) indicated that the rainfall duration had decreased during both seasons over the years.

The majority of the female farmers attributed the decrease in crop yields to the changes in climatic conditions

during the short and long rains seasons. Unlike the male counterparts who engaged in cash crop farming and therefore experience minimal effects of rainfall variations, the female farmers were vast with instances of short and long rain variations. This, they said resulted in a lot of uncertainties in farming among most household heads.

"*Over the years we have experienced a decline in the duration of rainfall in this place, both during the long and short rains. I think this is because the climate has changed a lot leading to little rainfall. We have tried to adopt some crop varieties that mature before the rain stop but still we still have insufficient harvests. The decreasing rainfall has greatly affected maize production. However, it has been favorable for indigenous vegetables"*

Source: Focus Group Discussion at Kobura Ward

From the excerpt above, it is evident that the farmers were aware that rainfall duration had decreased over time and caused decline in maize production during the short rains. However, the short rain duration to them favored growing of vegetables. When probed further, they said that they did not understood the cause of variability of rainfall duration, which is a global problem due to climate variability. They further confirmed that the rains may not have been sufficient for optimal production of maize, beans and African nightshade.

The results of the study agreed with findings Owino (2008) that observed that rainfall was insufficient for the production of most food crops within Nyando area. He also asserted that reduced rainfall duration affected maize and beans greatly but the drought resistant vegetable farmers such as African nightshade had positive fluctuations. Omondi (2018) on the other hand argued that, despite the reduced rainfall durations, the residents of the sub-County agriculturally relied on the flash flood from the neighboring Nandi County. This had sustained many households in terms of food availability. The results on maize and beans is similar to the findings by Omondi (2018) which observed more maize and beans productions among the farmers in Gem sub - County, Siaya County. He established that maize and beans were the staples among the Kenyan households who must at least consume these crops twice a day, thus the increase in production.

- *Relationship between Rainfall Duration and Maize, Beans and African Nightshade Production*

Regression analysis was conducted to determine the extent of relationship of rainfall duration on food crop production. The results are presented in Table 4.

Table 4 Relationship between Duration of Rainfall, Beans, Maize, and African Nightshade Production.

Model	R^2	df1	df2	F statistics	T	P-value	N
Maize Yield(bags/acre/annum)	.651	1	383	25.63	18.822	.001	384
Bean Yield(bags/acre/annum)	.474	1	383	20.42	-6.035	.001	384
Nightshade(kg/acre/annum	.382	1	383	19.41	-8.049	.001	384

Source: Field Data (2022)

Results in Table 4 indicated that there was a significant relationship between rainfall duration and maize yield [F (383) =25.63, P < .001, R^2 =. 651], beans yield [F (383) =20.42, P < .001, R^2 = .474], and African nightshade yield [F (383) =19.41, P < .001, R^2 = .382]. Further analysis of the model showed that maize had significant positive linear association with rainfall duration (t = 18.82, p < .001). Beans and Nightshade revealed a significant negative linear relationship (t = -6.04, p < .001) and (t = -8.05, p < .001), respectively, with the duration of rainfall in Nyando sub-County. About 65% of the variation in maize yield could be explained by change in rainfall duration. 47.4% of beans yield was affected by variability in rainfall duration, while 38.2% change in African Nightshade harvest was possibly affected by changes in rainfall duration.

The above findings justified that there was relationship between rainfall duration and the production of maize, beans and African nightshade. The study established that rainfall duration was good for the maize production since the long weeks of rainfall increased the maize yields by 65%. During the long rains, the black cotton soil in the area absorb enough water which is sufficient for the maturity of maize within the growth cycle. The longer rainfall duration did not have severe effect on maize crop since the crop mature faster thus passed the level of getting withered with excess water. However, the longer weeks of rainfall increased the surface run off which caused water logging of the farms thus affecting beans and African nightshade production, which are cover crops. The farmers who had practiced farming in the study area for the longest time (11-15 years) also confirmed that increase in the number of days of rainfall contributed to more water logging in the farms. The stagnation of water in the farms affected cover crops like beans and African nightshade since they become submerged leading of their destruction. This lowered the yields during the long rain duration.

From the current findings, increase in maize production with escalation in rainfall duration contradicted the findings of a study by Abukutsa (2010) in Uasin Gishu which reported a reduction in maize yield as a result of increase in rainfall duration. This is possibly because Nyando is a hot and dry agro-ecological zone in which longer rainfall durations result in increased maize production (Owino 2008). Uasin Gishu on the other hand, is a high altitude agro-ecological zone which receives high rainfall that results into rotting of maize on the farms before they are harvested. Both beans and the African nightshade showed a negative trend with reduced rainfall duration. This is because beans require moderate short rains for optimal yields while nightshade is a drought resistant crop (Owino 2008). Both beans and the nightshade yields were consistent with the findings of a study by Oseni & Masarirambi (2011)

that noticed a reduction in yield as a result of change in rainfall duration. The duo argued that reduced rainfall duration led to reduction in the moisture content in the soil thus causing the vegetables to dry in the farms.

V. CONCLUSIONS

This study examined the effect of duration of rainfall on beans, maize, and African nightshade production Nyando sub-County. The study found that rainfall duration was statistically significant in assessing the selected crop yields. Simple linear regression analysis indicated that there was significant effect of rainfall duration on maize yield [F (383) =25.63, $p < .001$, $R^2 = .65$], beans yield [F (383) =20.42, $p < .001$, $R^2 = .47$], and African nightshade yield [F (383) =19.41, $p < .001$, $R^2 = .38$]. Longer rainfall duration was good for maize yields ($t = 18.82$, $p < .001$). However, it negatively affected both beans ($t = -6.04$, $p < .001$) and the African nightshade ($t = -8.05$, $p < .001$) yields. This is because both beans and the African nightshade are cover crops which are susceptible to excess surface run-off caused by longer rainfall duration.

The study recommends that farmers should adopt other crops and resilient livelihoods. Emphasis be placed on maize production during long rain seasons with minimal production of both beans and African nightshade for output maximization. More beans than maize and African Nightshade be grown in short rains durations to curb climate-related loses and the low vegetable demands associated with long rains duration. The study further recommends a future study on the effect of rainfall duration on cash crops like sugarcane within the study area or other places with similar geographical conditions.

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