The Extent to Which Rainfall Variability has Affected Small Scale Dairy Farmers in Uasin-Gishu County, Kenya

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ABSTRACT

Dairy farming in Kenya remains among the key wheelers to the Nations GDP contributor at about 6- 8%. Majority of the farmers in this sector, are small scale who mostly have no knowledge and capacity to handle challenges posed by rainfall variability that causes frequent droughts, impacting on water and pasture supply to their animals. Objective of study was: To assess the extent to which rainfall variability had affected small scale dairy farming in Uasin-Gishu County in Kenya between years 2010-2020. Rainfall data was collected from the Kenya Meteorological Department (KMD), Eldoret. While milk produce data was obtained from Ministry of Agriculture Uasin-Gishu County. Structured Questionnaires were used to collect data from farmers with few key respondents interviewed on the same . The questionnaire was administered to small scale dairy farmers who were sampled in a stratified manner based on their sub counties, then randomly within the Sub County. In total about 368 small scale dairy farmers were sampled out of which 300 (82%) of administered questionnaire were fully responded to. Analysis of objective one was done by Pearson correlation to establish the relationship between various rainfall characteristics and milk produce. Total annual rainfall with total annual milk had correlation of r= 0.532, number of rainy days in a year to the amount of milk with Pearson correlation of r =0.375, P>0.05. Onset and cessation periods had Pearson correlation of r=0.305 and r=0,019 respectively. Average monthly rainfall to milk had Pearson correlation indicating a negative relationship of r= -0.424, P= 0.169, meaning months with high rainfall amounts had lower milk produced while dry ones had higher milk produced. The researcher therefore failed to accept the null hypothesis and adopted the alternative one that rainfall variability has had significant impact on small scale dairy farming in Uasin –Gishu County. Research recommended that farmers should keep more of cross breed animals which cope with climate variability unlike exotic ones. There was also need for farmers to join and strengthen cooperative societies to assist them adapt, this is besides use of digital methods of sharing challenges and solutions to rainfall variability

Keywords: Milk production, dairy farmers, Rainfall variability, onset and ceasation,

INTRODUCTION

Climate variability has had harsh effects on the environment, especially on water accessibility, agriculture, general food availability and people's wellbeing. The IPCC's report of 1990 projected an increase in temperature by between 0.15 and 0.3°C in the next 10 years. The IPCC report of 2007 also noted that greenhouse gases were rapidly increasing worldwide and it's anticipated that by the year 2030, their emission could rise by between 25%- 90% with increase in temperatures of between 1 and 2.5°C and could rise further to 3°C by 2050. This situation is expected to have far reaching impacts especially to many vulnerable poor people in the developing world. It is projected that variability in climatic elements like temperatures and rainfall is likely to have serious consequeses to agriculture. In general this will in turn affect farmers' returns. This may drive most of them away from farming or may push most of them to engage in other forms of agricultural activities that are less affected with climatic variability (Molua et al., 2010). Livestock and dairy subsector is expected to be the greatest casualty of this situation. Rainfall element in particular is expected to impact more to dairy farming than any other climatic element as it is predicted that it could cause loses to the tune of between 20- 30% of total dairy produce globally

(IPCC,2007).

Africa as a continent is already under pressure due to rainfall variability. Projections indicate that a third of the continents population stay in ASAL areas. Among these population, 220 million are faced with challenges of water scarcity due to rainfall variability and frequent droughts (Nkondze *et al.,* 2014.It is also worth noting that many of the poor people in Africa are rural dwellers who solemnly rely on agriculture thus any drought affects them most (UNFCC,2007).

In other African nations like Nigeria, Mali and Niger, dairy sector is on the brink of collapse due to ever reducing rainfall amounts and frequent droughts that have become almost a yearly hazard on the continent (Mendelssohn, 2008).

In Kenya, dairy contributes about 6-8% of total Nations G.D.P (Njarui *et al*., 2009). It has also employed over 1.5 million small scale farmers with the sector realizing 160 billion Kenya shillings in 2014 (Ajwang, 2014). The sector has also employed more than 500,000 million people directly as transporters, processers and distributors of dairy products (Kenya Dairy Board report, 2012). As a nation, Kenya produces adequate milk for local consumption and even surplus for export (FAO, 2010). However, seasonality in production due to rainfall variability has been one key bottleneck to this sector. Global Circulation Models (GCMS) envisaged an increase in global temperatures by over 4ºC and variation in rainfall by up to 20% in the year 2030 (Kabubo et al., 2006). Climatic variability is likely to upsurge drought conditions and increase flooding in the country. Rainfall variability has caused fluctuations in agricultural production and has also increased S production cost especially during low rainfall season where farmers are forced to buy animal feed supplements. This explains why even agriculture as a whole sector has been declining as a major contributor to the growth of the nation's economy. It is also worth noting that majority of dairy farmers are small scale who mainly rely on natural grass and water. High temperatures and rainfall variability degrades pasture and water leading to low production which in turn have severe consequences to these farmers who lack adaptive capacity (Mwiturubani et al.,2010).

The situation remains the same with Uasin-Gishu County. In the year 2012 the County realized 3 billion shillings from the sale of 186 million liters of milk (Ministry of Agriculture report, 2012). This situation of good production is at risk due to rainfall variability as Bii (2012) notes, 2009 drought and low rainfall in Uasin-Gishu County made farmers' milk production to drop by half. During this time, a bale of hay that costs 100 shillings went at 250 shillings. This necessitated this research to establish the extend of rainfall variability impact to this sector.

Statement of the Problem

Changes in rainfall patterns have become a norm all over the world, Kenya is no exception. Kenyan vision 2030 acknowledges the fact that variability of this element is a big threat to the nation's realization of its GDP growth of 10 percent per year. IPCC (2013) indicates that climatic variability is real and livelihoods are more likely to be affected and disrupted with climatic variation effects in the days to come. Rainfall variability has immensely increased with declined long and short rain seasons. (Darkoh *et al*., 2014). Dairy production is important to Kenyan economy and food security.

In Uasin-Gishu County, Small scale dairy farming plays a key role as it is a major source of food to many. It is a source of income and has even employed many people directly and indirectly. However, Seasonality in production and low rainfall periods has remained the main challenge to this sector. Low rainfall periods have reduced milk quantities and increased the cost of production. This is because pastures and water points dry up. This has mainly affected small scale dairy farmers who in many cases have no capacity to adapt to this situation. While on the other hand, high erratic rains lead to excessive production and wastages. Case in point was in 2010 where there was overproduction of milk which forced the government to buy driers to turn excess one to powder. This came too late after farmers had incurred huge losses by literally

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pouring their excess milk (Ministry of Agriculture report, 2012).

The government through National Disaster Management Authority (NDMA) has tried to come up with interventions like drought warnings systems, livestock restocking and off take systems, targeting only ASAL areas. The focus has therefore majorly been to pastoralists targeting arid and semi-arid counties. There was need therefore for this research to focus on dairy as little research had been done on the same.

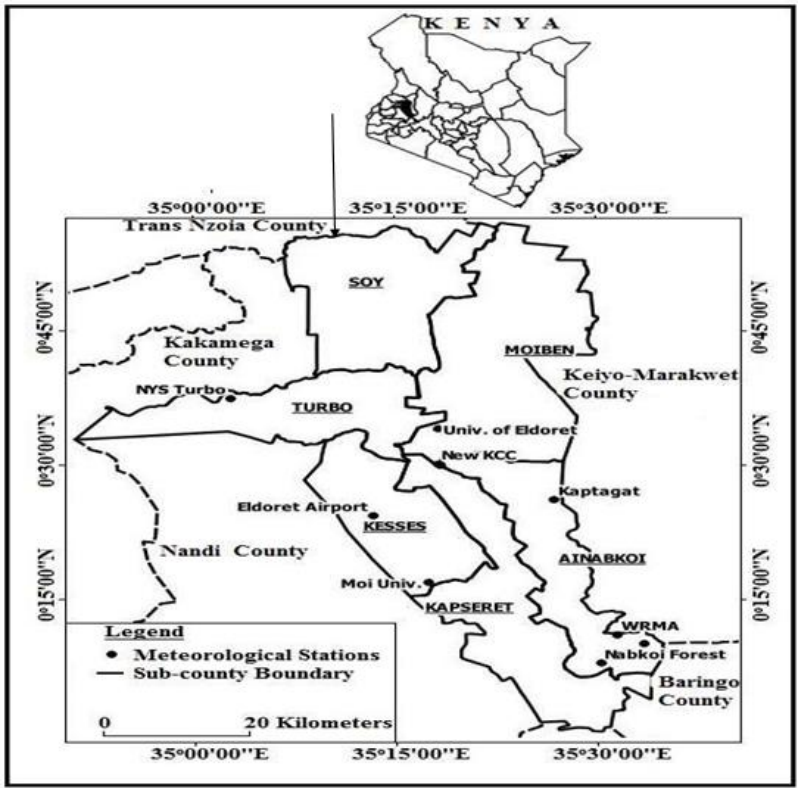
RESEARCH METHODOLOGY

Study Area

Uasin-Gishu County is among the 47 counties of Kenya, and is found in the Rift Valley region .It has a total area of 2,955 km² (KNBS, 2019). The county is made up of six Sub counties that include: Turbo, Kesses, Moiben, Kapseret, Ainabkoi and Soy. In total it has 27 wards, 51 locations and 97 sub locations. It lies within latitudes 0°10'N- 0°50'N and longitudes 35°37'W – 35°30'. The county, borders Trans-Nzoia County in the north, Elgeiyo Marakwet and Baringo to the East, Kericho and Nandi to the south and Kakamega County to the west (GoK, 2013).

The Counties altitude ranges from 1500m – 2700m above sea level. In terms of climate, the area receives rainfall of between 1000-1250mm in the northern and central parts in a year, while the western parts receive up to 1500 mm of rain per year (GoK, 2014). The area is cool with temperatures ranging from 15°- 21°. (GoK, 2014). Uasin-Gishu County has a population of 1,133,186, according to 2019 census. The population growth rate is at 3.8%, (KNBS, 2019).The poverty level stands at 47%. Agriculture accounts for 80% of the counties income. Inhabitants mainly practice wheat, maize and dairy farming (Gok, 2014). Majority of dairy farmers (70%) are small holders and keep high grade breeds of dairy cattle. Their cattle heavily rely on natural grass, with few using nappier and fodder crops. The growth of these grasses majorly depends on rainfall amounts and in turn affecting productivity (Gok, 2014).

Figure 1: Map of Uasin-Gishu County Showing the Location of Meteorological Stations



Source: Uasin-Gishu County Integrated Development Plan 2013-2018

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Data Collection

Rainfall data was acquired from the Kenya Meteorological Department (Eldoret main office). The data collected was daily rainfall amount between years 2010 and 2020. Milk data was obtained from the Ministry of Agriculture Uasin-Gishu County. This data was collected in relation to a mount of milk produced in kg per month for the entire period of study. Structured Questionnaires were administered to a selected sample of farmers from a list of registered small scale dairy farmers at the county's Ministry of Agriculture, dairy section. According to their records, they had a total of about 4580 registered small scale dairy farmers. Data collected from farmers included: challenges of climate variability, adaptation strategies and challenges of adaptation process. Key informants were also identified and interviewed on the same theme. They included; County dairy Officer, County Livestock Officer, County Veterinary Officer and Sub county dairy officers.

Sampling methods and Size

Proportionate stratified random sampling was used .The six sub counties that constitute Uasin-Gishu County were involved in the research since small scale dairy farming is carried out in all of them. Sample size was calculated using Yamane's, (1997) equation.

Equation is expressed as: n = $\frac{N}{1+N(e)^2}$

Where n = Sample size = Population size, e=margin of errors.

In this case N=4580 While e= 5% margin of error

N = $\frac{4580}{1+4580(e)^2}$ Therefore n = 368

From the above target population, respondents were allocated to the six sub counties proportionately based on the following formulae:

$n=p/\mu \times 368$

Where; **n** is the sample population in each sub-county, **p** is the population of registered small scale dairy farmers in the Sub county, **μ** is the total number of registered small scale dairy farmers in Uasin Gishu County. From the above formulae, the sample population was allocated as follows: Turbo Sub County 82, Soy 78, Moiben 65, Kesses 60, Kapseret 52 and Ainabkoi Sub County 31 respondents as shown in table I below.

Table I: Table showing population of registered farmers per Sub County

Sub County	No. of farmers	Sample size
Turbo	1024	82
Kapseret	652	52
Soy	965	78
Kesses	754	60
Moiben	805	65
Ainabkoi	380	31
Total	**4580**	**368**

(Source: Uasin- Gishu County Livestock office 2020)

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Simple random sampling was then used to select farmers in the sub counties who filled questionnaires. Farmers per Sub County were given numbers in order of their appearance in the County register. Numbers were then mixed up before the sample size per Sub County was picked at random.

RESULTS AND DISCUSION

Characteristics of survey Respondents

A number of respondents' characteristics were included as part of the research questionnaire; Gender, age, education levels, years of stay in an area among other factors

Gender of the Respondents

Respondents stated their gender with responses are as shown in Figure 2

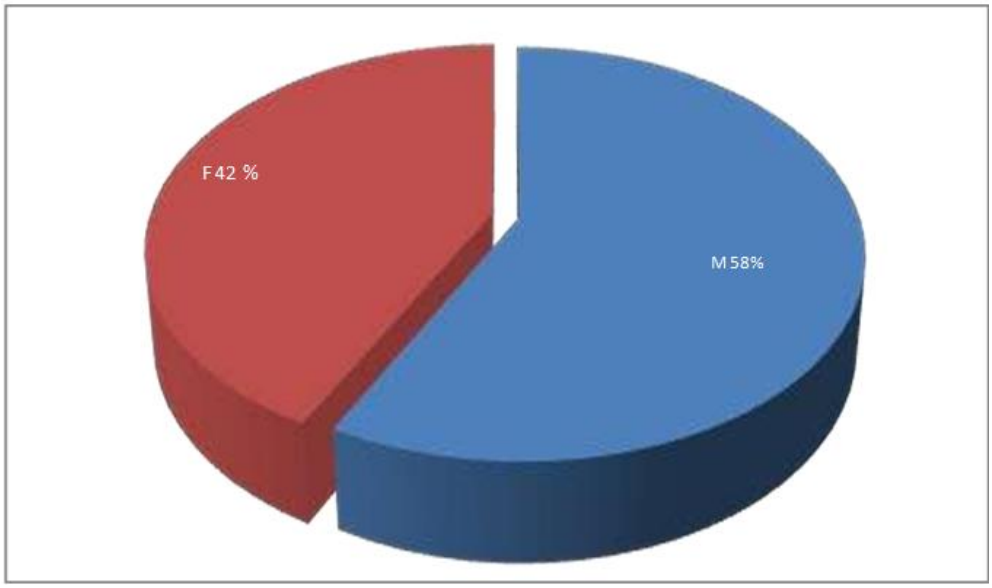

Figure 2 Respondents gender

From Figure 2, (58) were male while female were 42% .This gave an indication that many families in the study area were headed by male and thus most of the key farming decisions were made by them. Research findings noted that responses to questions for both gender was almost the same. Chi-square test conducted on household gender responses to adaptation mechanisms gave). This showed that there was no significant difference ($P > 0.05$) on the responses of male to that of the female respondents.

Years of stay in the area of study

This study also sort to find out the length of time and duration of stay of respondents in the study area since it had been supposed to have had a bearing on the respondent's know how on rainfall variability matters and even adaptation to the same (Jokastah et al., 2013). The results were summarized in Table II.

Table II Duration of stay in the study area

Duration in years	Frequency	Percentage
Less than 10 years	30	1
Less than 10 years	30	1
10- 19 years	123	41

20- 29	years	60	20
30- 39	years	69	23
40	years and above	18	06
Total		300	100

The findings in Table II indicate that majority of the households had stayed in the study area for between 10 – 19 years This implies that majority of farmers understood rain variability matters that affect this region as was evident in their responses. According to Jokastah et al. (2013), farmers who stay in an area for more than 10 years understands rainfall variability in the study area. He noted that Information collected from such a group could be reliable and gives correct position of the climate variation of the region.

Level of Education of respondents

Majority of the respondents; 61% had attained secondary level of education. 20% post-secondary 16% had primary level qualification while the remaining 3% had no formal education as shown by table III

Table III. Respondents' levels of education.

Level of education	Frequency	Percentage
No formal education	9	3
Primary level	48	16
Secondary level	183	61
Post-Secondary level	60	20
Total	300	100

Norris (1987) noted that an educated farmer is better placed to make sound agricultural decisions especially on climate variability matters.

Duration in Dairy Farming

The study sought to establish the duration that the sampled respondents had participated in dairy farming. The results are as shown in Figure 3

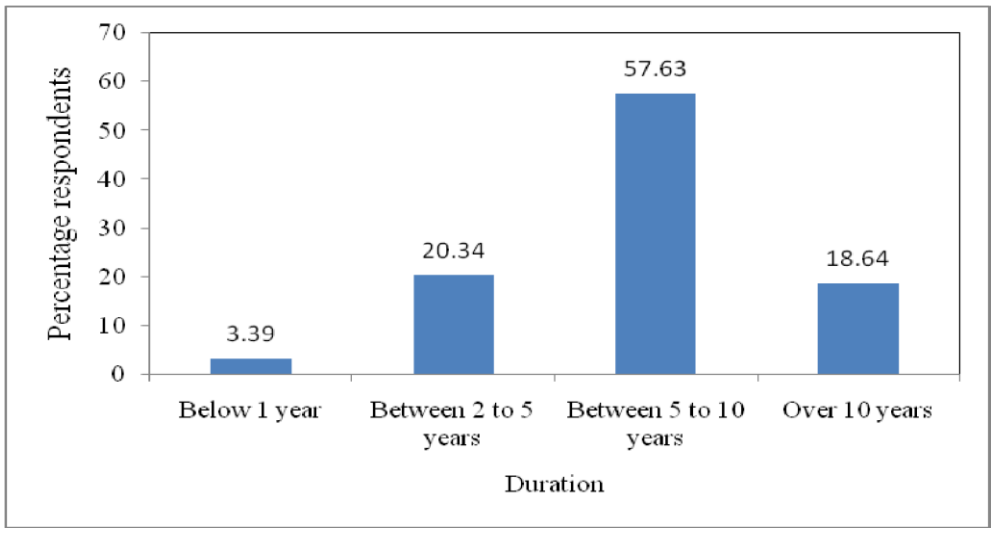

Figure 3: Duration in Dairy Farming

From Figure 3, majority of Questionnaire responses noted that majority of farmers had practiced dairy

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farming for between 6- 10 years. Long time farmers seemed to have more experience and know how on adaptation mechanisms. This is in agreement with the findings of Mintewabi, et al. (2013), which noted that farmers who had carried out farming for over 10 years had knowledge and experience to adapt to climate variability more than younger farmers.

Main Source of Food to Dairy Animals during Wet and Dry Season

The study was interested in establishing the main source of food to dairy animals during rainy and dry season. The results are indicated in Figure 4

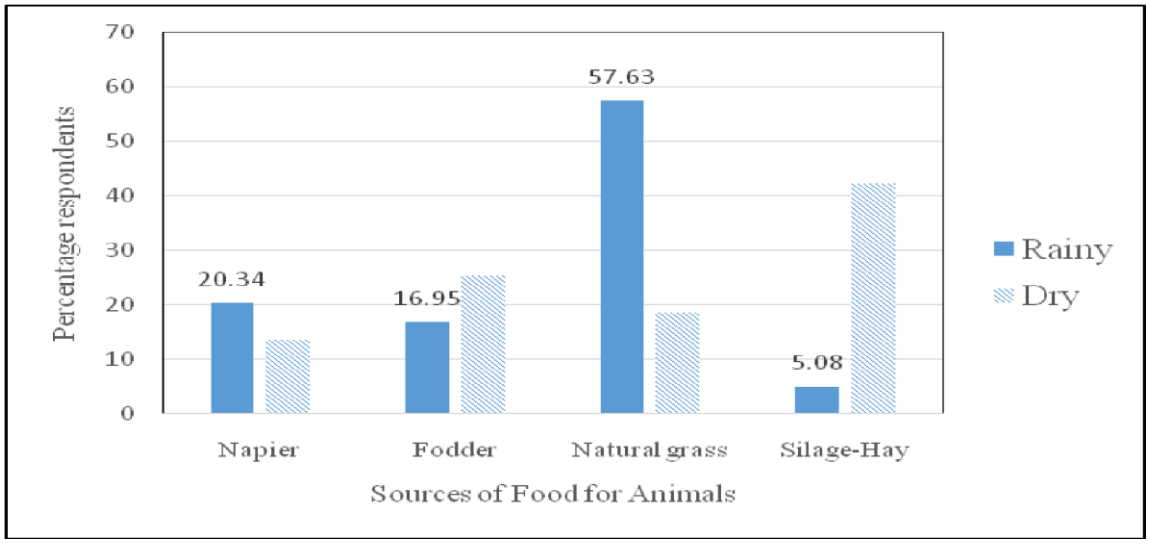

Figure 4: Main Source of Food for Dairy Animals

From the questionnaire responses as presented in Figure 4, during dry season, most of sampled farmers dependent on silage/hay as indicated by 42.37%, fodder at 25.4% natural grass 18.6% while Napier was at 13.6% . During rainy season, most of the farmers relied on natural grass as main source of food for their dairy animal as indicated by 57.6% while 20.3% relied on Napier grass, fodder 18% while hay and silage was least used at only 5%. This shows different feeding habits of dairy animals during different seasons of the year. According to the respondents, during rainy season, natural grass is readily available to them thus no need to use hay and silage because it is expensive

Main Source of Water for Dairy Animals

The researcher also sought to establish the main source of water for dairy animal. The results are as

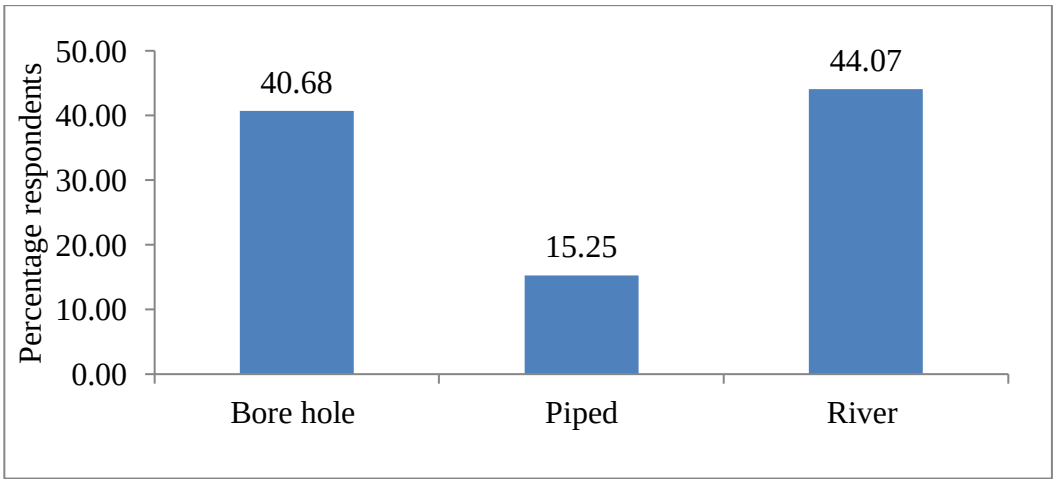

Figure 5: Main source of water

From Figure 5, the main source of water for sampled respondents was rivers as indicated by 44.1% while boreholes were 40.7% of the respondents. Few of the sampled dairy farmers; 15.3% relied on piped water as their main source.

Climatic Vagaries that affected Farmers

On the climatic hazards that had affected farmers regularly in Uasin- Gishu County, respondents gave their responses are as shown in Figure 6.

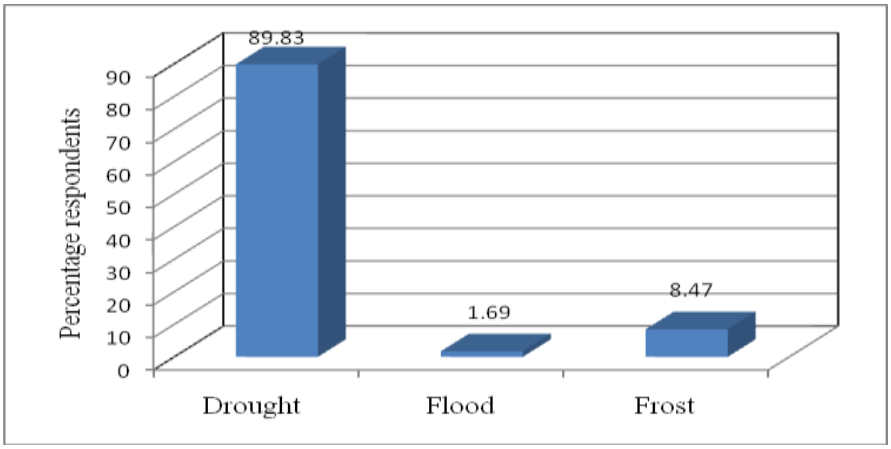

Figure 6: Climatic vagaries facing dairy farming

Types of Dairy Animals

The study further sought to establish types of dairy animals that the farmers were rearing. The results are as shown in Figure 7

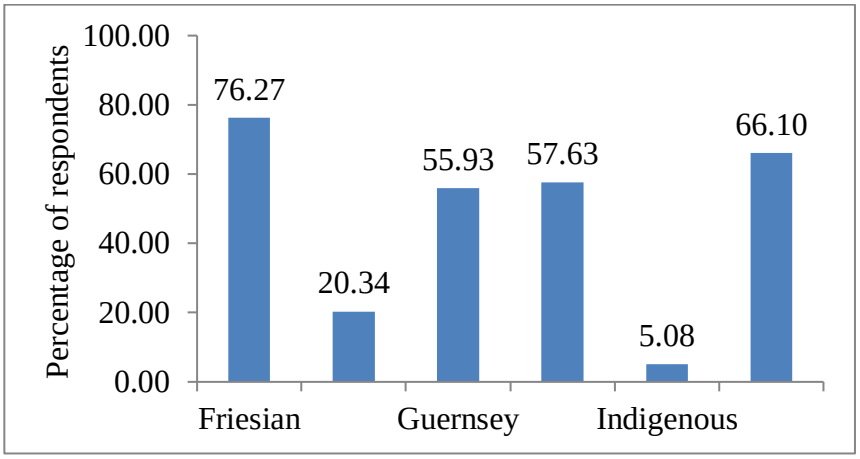

Figure 7: Types of dairy animals

From Figure 7, most of the sampled dairy farmers were rearing Friesian breed of cows as indicated by 76.3% while 66.10% were rearing cross-breed, 57.6% , Ayrshire, 55.9% Guernsey while 20.3% were rearing Jersey. Only 5.1% reared indigenous breed. Most of respondents and key informants like veterinary officers noted that though Fresian and other exotics yields highly, they are highly susceptible to rainfall variability

Kilos of Milk during Dry and Wet Season

The study was interested in establishing the amount of milk in kilograms that sampled farmers got daily per one dairy cattle during rainy season and in dry season. The results are shown in Figure 8

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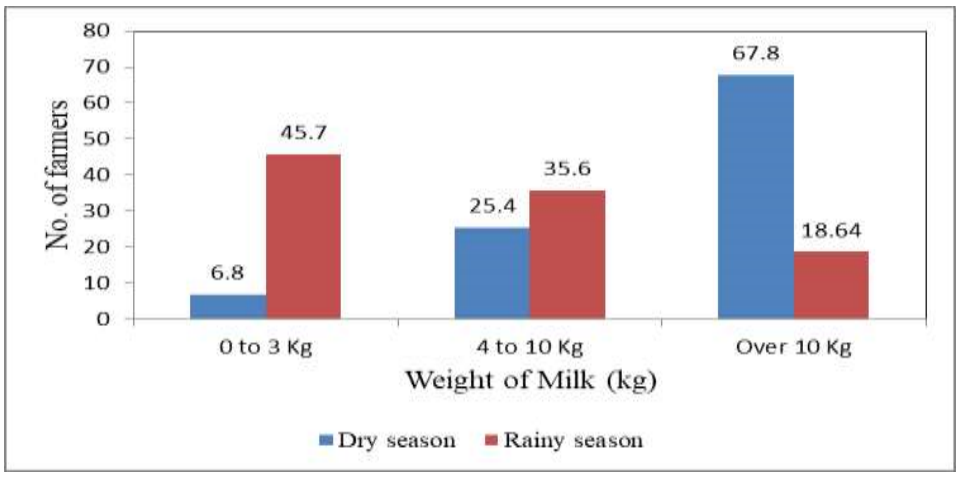

Figure 8: Kilos of Milk during Dry and Wet Season

From figure 8, in dry season, 6.8% of the respondents got 3 kilos of milk 25.4% had 4 to 10 kilos with 67.8% getting over 10 kilos of milk. During wet season, 45.7% of dairy farmers gathered less than 3 kilos, 35.6% between 4 to 10 kilos while only 18.6% of the respondents managed over 10 kilos of milk. Respondents noted that both dry and rainy seasons had strengths and challenges to dairy. For instance: over 50% of them noted that in rainy season, water and fodder sources will be available. However, they observed that in same period, animal diseases like mastitis, milk fever and ketosis which cause death to animals and even reduce milk produce increase. Equally, in the same period, roads become impassable thus milk cannot reach markets leading to wastage. Majority of farmers also shift to crop farming during this time because they are mixed farmers thus reducing grazing fields for dairy animals. In dry periods: though water points are reduced, the area has sunken boreholes and rivers that provide water, grazing fields are available after maize and wheat is harvested, their left overs also act as feeds, roads are passable and reduced diseases. This explain why they have more milk in dry than rainy periods as in fig 8.

Adaptation to Rainfall Variability

The respondents Farmers' responses were as indicated in table IV.

Table IV. Adaptation to rainfall variability

	Frequency	**Percentage**
Supplementary Feeding	88	29.2
Vaccination	50	16.7
Fodder production	47	15.6
Strengthening of Dairy Cooperative movement	80	27.1
Sinking of boreholes	35	11.5
Total	300	100

From Table IV,, respondents put supplementary feeds at 29.2%, 16.7% placed animal vaccination and 15.6% fodder production as key adaptive measures Other strategies were strengthening of dairy cooperative movement at 27.1% and construction of bore holes with 11.5% of the respondents. Key informants lauded key role that farmers' co-operative societies had played in adaptation.

Role of County and National Governments in adaptation

The study noted that the County government or National government had tried to assist farmers to adapt. Their contributions are as shown in Figure 9.

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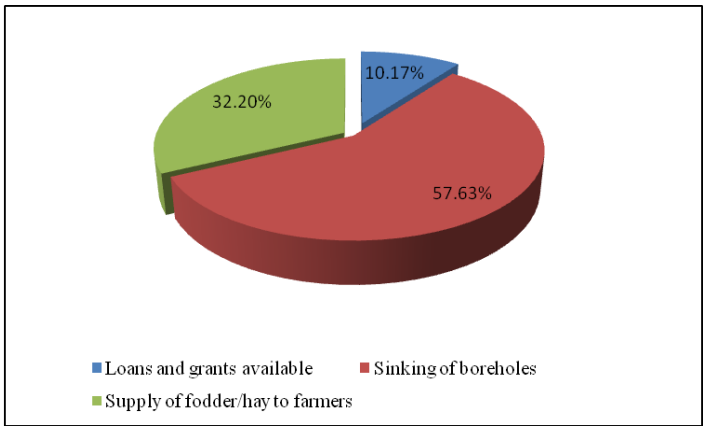


Figure 9. Role of County and National Governments in adapting to rain variability

From Figure 9, 10.17% of the respondents noted that both governments had offered loans and grants to small scale dairy farmers to solve experienced hazards while 57.63% indicated both governments had sunk boreholes. 32.20% indicated that both governments had supplied fodder/hay to small scale dairy farmers.

Challenges faced by scale dairy farmers in adapting to the rainfall variability

The main challenges that farmers faced in adaptation are indicated in figure 10.

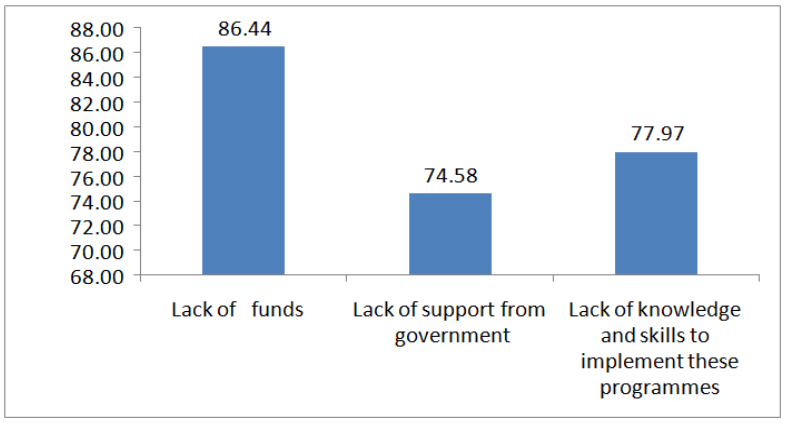


Figure 10: Challenges small scale dairy farmers have faced in adapting to the rainfall variability

Lack of adequate funds, minimal support from the Government and lack of adequate knowledge to implement challenges were the key setbacks to adaptation to rainfall variability by farmers

Rainfall onset and cessation dates

In Uasin- Gishu, rainfall onset and cessation dates varied in years as from 2010 to 2020. In the year 2011, 2013, 2018, and 2020, the onset of rains was in the month of March. In the year 2012, 2015, 2016, 2017 and 2019 rainfall onset was in the month of April. Earlier Onset of rain was noted in the month of February in year 2010 as shown in table 2. This showed that there was a lot of variability in onset dates of rains in this region because the average long rain onset date in Kenya were March 17th and 21st (Alusa 1974) as shown in table V.

Table V: Rainfall onset and number of rainy days during the period 2010 – 2020

Year	Onset	Cessation	Number of rainy days
2010	Feb – September	Late Sept.- Early Feb.	158

2011	March-November	Late Nov. –Early March	150
2012	April- December	Late Dec.- Early April	157
2013	March-November	Late Nov – Early March	159
2014	July-November	Late Nov. –Early July	98
2015	April-November	Late Nov.- Early April	150
2016	April-November	Late Nov.-Early April	138
2017	April-November	Late Nov.-Early April	156
2018	March-August	Late Aug.-Early March	147
2019	April-December	Late Dec.-Early April	166
2020	March-November	Late Nov. –Early March	173

On the numbers of rainy days, more days were observed in the year 2017, 2019 and 2020, fewer rainy days were in the years 2014, 2016 and 2018 as indicated in figure 11. During period 2011 to 2013, the number of rainy days showed an increasing trend as illustrated in the equation Y = 1.3x + 142.38 (Where y is the number of rainy days and X is the years).

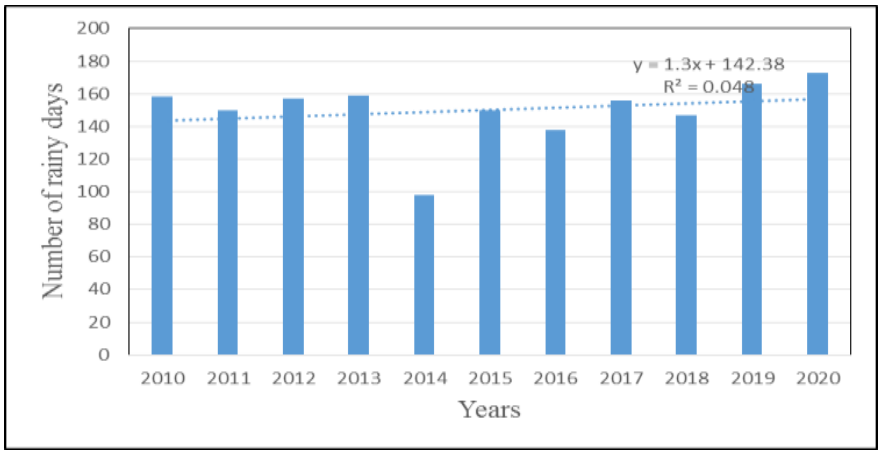


Figure 11: Number of rainy days in each year during the period 2010 – 2020

Average monthly number of rainy days

During the period (2010 – 2020) the average number of rainy days in each month was computed. More rainy days were recorded in the month of August (18.3 days), month of July (17.2) days and in the month of April (16.5 days). However, the months of January, December, February and March recorded the least number of rainy days at 4.5, 6.2, 6.4 and 8.3 respectively as indicated in Figure 12.

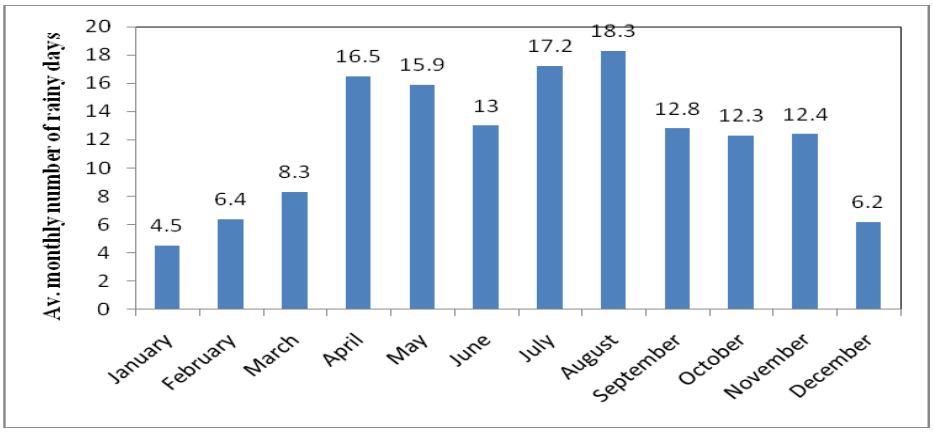


Figure 12: showing the trend of the average number of rainy days in a month over the study period (2010 – 2020).

Average monthly rainfall variability in Uasin-Gishu in the years 2010 – 2020

Over the period 2010 – 2020, the average monthly rainfall in Uasin- Gishu was lower in the months of January to February (36.8 mm and 39.5 mm respectively) and November to December (64 mm and 57 mm respectively). The highest average amount of rainfall was recorded in the months of April (159.6 mm) and in the month of August (169.1 mm). This showed that the rainfall onset in Uasin Gishu was in the months of March while the rainfall cessation period was in the month of September. Over this period of study (2010 – 2020), the results indicated that there was a significant increase in the rainfall amounts for months of April-June as depicted by an equation $Y = 1.310X + 92.78$. With $R^2 = 0.009$ (Where Y is the average monthly rainfall (mm) and X is the month as in Figure 13. However, this rainfall increase was not significant.

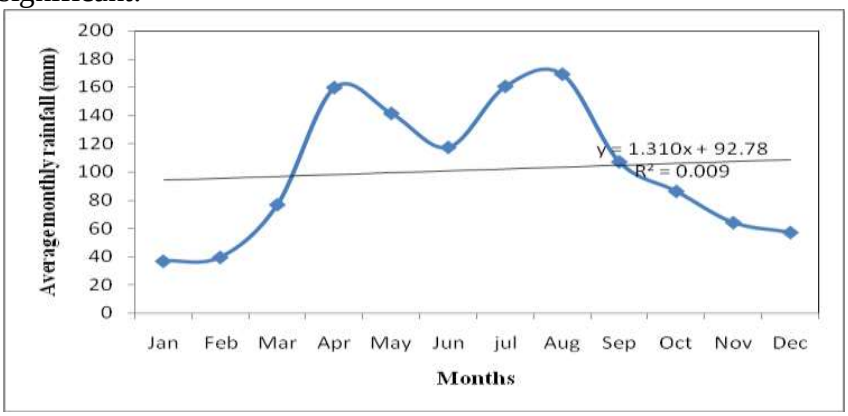
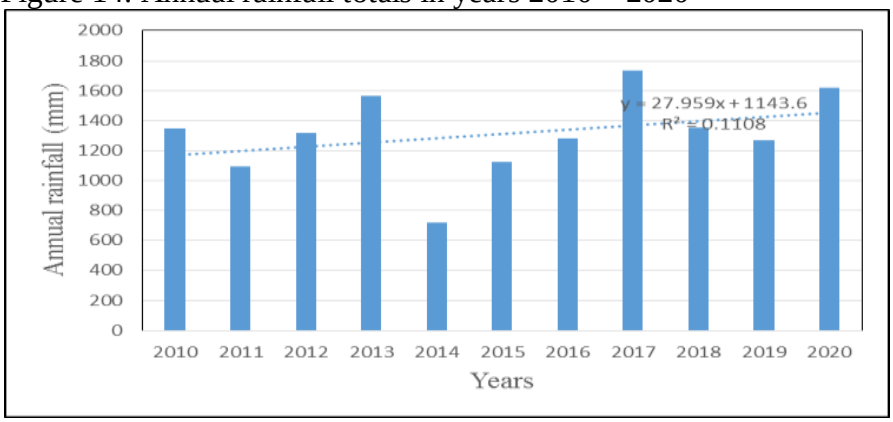


Figure 13: Average monthly rainfall (mm) over the period (2010 – 2020)

Annual rainfall variability

During the period 2011 – 2013 and 2014 to 2017, annual rainfall in Uasin-Gishu showed an increasing trend with an equation of $Y = 27.959x + 1143.6$, With $R^2 = 0.1108$ (Where; Y = amount of rainfall, x = year) as shown in the figure 14. This showed that the increase was significant. The highest rainfall in this area was recorded in the year 2017 (1868.2mm), whereas the lowest amount of rainfall was about 800 mm in year 2014. The graph indicates sharp fluctuations of annual rainfall in years 2010- 2020.

Figure 14: Annual rainfall totals in years 2010 – 2020



Source: Computed from field data, Jan 2022

Average monthly and annual milk production in Uasin –Gishu in years 2010-2020

Average monthly milk production in Uasin- Gishu during the period (Year 2010 – 2020) was used to establish the total amount of milk produced in a given year. More milk was produced in the years 2010, 2018, 2017 and 2019, as in Figure 15. The lowest amount of milk was produced in years 2012, 2013 and 2014 . From year 2015 to 2018, the milk produce was on an upward trend.

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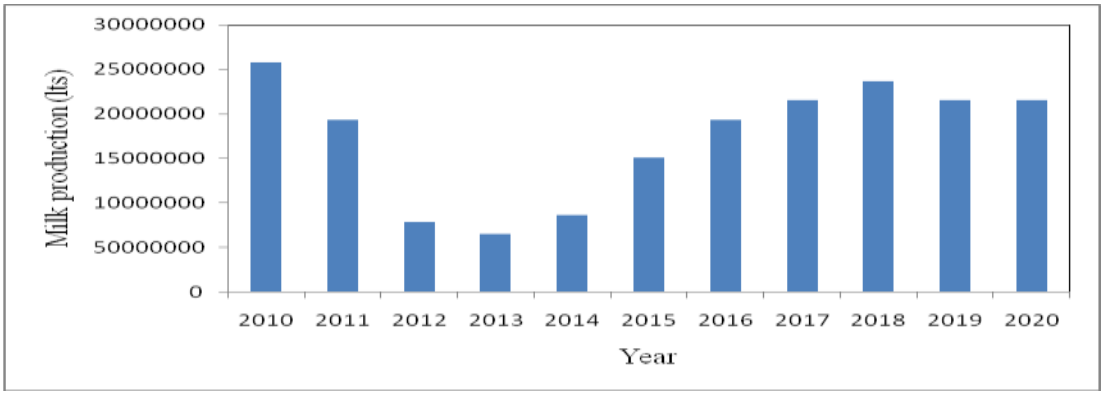

Figure 15: Total milk production in a year during the period (2010 – 2020)

Monthly milk production in Uasin- Gishu

Higher amount of milk were produced in the months of January, November and December while the months of April and May had the lowest milk produced in Uasin- Gishu County as depicted in figure 16. The trend also indicate that there was an increasing milk production from the month of July, August, September, October all the way to January of the following year .

Figure 16: Milk production trend in months during the period (2010 – 2020)

Considering dry season (November to February) and wet season (March to October), Average monthly Milk production in the four months (dry season) was 225,612,186 litres while the average monthly milk production in the 8 months (wet season) was 154,761,276 litres. General increase in milk production had an R^2 value of 0.170, which implied that the line of best fit accounted for 17.0% of the regressed points.

Variation in Milk production with monthly rainfall

Figure 17 shows the average monthly rainfall and the monthly milk production in Uasin -Gishu during the period 2010 – 2020. From the trend, the months with higher average monthly rains recorded lower milk amounts, cases in point were the months of March, April and May with an increase in milk production during low rainfall ones of December, January and February.

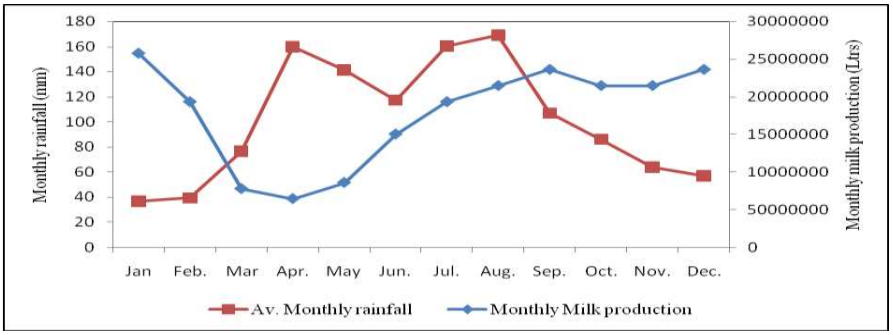

Figure 17: Average monthly rainfall and monthly milk production

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Relationship between average monthly milk production and the average monthly rainfall

In establishing the relationship between monthly milk production to monthly rainfall during this period, Correlation analysis was used and it showed that there was a negative relationship (r =- 0.424). This showed that in the months where higher rainfall was recorded, the amount of milk produced was lower. More milk was produced in the months that had lower rainfall, hence the negative correlation value. However, the reduction was not statistically significant (P > 0.05) as shown in table VI.

Table VI: Correlation between milk production and average amount of rainfall in a month

		Milk	**Amount of Rain (mm)**
Milk	Pearson Correlation	1	-0.424
	Sig. (2-tailed)		0.169
Amount Rain	of Pearson Correlation Sig. (2-tailed)	-0.424 0.169	1
	N	12	12

Variability of Milk production and the number of rainy days

Months that had higher number of rainy days were found to have lower milk produced. This was noted particularly in the months of March, April and May which had high number of rainy days and low milk production (Figure 18.). In the same figure, months which had fewer rainy days like January, February, September and December realized higher milk produce. This findings thus noted that months with many rainy days (wetter ones) received low milk production unlike drier months which realized high milk produce.

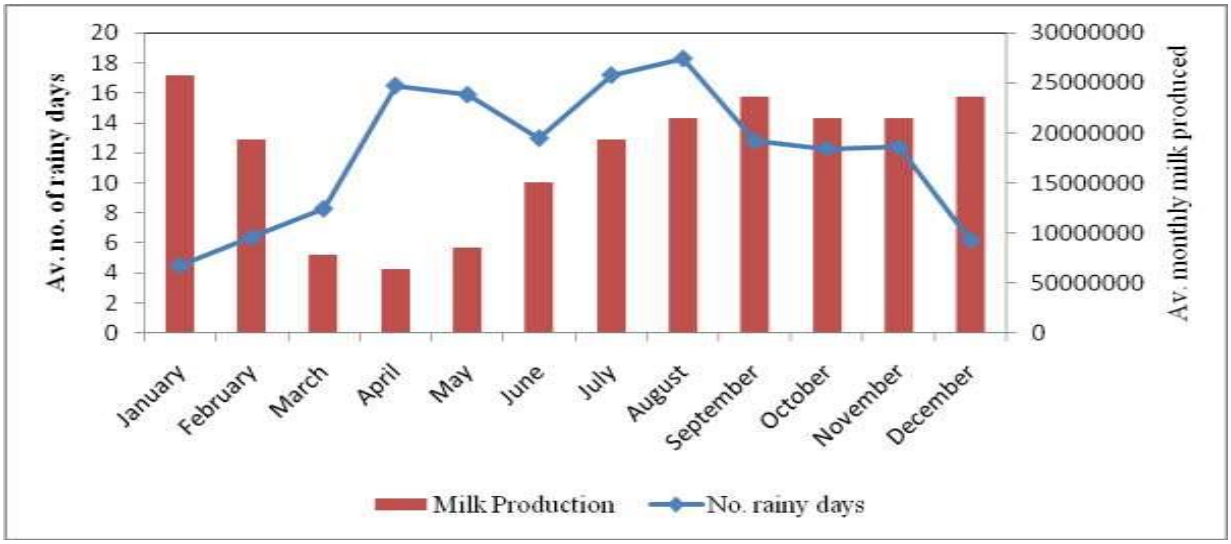

Figure 18: Average monthly Milk production and the number of rainy days

These findings were reinforced with the explanations given by key informants and farmers who explained that low milk production in rainy season was due to reduced grazing fields since during this time most of the farmers cultivate farms in readiness for growing of crops like maize, wheat and Irish potatoes. But during dry periods, they claimed that the grazing fields were always available as food crops would have been harvested, meaning dry matter which is very key to dairy animals like maize and wheat leftovers are available. This observation is however the opposite with the findings by Kirui, (2012) who noted that in

Kosirai Nandi and Namayumba Uganda, during high rainfall months, the milk production is high between 5-8 litres per cow while in dry months production is low (2-3) litres.

Effect of number of rainy days on total milk produced in the year

Table VII revealed that the number of rainy days in the period 2010 to 2020 had no significant effect on milk production in the year when tested using Pearson correlation analysis ($r = 0.375$, $p > 0.05$). However, positive correlation value indicates that increase in milk production was recorded when there were more rainy days in the year.

Table VII: Correlation between milk production and number of rainy days in the years of study

	No. of rainy days	Milk production
No. of rainy Pearson Correlation days	1	.2264
Sig. (2-tailed)		.5031
N	11	11
Milk production Pearson Correlation	.2264	1
Sig. (2-tailed)	.5031	
N	11	11

During this period (2010 – 2020) the highest numbers of rainy days were in the year 2020 while the lowest was in the year 2014. In the years 2011 to 2013 rainfall, total number of rain days remained high but with a drop in the milk produced during the same period (Figure 19) According to the farmers and the agricultural officers who were interviewed, this was because of change of government and devolving agricultural sector after the inauguration of the 2010 constitution. They claimed that change over affected the reconciliation of milk records in the County, therefore some of the dairy records from the sub counties may not have been submitted accurately. They also claimed that some of the agricultural measures which were in place like government loans to farmers through Sacco's, supply of hay to farmers and others had been temporarily halted due to devolution of agricultural functions, this according to informants might have affected milk production in this period. In 2014- 2017, the milk production was on an upward trend because according to the farmers interviewed, besides increased number of rainy days, the County Government had put in place mechanisms to improve the sub sector like the adaptive mechanisms to rain variability.

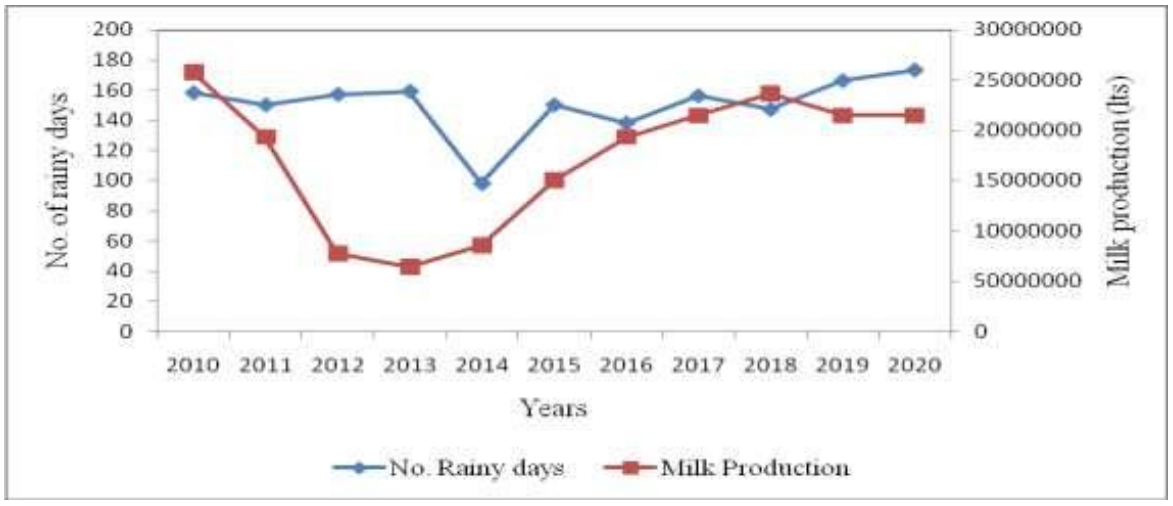

Figure 19: Number of rainy days in a year and the total milk produced in the year

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Relationship between annual milk production and total annual amount of rainfall

From Figure 20, years 2010 to 2013 recorded a decline in annual milk production despite the same period having a significant increase in the total amount of rainfall annually. The County Dairy officer indicated that the challenges could have been caused by lack of sufficient records from the fields because the County Governments came in during this time and they had challenges in getting clear records as few farmers had registered with national government before year 2010. Though there was fluctuation in annual rainfall amounts from 2015 to 2020, milk production seem to have been increasing yearly. According to the farmers' responses, milk production could have been affected by other factors like improved markets, Government interventions and role of co-operatives societies which made it easier to collect milk from small scale farmers in rural areas.

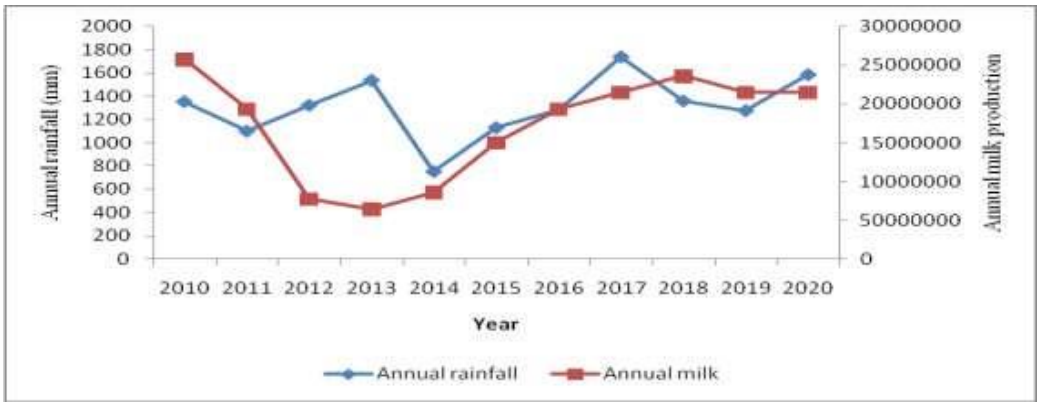

Figure 20: Annual rainfall and the total milk produced yearly in Uasin Gishu

In assessing the extent to which rainfall variability has affected small scale dairy farming in years 2010-2020, a Pearson correlation analysis was carried out and the result showed that amount of milk produced in a year in this period increased with an increase in rainfall ($r = 0.532$). A linear regression analysis on milk production on rainfall therefore indicated a regression equation of; $Y = 7.599 + 96504x$ (Where Y = milk produced (litres), and x = rainfall (mm).

These findings were in agreement with the observations made by the key respondents who alleged that years with high rainfall amounts will most likely have more rainy days which will eventually lead to surplus feeds and water to the dairy animals which automatically increases the milk yields to farmers. The same observation was made by Masese, (2016) who noted that years with higher total rainfall amounts recorded both higher crop and dairy yields in Kisii Central region. Kurukulasuriya (2006) while analyzing economic effects temperature and rainfall on African countries also noted the same findings; that increase in total annual rainfall will have some benefit to a farmer especially dairy ones, while decrease in rainfall is harmful to dairy and other livestock farmers.

However, the findings appeared contrary to the findings of Huho et al, (2012) who noted that in Laikipia East region between years 1976-2005, there was annual increase in rainfall in the area but did not lead to increased milk production.

Correlation analysis for the milk production against Rain onset, cessation and number of rainy days

Milk production was positively affected by onset ($r = 0.305$) number of rainy days ($r = 0.226$) and cessation of rain ($r = 0.019$) during the period (2010 – 2020) as shown in Table VIII. Considering the correlation values obtained, none of the tested parameters were significantly affecting milk production during this period ($P > 0.05$). However, milk production increased with an increase in the number of rainy days in a year.

Table VIII. correlation analysis of milk production against onset, rainy days and cessation

```
. pwcorr milkprod NumberRdays onset Ceasation, obs sig star(5)
```

	milkprod	Number~s	onset	Ceasat~n
milkprod	1.0000			
	11			
NumberRdays	0.2264	1.0000		
	0.5031			
	11	11		
onset	0.3045	-0.2059	1.0000	
	0.3626	0.5437		
	11	11	11	
Ceasation	0.0190	-0.0567	0.0122	1.0000
	0.9559	0.8685	0.9715	
	11	11	11	11

Regression analysis for the milk production and rain onset, cessation and number of rainy days

Regression analysis was done further to ascertain the extent to which each rainfall characteristic had affected dairy. The amount of milk produced during this period were dependent on the parameters in a regression model of: $Y = \text{constant} + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon$. Where; Y = milk produced in liters, X_1 = onset of rain, X_1 = cessation of rain, X_3 = number of rainy days, β is the beta coefficient of the factor, ε is the error term. Effect of the three factors therefore becomes;

$Y = 166000000 + 1083657\ x_1 + 90331x_2 + 152461.9x_3$ as illustrated in Table IX . This showed that milk production was mainly affected by; onset of rains, number of rainy days and to small extend cessation. This had an R^2 value of 18.1% accounted for in the line of best fit.

Table IX. Regression of milk and rainy days, onset and cessation

```
. regress milkprod NumberRdays onset Ceasation
```

Source	SS	df	MS		
				Number of obs	= 11
				F(3, 7)	= 0.52
Model	1.7659e+14	3	5.8862e+13	Prob > F	= 0.6845
Residual	7.9908e+14	7	1.1415e+14	R-squared	= 0.1810
				Adj R-squared	= -0.1700
Total	9.7567e+14	10	9.7567e+13	Root MSE	= 1.1e+07

milkprod	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberRdays	152461.9	175739.8	0.87	0.414	-263096.7	568020.5
onset	1033657	985553.6	1.05	0.329	-1296807	3364121
Ceasation	92334.39	998318	0.09	0.929	-2268312	2452981
_cons	1.66e+08	2.86e+07	5.81	0.001	9.87e+07	2.34e+08

Testing for Hypothesis

Rainfall variability has not had significant impact on small scale dairy farming in Uasin-Gishu County in the

years (2010-2020). In testing this hypothesis, various rainfall characteristics were correlated against milk produce. Correlation indicated that there was some significant effect of each rainfall characteristics on dairy as follows: Total annual rainfall in the area (positive Correlation, r = 0.532), onset r = 0.305, rainy days =0.226 and cessation at 0.19. The researcher therefore fails to accept the null hypothesis and adopt the alternative one that rainfall variability has had significant impact on small scale dairy farming in Uasin –Gishu County.

CONCLUSION AND RECOMMENDATIONS

Summary of the Findings

The research established that rainfall variability in Uasin –Gishu County was real especially between 2010 and 2020. Rainfall variability characteristics of onset, cessation, frequency, seasonality and total amounts were analyzed. The Average onset and cessation months of rainfall in the County was in April and November respectively. However, it kept varying from one year to another. For instance, in 2010 rainfall onset was in February and September with cessation in November. In 2011, onset was in March and November with cessation in early March. In 2012, onset was in April and December with cessation in April. By year 2020, Onset was March and late November with cessation in early March. During the same period, the number of rainy days also varied; like the years 2019 and 2020 had the highest number of rainy days. While 2014 and 2016 had the least number of rainy days with an increasing trend of R^2 value of 0.05 and in equation Y=0.722X +133.4 (Y –is the number of rainy days while X is the years. On Monthly rainfall ,January and February had the lowest amounts in all the years but the total rainfall amount had some slight increase depicted with equation Y=1.310X+92.78.

On how rainfall variability had impacted on small scale dairy farmers, wet season recorded low milk produce, like in the months of March, April and May while high yields were realized during drier season of November, December, January and February. Pearson correlation showed r =0.424, P=0.169. Correlation of other rainfall factors indicated that total annual rainfall had the correlation of r =0.532, Onset r =0.305, rain days r =0.226 while cessation r =0.019. Considering the correlation values obtained, none of the tested parameters were significantly affecting milk production during this period (P > 0.05). However, milk production increased with an increase in number of rainy days in a year and an increase in total annual rainfall.

Conclusion and recommendations

Findings from the research noted that rainfall characteristics of total rainfall amounts, seasonal a mounts, onset and cessation dates and number of rainy days had some impact on small scale dairy farming in Uasin Gishu County, though the effect was insignificant (P > 0.05). Regression done also indicated that these factors influenced small scale dairy farming differently. There was notable variability especially on total annual rainfall between 2010 and 2020 varying from an annual total of 1800 mm to 1000 mm in 2017 and 2011 respectively. Standardized scores of rainfall indicated an increasing variability implying that farmers should be ready for this trend of rainfall variability in the unforeseeable future.

Milk production varied with rainfall variability such that low milk production was realized during low total annual rainfall years while high milk production corresponded with high total annual rains. However it was noted that high amounts of milk was produced during the drier seasons of the year. Therefore, the study concluded that rainfall variability has affected small scale dairy farming in Uasin-Gishu County.

It was evident from the research that onset, cessation dates of rainfall and total amounts vary from time to time and had a significant impact on small scale dairy farming in terms of milk production. Farmers should be encouraged to keep cross breed dairy animals more because they seem to be resistant to rainfall

variability and also use less feed and water compared to exotic ones, this is beside them using of modern digital methods of finding out and sharing of climate variability matters as farmers to enable them plan for their future farming activities to make this enterprise more profitable. 0ther ways of assisting farmers to adapt to rainfall variability like initiating irrigation programs to ensure constant supply of pasture to dairy animals. The farmers should also be encouraged to join co-operative societies (Those who had not joined) as it appeared like cooperative societies play a key role in solving not only climate variability but also marketing and other financial challenges that small scale farmers encounter.

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CONFLICT OF INTEREST

This manuscript was my own research and was not sponsored by any organization or an individual who can claim any recognition. No any conflict of interest will be raised on publication of this research.

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