Farmers' Perception and Adaptation to Climate Variability in Nandi County, Kenya

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Abstract

Climate variability impacts environment social and economic growth. Much of these effects are felt by smallholder farmers whose livelihoods depend on natural resources. However, smallholder farmers have limited knowledge to link anticipated climate variability impacts at the local levels. In this study, farmers' perception and level of awareness about climate variability and how it impacts smallholder dairy farming was analyzed. A total of 350 smallholder dairy farmers from eight sub-locations of Aldai Sub-County, Nandi County, Kenya were interviewed and compared farmer's perceptions about climate variability with trends from Meteorological Data. Analysis was done using a multivariate Probit regression model. Results showed that, on average, temperatures were rising, and this rise was more prominent during the short rainy seasons. Given the rising trends in temperature, the respondents above 50 years were asked to compare the current weather conditions with those observed in the last 32 years ago (i.e., from January 1980 to December 2012) as a way of measuring their perception about climate variability. The majority (70%) of smallholder farmers identified drastic changes in temperature patterns. Only 38.12% with at least one year of farming experience were able to note the rise in temperature levels. These results indicate that smallholder farmers who are considered to have limited information about climate variability were more likely to perceive changes in weather patterns. In conclusion, we found that access to extension services, type of land tenure, and access to credit facilities are important in enhancing the adaptive capacity of farmers.

Keywords: Adaptation, Climate Variability, Farmers' Perception, Mitigation

INTRODUCTION

The rising climatic variability is putting more pressure to farmers, thus making them change their way of farming in order to cope up with the new challenges (Easterling et al., 2000; Thornton et al., 2009). In the last 20 years, the frequency of occurrence of extreme weather events like drought, floods and storms which are attributed to climate variability have been shown to cause anthropometric global warming (Ngeno et al., 2013). Easterling et al., (2000) using models predicted that global temperatures are expected to rise in the next 20 years. It is anticipated that these will cause thermal stress on livestock species, impair feeding practices, metabolic activities, and hinder defense mechanism of domesticated livestock thus affecting livestock productivity (Nardone et al., 2010; Ngeno et al., 2013). In addition, the species composition of rangeland habitat, pasture growth, water availability, disease distribution, crude protein and digestible organic matter contents of plants will be affected (Blummel, et al., 2010). This would lead to increased feeding and veterinary costs and also causing nutritional stress to grazing animals (Abbas et al., 2009: Thornton et al., 2009; Hiernaux et al., 2009; Craine et al., 2010).

Intergovernmental Panel on Climate Change (IPCC), (2007; 2014) reports indicate that high temperatures are expected to increase in the near future, thus causing frequent droughts, high water stress, storms, and coastal flooding. These impacts are felt mostly by smallholder farmers who depends on rain-fed agriculture for livelihood support. Over 80 % of the Kenya's landscape is arid and semi-arid and majority of rural households practice rain-fed agricultural production. This means that changes in weather patterns can vastly impact farmers' welfare through failed crops, livestock deaths, and famines. Low profitability of smallholder farming activities, farmers experience slow graduation pace out of poverty (Bruckner, 2008;).Farm families are caught in a poverty spiral, characterized by declining food intake, poor service delivery, degraded soils, and small land sizes necessary for livestock herding. As a result of these challenges, income generation by smallholder households from dairy production is insufficient due to limited access to improved production technologies and limited linkages to high-end markets (FAO, 2009; 2006; Orindi, 2007). As a result, there is need to identify climate smart agricultural technologies which can help smallholder farmers mitigate the effects of climate variability and change. Such information forms excellent baseline information necessary to enhance local capacity especially on vulnerability and adaptation measures.

In 2008, East Africa Dairy Development (EADD) programme was launched to support about one million smallholder farms (those owning 1-5 acres) in the East African region to move out of poverty by improving the management and profitability of their dairy enterprises (Zagst, 2011). This programme aimed at assisting farm families to meet their daily nutritional needs by increasing milk production and quality. The project was implemented in Kaptumo ward in Nandi County, Kenya. The project established demonstration sites for selected fodder crops like Napier grass, Rhodes grass, Lucerne, Desmodium, Calliandra, and Sesbania. In addition, EADD engaged in creating awareness for the need to improve dairy productivity by organizing farmers into dairy groups, provision of extension advice, and strengthening of linkages between dairy value chain actors (Zagst, 2011).

The Mitigation of Climate Change in Agriculture (MICCA) program was working closely with EADD programme. Kaptumo division was selected as the site for integrating climate-smart agricultural technologies (CSAT) of which there were existing mixed-farming systems. The MICCA project aimed at understanding the options for reducing greenhouse gas (GHG) emissions from mixed-farming systems that was predominant in the area and how these options could be scaled up. The EADD engaged in creating awareness of the need to improve dairy productivity, mobilized farmers into functional dairy groups, provided extension advice to farmers, established and strengthened linkages between the farmers, milk processors and input suppliers. The EADD project introduced the concept of CSAT to farmers through collaboration with International Council for Research in Agro-forestry (ICRAF) in Kaptumo/Kaboi ward of Nandi County. It promoted production of fodder shrubs and herbaceous legumes, zero-grazing units, artificial insemination, tree planting, growing of drought resistant fodder crops, silage making using polythene tubing method, installation of biogas, appropriate management of manure, water harvesting and storage technologies for domestic and livestock use. The aim of this study was to investigate the perception and knowledge of smallholder farmers on climate variability and their current coping methods aimed at determining the effects of past, present and future climate change on dairy production.

RESEARCH METHODOLOGY

Study Area

This study was undertaken in Aldai Sub - County, Nandi County, Kenya. The County is located in the North Rift region of Kenya, occupying an area of 2,884.4 square kilometers (KM^2). It has a population of 752,965 (KNBS, 2019a). It is bordered to the West by Kisumu,

East by Nakuru, South by Kericho and to the North the Uasin-Gishu Counties. The altitude ranges from 1,400 - 2,400m above sea level, with average temperatures of 18 - 25°C and annual rainfall of between 1,200 - 2000milimeters (mm). Majority of the households are smallholder dairy farmers (SHDF) and also practice cash crop production. Aldai Sub-County is located within latitudes 0°34″ North and longitudes 34° 44″ and 35° 25″ East administrative Counties of Kenya. Aldai Sub-County was one of the project areas selected by EADD funded by the Bill and Melinda Gates Foundation in partnership with Heifer International, ICRAF, International Livestock Research Institute (ILRI), Techno Serve, and African Breeding Systems (ABS). The project started its operations in 2008 in Kenya.
Sampling Procedure

Nandi County in Rift valley region was purposively selected because the County had farmers' who participated in EADD project. The County has 6 Sub-Counties namely: Aldai, Mosop, Nandi Hills, Tinderet, Chesumei, and Emgwen. Subsequently, Aldai Sub-County, which has 6 wards (Terek, Chepkumia, Kibwareng, Kemeloi/Maraba, Kaptumo/Kaboi, and Ndurio/Koyo), was thereafter selected. However, Kaptumo/Kaboi and Ndurio/Koyo wards were selected because most farmers from these wards were the main suppliers of milk to Kaptumo Dairy Cooperative Society Limited (KDCL) and also, EADD project was active in these wards. A list of 1,600 smallholder dairy farmers' who participated in EADD project was obtained from KDCL.

Sampling Size Determination
A total of 385 dairy farmers who participated in EADD project were drawn from 7 sub-locations (4 in Kaptumo/Kaboi and 3 in Ndurio/Koyo wards) and interviewed (Table 1). However, 34 respondents were dropped because of incomplete information, leaving 350 farmers with complete information for analysis. In addition, key informants (community opinion leaders, extension agents and non-governmental organization's officials working in the dairy sector) in the study area were interviewed.

Table 1: Distribution of farmers in seven sub-locations in Nandi County

Wards	Sub-location	Number of farmers interviewed	Key informants interviewed
Kaptumo/Kaboi	Chepkong'ony	53	3
	Mosombor	62	3
	Ibanja	54	3
Ndurio/Koyo	Kaboi	50	3
	Mugundoi	48	3
	Kapsoo	63	3
	Kamarich	54	3
Total		384	21

Data Collection and Analysis
Data collection was done using structured and semi structured questionnaires, focus group discussions, and key informant interview. Focus group discussion targeted key persons from the Ministry of Agriculture, Nandi County, opinion leaders in the community and the key farmers. The pre-tested questionnaire was administered by trained numerators and focused on socio-economic, institutional and weather-related factors, farmer's perception and awareness of climate variability on dairy production, CSAT adopted by smallholder farmers, constraints to adoption of CSAT and finally, milk production of smallholder dairy farmers. Key informants interview captured information concerning knowledge on CSAT, attitude towards CSAT, practices of CSAT, factors influencing adoption levels, institutional and policy context regarding to the adoption of CSAT in the study area.

Analytical Technique
A multivariate Probit regression model (Okello et al., 2021) was used to analyze the likelihood of farmers' adaptation options to climate variability. Outcome variables were constructed as dummy variables which equals 1 if a farmer adopted a given climate variability options and 0 otherwise. Farmer's decision to adapt and use a given CSAT was coded as binary variable, implying that every farmer makes decision to either adopt or not to adopt. Particularly, adaptors of CSAT were grouped into three: low, medium or high adopters. We merged low, medium and high adopters to depict a farmer have adopted a technology and zero otherwise. This means that a smallholder dairy farmer was given a value of 1 if he adopted (i.e., if he reported either of the adoption categories, i.e., no, low, or high adoption status) and 0 otherwise. This therefore implies that our dependent variable is a dummy variable. A binary dependent variable was analyzed using a Probit model. The model used for estimation is as below.

$$Q_{ik} = \beta_k X_{ik} + \partial_k S_{ik} + \varepsilon_k \text{, where } k = 1,\ldots m,\ Q_{ik} = 1 \text{ if } Q_{ik} > 0 \text{ and 0 otherwise}$$

Where Q_{ik}, is the latent variable representing the unobserved characteristics associated with the *ith* farmer who have adopted a *kth* CSAT in the study area (where k = 1…,m). In the model, represent climate adaptation strategies adopted by smallholder dairy farmers, is a binary dependent variable. Different regression specifications for each of the CSAT were run. $X_{ik}$is a vector of explanatory variable (i.e., those related to farm and households) hypothesized to influence adoption status of CSAT by individual dairy farmers. S_{ik} denotes climate related factors that impact adoption level of each farmer like awareness levels. β_k and ∂_k are vectors to be estimated while ε_k is the error term which is distributed with a mean of 0 and a unitary variance, $\varepsilon_k \sim (0, \delta)$.

RESULTS AND DISCUSSIONS

Socio-economic, institutional and farm-specific characteristics of dairy farmers in Aldai sub-County, Nandi County, Kenya
The characteristics of dairy farmers in the study area can be grouped into two: those related to households and institutional factors (Table 2). Household characteristics of interest in this study include household size, age of household head or respondent, marital status, gender of household and education level. On the other hand, institutional factors include aspects that may influence farmers such as membership to association, dairy farming system practiced, land tenure system, access to extension service and access to formal credit facility.

Our findings indicate that each farm household is made up of about 2 members eating from the same pot (Table 2). This low household size can be attributed to; first the small land sizes caused by increasing human population leading to land sub-division and, second, the burden of accessing food and other social amenities. The high cost of living of maintaining large families is likely to encourage farmers to use modern family planning methods. The mean household land holdings cultivated are small ranging from 1-2 hectares. This is consistent with the fact that most land holdings in the study area are mainly under large scale tea farming by multi-national companies.

Results in table 2 show that about 29.1% of dairy farmers belonged to farmer associations. This number is low considering that dairy farming in the study area is mainly practiced by small-scale farmers. This low membership to farmer associations may be explained by several factors. First, farmers might have joined these associations expecting some windfall in form of cash bonuses which never happened. Therefore, most of them may have opted to leave and join other associations for which we do not have information about. Secondly, this low membership to farmer associations might be attributed to the low levels of education of most of the dairy farmers (Table 2). The low literacy as indicated in this study limits farmers from participating in the activities organized by the association and any benefit that may accrue to them as a result of participation from the associations.

Table 2: Socio-economic, institutional and farm-specific characteristics of dairy farmers in Aldai sub-county, Nandi County, Kenya

Variables	N	Mean	S.D.	Min	Max
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Household size (Continuous)	350	1.491	0.523	1.000	3.000
Membership to association (Dummy, 1= Yes)	350	0.291	0.455	0.000	1.000
Dairy farming systems	350	2.869	1.211	1.000	6.000
Age of household head (Years)	350	2.814	0.827	1.000	4.000
Marital status (Dummy, 1=Married)	350	0.874	0.332	0.000	1.000
Gender of the household (Dummy, 1=Male)	350	0.709	0.455	0.000	1.000
Education level of the respondent	350	2.731	0.588	1.000	4.000
Land tenure (Dummy, 1=Secure)	350	0.929	0.258	0.000	1.000
Access to extension services (Dummy, 1=Yes)	350	0.537	0.499	0.000	1.000
Access to credit facilities (Dummy, 1=Yes)	350	0.303	0.460	0.000	1.000

N = 350 smallholder dairy farmers; SD = the standard deviation; Min = the minimum value of an explanatory variable; Max = the maximum value of a variable; (1) = zero-grazing; (2) = semi-intensive; (3) = Tethering; (4) = Extensive/free-range; (5) = Paddocking

Semi-intensive system of livestock farming was dominant in the study area. Interestingly, this farming system has medium returns compared to other modern and more effective systems like zero grazing. The high number of farmers using this method can be attributed to the lack of sensitization, awareness, knowledge of new farming system and capital to start more intensive farming system like zero grazing due to poverty levels.

Most respondents (45.1%) were aged between 40 and 50 years old (Table 2). Indicating that few young people (aged below 40 years) were engaged in dairy farming in the study area, despite high returns from dairy farming and high unemployment rate of the youths (15 - 24 years) in Kenya, above 7.27% (International Labor Organization, (ILO, 2020). This further means that young people who are able to grow the dairy sector are not pro-active in the sector. These results are in congruence with the findings of Murage et al. (2019), who found out that there were more elderly farmers (aged 60 years and above) in Kenya, compared to other East African countries. Similar findings were also established by Wemali (2014) and Mironga, (2005) in Kenya. These results affirmed United Nations Development Program (UNDP) position that Kenya's farming population is aging because agriculture remains unattractive to youths (UNDP, 2011). Over 87.4 % of the respondents were married. This high percent can be explained by the fact that married people have more family responsibilities to carry such as paying school fee for the children and provision of the basic needs This therefore made them to work hard to meet these household responsibilities.

Both male and female were actively involved in dairy farming in the study area although male dominated (70.1%) compared to their female counterparts (Table 2). This has implications for gender equality and therefore calls for mainstreaming of women in agricultural sector. Interestingly, female household heads constituted the bulk of agricultural workforce in Kenya. These findings concur with Okuthe et al., (2013), who reported an existing bias in extension service provision where it was mainly offered to males compared to female farmers. Despite the skewness in gender involvement in dairy farming, it remains the main source of livelihood (80%) of the rural residents in the study area (GoK, 2009).

Education, measured in years of normal schooling of household head is a proxy for managerial input (Maddison, 2006). Higher level of education diminishes the probability of new technologies adoption as respondents are able to distinguish between the benefits and the costs of adopting a given technology. In this study, majority of the respondents had secondary level of education. This is the minimum level of education as prescribed by the government of Kenya, an indication that most of the farmers in study area had sufficient basic knowledge to understand and apply farming principles, and therefore capable of adopting CSAT. In addition, a large number (93%) of the respondents reported owning land or were in possession of inherited land in the study area. This is important because land is an important asset in technology adoption because without it, a farmer cannot adopt technologies requiring long period of time.

Access to extension service refers to the number of contacts that a farmer has been with extension agents. This is important in that it increases the farmer's knowledge, skills, and awareness towards new agricultural technologies, which in turn influences adoption of technology. Majority of the respondents (54%, Table 2) had access to agricultural extension services. This finding is consistent with the previous studies showing that smallholder dairy farmers depend on agricultural extension as source of farming information and advice. This can be attributed to the fact that extension service in Kenya is free of charge or is subsidized by the government. The accessibility of extension services by farmers impacted some relevant basic skills required in farming, and therefore enabling them to adopt CSAT. Our findings indicate that these farmers were visited at least once every 3 months by an extension officer, an indication that those extension officers were proactive in reaching many rural farmers. The quality of interaction between extension officers and farmers determines the effectiveness in extension service delivery (Howley et al., 2012). There is a positive relationship between extension contact and farmer's adoption decision (Maponya and Mpandeli, 2013; Obayelu et al., 2014; Shongwe et al, 2014).

Access to credit is vital in supplementing the meager resources of the farmers (Jones et al., 2013). With limited credit access, farmers are constrained in terms of investing in technologies such as CSAT. About 70% of dairy farmers in the study area did not have access to credit facilities. Our findings contradict the reported cases on access to credit services in Kisii County where only 16% of households had access to credit services from formal financial institution (ASDSP, 2014). This low access to credit can be attributed to lack of information and financial institutions in the study area. In Kaptumo ward, farmers have to travel to either Kapsabet or Nandi hills towns to access banking services. Given that most dairy farmers are of old age, they are not likely to have frequent visits to these institutions. Secondly, because of the age factor, farmers lacked the required collateral to allow them access credit from the financial institutions. In some instances, farmers lacked knowledge about existing credit facilities within the financial sector. Finally, most financial institutions do not have agricultural loans product that can meet the demand of small-scale farmers, and if they have such products, the interest rates are very high, and the requirements are strict. This means that farmers have to rely on local cooperative societies with low capital base for financial support.

Farmer's Perception about Climate Variability in Aldai Sub- County

To understand farmers' perception about climate variability, historical weather data of temperature and rainfall trends for the past 32 years was obtained (i.e., from January 1980 to December 2012) from Kenya Metrological Department (KMD). This weather data was then summarized into yearly averages, and by seasons (either dry or wet) to show trends in weather variability across the study area and Kenya over similar periods. Results on temperature and rainfall patterns are presented in Tables 3 and 4 and Figures 2 and 3.

The average temperature was on the rise in general, and this rise was prominent during dry seasons. During short rains, the maximum and the minimum temperature were about 18.7 and 16.2^{0}C thereby giving a difference of 2.5^{0}C compared to long rain's deviation of 1.6^{0}C. Temperature results in the study area were compared with that of the national (Kenya) averages, and an increasing trend was observed, much of it during the short rains, with a deviation of 0.7^{0}C compared to long rainy season's average of about 0.5^{0}C.

Table 3: Average temperature data (January 1980 to December 2012) in Aldai Sub County and Kenya during short and long rains

Parameter	Annual	Short rains	Long rains
Kenya temperature data			
Mean (^{0}C)	24.320	25.003	23.832
Standard Deviation (^{0}C)	0.389	0.420	0.397
Minimum (^{0}C)	23.609	24.204	23.125
Maximum (^{0}C)	25.135	25.880	24.703
Nandi County temperature data			
Mean (^{0}C)	16.957	17.582	16.511
Standard Deviation (^{0}C)	0.349	0.449	0.378
Minimum (^{0}C)	16.225	16.180	15.771
Maximum (^{0}C)	17.767	18.660	17.357

A smooth trend in the rising temperatures compared to rainfall trends over similar periods was observed. The highest temperatures were recorded in the year 2007; the highest over the 32 years. The same pattern was also observed in Kenya.

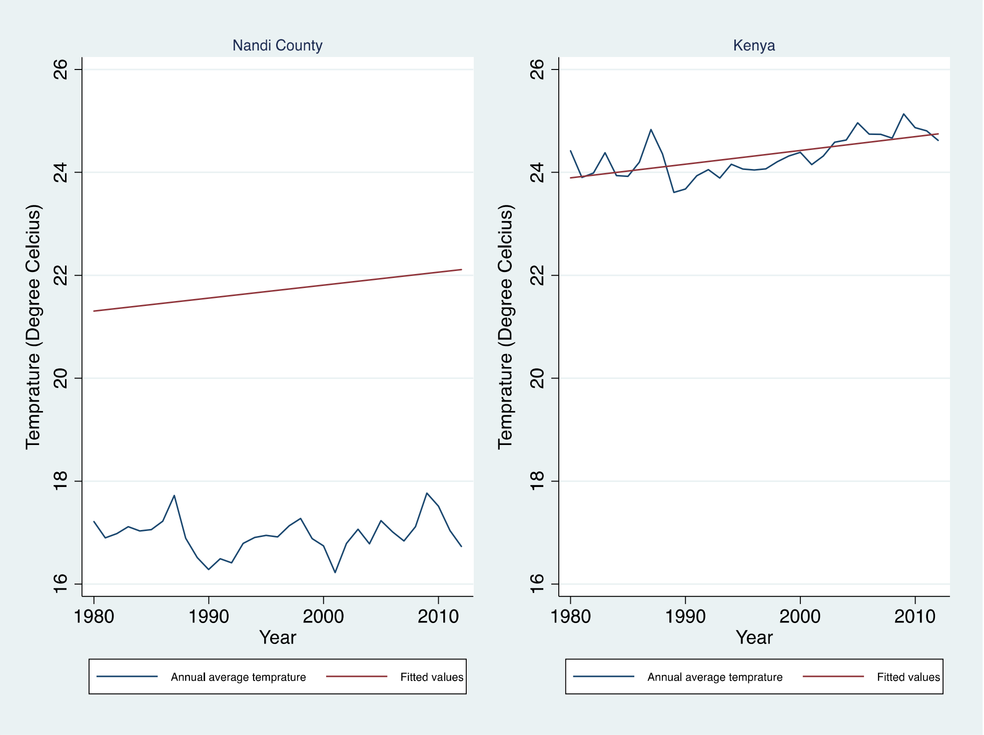

Figure 1: Annual trends in average temperature data per annum: from January 1980 to December 2012 for both Nandi County and Kenya

Rainfall trends showed arising pattern, and this rise was more prominent during the short rainy season. A maximum and a minimum rainfall of 722.3mm and 221.5mm respectively was reported thereby giving a difference of 500.8 mm compared to rainy season's deviation of 754.2mm. Nandi County rainfall patterns were compared with the national (Kenya) averages. An increasing trend was observed during short rainy season, a deviation of 345.8mm compared to long rainy season's average of about 369.3mm.

Table 4: Average total rainfall data (January 1980 to December 2012) in Aldai Sub County and Kenya during short and long rains

Parameter	Annual	Short rains	Long rains
Annual rainfall (mm) for Kenya			
Mean (mm)	706.552	284.029	422.523
Standard Deviation (mm)	144.0806	84.709	82.646
Minimum (mm)	472.187	165.749	269.381
Maximum (mm)	1,140.304	511.598	628.706
Annual rainfall (mm) for Nandi County			
Mean (mm)	1,559.191	415.20	1,143.991
Standard Deviation (mm)	200.623	118.441	162.799
Minimum (mm)	1,025.100	221.500	727.800
Maximum (mm)	1878.900	722.300	1482.100

A high level of climate variability was observed especially from around the year 2000. The highest and lowest levels of rainfall pattern were recorded in the years 2005 and 2007 respectively (Figure 3).

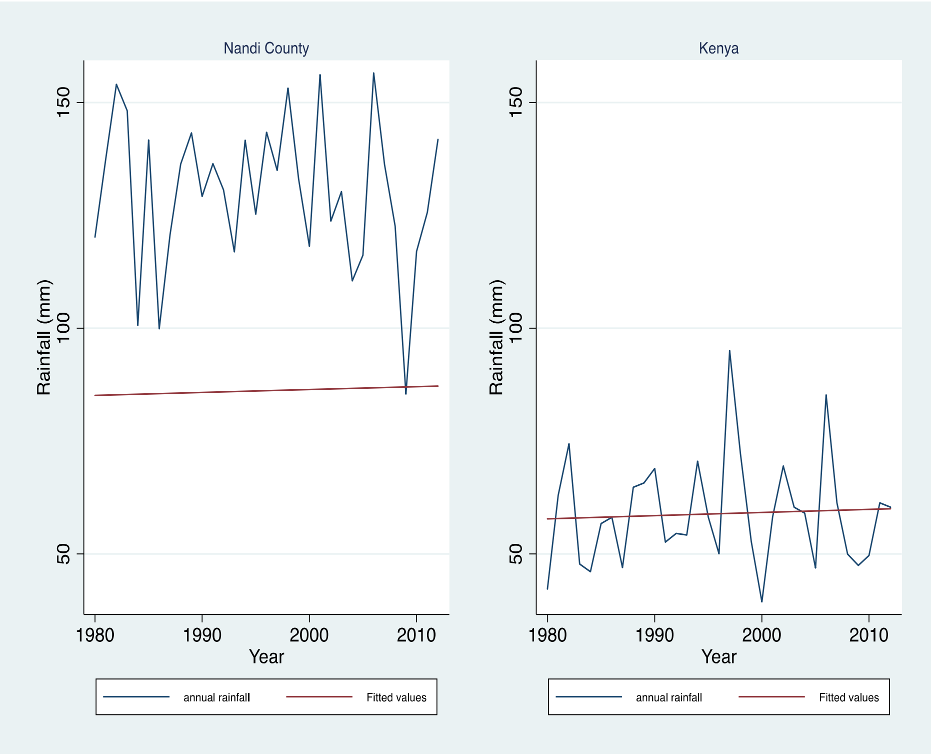

Figure 2: Annual trends in precipitation in Kenya and Nandi County, from January 1980 to December 2012 for both Nandi County and Kenya

Level of climate variability awareness in support of smallholder dairy farming

Given the rising trend in weather patterns in the study area and Kenya as a whole, respondents were asked to compare the current weather conditions with the previous trends for 32 years ago (from January 1980 to December 2012) as a way of measuring perception of their climate variability. The results from the farmers' perspective are presented in Table 5 below.

Table 5: Level of climate variability awareness in percentage (%)

Type of climate variability	Intensity (% of respondents)			
	No	**Low**	**Medium**	**High**
Excess rainfall	1.88	28.14	65.00	5
Delayed rainfall	3.12	48.12	43.75	5.00
Low temperature	1.88	56.88	40.00	1.25
High temperature	22.5	60.52	15.62	1.25
Storms	21.5	68.75	8.75	0.62

The Majority of the respondents had perceived drastic differences of climatic condition over the years. A higher number (70%) of the respondents reported experiencing high rainfall in the study area. The existence of excess rainfall may be attributed to the fact that the study area is a highland, situated on the windward side of Mau Forest, and therefore attracts high rainfall. However, most farmers in the study area are of old age category (> 60 years) and were not able to recall rainfall patterns experienced in the recent past. For the delayed rainfall, more than 51% of the respondents reported low levels of awareness and perception. This can be attributed to the timing of data collection exercise which happened during high rainfall season. Therefore, people could not remember periods of delayed rainfall which happens between January-March every agricultural season.

The temperature patterns are assumed to be important elements of climate variability. Our results revealed that most farmers observed low intensity of climate variability (Table 5). This implies existence of low perception about temperature changes in the last 32 years. The low temporal variation observed is important because temperature negatively affect agricultural production. In Ethiopia, Solomon and Rao (2021) showed that these features of climate variability negatively impact livestock and crop production. High temperatures' poses thermal stress on livestock species, impair feeding practices, metabolic activities, and hinder defence mechanism (Nardone et al., 2010). Other studies with similar results are IPCC, 2007; Kalungu et al., 2013 and Murgor, 2014. A survey conducted by Agricultural Sector Development Support Programme (ASDSP) in Kenya observed significant changes in distribution, frequency and intensity of rainfall, degraded soils, drying up of wells and rivers, and incidence of diseases and pests in the environment (ASDSP, 2014). These changes in both rainfall pattern and temperature accounts for significant adverse effects to dairy production among farmers. There are low levels of awareness and perceptions about storm. About 89% of the respondent indicated (in Table 6) that they fall into either no intensity or low intensity categories. These can be attributed to low number of rivers or no lake and ocean in the area.

Farmers Awareness about Climate Variability

The most common observation in the study area regarding to climate variability was 'changes in weather' which over 45.7 % of the farmers stated that they were aware while 54.3 % were not aware (Table 6).

Table 6: Farmer's Awareness about Climate Variability

Awareness of climate variability	Descriptive statistics	
	Frequency (N)	**%**
Yes	160	45.71
No	190	54.29
Total	350	100

Other common observations were unpredictable, erratic, and increased rainfall. From our focused group discussion, farmers noted changes in the patterns of precipitation. In fact, there were prolonged dry season and short rainy season alternating in a season. This attribute to observed changes thus unpredictable weather in the area. In their words, the rhythms of seasons have changed significantly. In fact, farmers mentioned that rivers are drying due to shortage of rainfall, which leads to lack of drinking water problems for the animals. Partly, they reported a decline in soil fertility due to a rise in the number of exotic trees such as eucalyptus leading to poor replenishment of soil nutrients.

Indigenous trees, bushes, and shrubs have become extinct in their opinion. Households offered different explanations about the term ‘climate variability ‘and gave possible explanations which they associate with this term. These results are in line with the statements given by the farmers that they observe more rainfall and prolonged dry seasons. They indicated that climate variability is predominantly experienced by less or more water, rather than through changes in temperature or other indicators such as the death of livestock. A decrease in milk production was observed by the respondents. However, the farmers were more familiar with the terms weather changes, rainfall, and drought, rather than climate change and variability. Although the farmers were found to be aware of climate change, only a few of them understood what climate change and variability entails. The study findings indicate that the farmers who seemed to understand more on climate change and variability appeared to be more exposed to and in one way or another had direct contacts with researchers and/or extension officers. These findings confirm those by Rogers (2003), who observed that an individual’s level of awareness can affect one’s ability to acquire knowledge and adopt innovations.

A similar study by Nega et al., (2015) on climate variability perceptions by different age groups (young, adults, and elder farmers) indicated that young farmers were less likely to perceive climate changes than their adult and elder farmers. Therefore, the disaggregated result revealed that farmers who are in adult age group, educated and male were better to understand the perceived changes in climate levels as compared to young farmers. The farmers’ perception on climate variability was thus confirmed by the key informants’ viewpoint. That is in our experience, the wind used to blow in the direction of east to west, commonly during on-set months of the rainy season (March-May and October to December), owing the inference of good season. As a result, livestock keepers who were in migration with the herds returned to their villages having the faith of worthy season from the wind based indigenous prophecy. Nonetheless, in recent years the wind direction was altered to appear in unspecified ways and made the local prediction to be unreliable. As a result, recurrent incidences of drought caused poor livestock productivity and higher death rates due to meager early preparedness for the incidence.

Years of farmer’s awareness about climate variability

Table 7 presents the level of awareness of farmers about climate variability, measured as intensity. These levels of intensity of awareness were reported by 160 small scale farmers who answered yes to the first question in Table 6.

Table 7: Famer’s years of awareness about climate variability

Intensity of Awareness of Climate Variability (Years)	**Descriptive statistics**	
	Frequency (N)	**%**
1	61	38.12
2	57	35.62.
3	25	15.62
4	9	5.62
5	7	4.38
6 and above	1	0.62
Total	**160**	**100**

Farmers with 1 year (38.12%t) indicated that there was climate variability due to increasing and decreasing temperature and rainfall respectively. On the other hand, farmers with 2 years (35.62%) indicated that they were aware of climate variability. This indicated that farmers with fewer years on information awareness about climate variability are more likely to perceive changes. The results also confirm that access to extension service and the level of education increases the probability of perceiving change in climate variability.

Modeling farmers' adaptation strategies to climate variability

This section describes barriers to adaptation and alternative approaches adopted by farmers to mitigate the effects of climate variability in the study area. Understanding the likely adaptive responses of farmers to anticipated climate variability represents serious challenges. One major challenge is to isolate other stimuli such as policy market and others from climate stimuli response that farmers face in the real world. Secondly, farmers are concerned in short-term but not long-term climate variability. However, the ability of farmers to cope with current climate variability is an important indicator of their capacity to adapt to future climate change. Thirdly, the more fundamental barrier to improved knowledge of climate change adaptation is derived from the simple fact that humans can respond in highly variable ways to similar external stimuli (Belliveau et al., 2006).

Table 8: **Barriers to adaptation in Aldai Sub-County, Kenya**

Variables	**Mean (1)**	**SD (2)**	**Min (3)**	**Max (4)**
Insufficient Labour supply	0.151	0.359	0.000	1.000
Lack of information on suitable Fodder crop	0.637	0.482	0.000	1.000
Limited access to capital	0.811	0.392	0.000	1.000
Small land size	0.669	0.471	0.000	1.000
Availability of certified seeds	0.851	0.356	0.000	1.000
Lack of pasture	0.354	0.479	0.000	1.000
High cost of seeds	0.131	0.338	0.000	1.000

N is the number of observations; SD is the standard deviation; Min and Max are the minimum and maximum values f respective variable; N=350

In Table 8, the important barriers which hinder farmers from using adaptation options which can help them minimize the effect of climate variability are presented. The results show that about 15% of the respondents indicated lack of labour as a constraint to using available adaptation strategies. This low numbers of farmers may be attributed to the fact that most of them are small scale and therefore do not require larger number of labourers. As such, most farmers are family owned and labourers are mainly family members.

Over 64% of the farmers affirmed lack of information on suitable fodder species as major factor influencing the adoption, which may be attributed to the lack of extension officer(s) to reach the entire farmers in the study area. In addition, farmers might not be organized in groups or associations where they can easily get the information. This influences the decision of the farmer to adopt climate variability adaptation strategies.

Majority of the respondents (81%) indicated lack of capital as a major influence to use of adaption of the strategies. This can be accredited to lack of money to pay labour of work done, buying of seeds and buying or leasing of land, hindering access to extension services and transport costs. On the other hand, farmers who had money or capital were able to access quality seeds, land, and other important information which enabled them to adopt the strategies. Land is an important asset that impacts the choice and use of climate variability adaptation strategies. In the study area, about 66.7% of the farmers indicated that their small land sizes do not allow them to adopt some strategies. This is true because adopting strategies like fodder and pasture management requires not only land but fertile land which can provide the nutrients, more so minerals which are important for growth of pasture and fodder.

Our results further (Table 8) show that 85% of the respondents reported lack of quality seeds as a major hindrance to adoption of adaptation strategies. Finally, 62% of the respondents indicated that pasture establishment may not influence the decision to adopt the strategies. The establishment of pastures just like fodder crop plays a major role as a variable to adaptation strategies. In the study area, 47% of the respondents indicated that pasture establishment and management influence the adoption of climate variability adaptation strategies.

CONCLUSION AND RECOMMENDETIONS

First, we observed a rise in temperature and a decrease in rainfall. However, few farmers identified variations in temperatures and rainfall patterns. Determinants of adaption to climate change were access to extension service, education level of farmers while lack of labour, limited information on fodder species, capital, land size, and availability of quality seeds were a hindrance. There was increasing awareness on climate variability problem among small scale farmers and emerging need for adaptation to climate change effects through adoption of climate smart agricultural technologies. However, a significant proportion of farmers and county policy makers were still oblivious of the climate variability challenge. Hence the limited focus on climate variability adaptation and adoption of climate smart agricultural technologies

Based on the conclusions above, the study recommends the following. First, national government should set aside funds for climate variability and adaptation strategy to help smallholder dairy farmers adapt to the negative effects of climate change. This climate adaptation fund should be expanded even to crop sub-sector because farmers usually integrate crops and livestock simultaneously. At a local level, we encourage Nandi County government to enhance the capacity of climate change experts available in the area to help farmers adapt to climate change.

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Conflict of interest
The authors declare that there is no conflict of interest.

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