Coping mechanisms employed by smallholder dairy cattle farmers in response to the effects of climate change in Bungoma County, Kenya

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ABSTRACT

Dairy farming has improved food security, employment, and poverty in Bungoma County. The County has 43% food insecurity and 53% poverty. 31% of household income comes from dairy and livestock. Climate change affects the County's rain-fed mixed farming. The study examined the coping mechanisms employed by smallholder dairy cattle farmers in response to climate change effects. The research was founded on the Sustainable Livelihoods Framework (SLF). The study adopted a correlational research design to explore the impact of climate change on dairy cattle production among smallholder farmers in Bungoma County, Kenya, a region selected for its agricultural potential, high poverty rates, and underperforming dairy sector. The research focused on three sub-counties—Mt. Elgon, Kimilili, and Tongaren—deemed representative of the county's nine sub-counties. A multistage random sampling technique was used to select 415 respondents from a target population of 1,200 farmers, proportionally allocated based on sub-county size and farmer population. In addition, key informants from Non-Governmental Organizations (NGOs), Faith-based organizations (FBOs), and government departments were selected through purposive sampling. Data was gathered through observation, questionnaires and key informants. Quantitative data were analyzed using SPSS through descriptive statistics such as frequencies and percentages, while qualitative data were examined using thematic analysis to identify patterns and deeper insights, following Fowler and Floyd's analytical framework. From the study, smallholder dairy farmers have evolved a number of climate change coping mechanisms; Key among these is reverting to rearing indigenous zebu and cross breed cows that are more resilient to the adverse effects. Integration of dairy and crop farming, use of farm waste as animal feeds, altering acreage, matching stock rates are among the coping mechanisms adapted by smallholder dairy cattle herd farmers. Diversifying to other forms of livestock and income generating activities e.g. chicken, goats, sheep, pigs and beekeeping. This study recommends to all stakeholder to formulate policies to empower farmers to effectively adapt to climate change and variability for enhancing smallholder dairy cattle herd productivity in the county.

Keywords: Bungoma County, Coping Mechanisms, Climate Change, Small Holder Dairy Farmers

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I. INTRODUCTION

Governments worldwide are concerned about climate change and variability. This change has affected agriculture, economics, forestry, livestock, and fisheries worldwide (Wambugu et al., 2011). The Intergovernmental Panel on Climate Change reports a 0.76°C global mean surface temperature increases over 150 years (Intergovernmental Panel on Climate Change [IPCC], 2014). Trends in relative sea level, which is rising globally (Church et al., 2014), vary greatly by region due to a variety of factors, including El Niño/La Niña cycles and local tectonic activity (Nicholls & Corfee-Morlot, 2013). Sea-level change concerns are difficult to generalize across varied regional groups like small islands (IPCC, 2014). 92 nations have included livestock to meet their national reduction targets under the Paris Agreement (Wilkes *et al.*., 2017).

Ocean acidification, another ongoing effect of rising CO_2 concentrations, is stronger at high latitudes due to their reduced buffer capabilities (Rhein, 2014). These trends are likely to affect calcifying species, but organismal to ecological uncertainties remain (IPCC, 2014). Global warming has increased precipitation patterns, extreme weather events, and mean worldwide sea levels. These events cause constant flooding, population displacement, property damage, and crop loss. A study of farmers in 10 African nations (Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, and Zambia) to detect and adapt to climate change. These studies show that farmers notice climate change and adjust (Lema & Majule, 2019).

Kenya's climate change and variability are shown through unpredictable rainfall, torrential downpours, rising temperatures, and generally severe weather (Government of Kenya, 2018). Minimum and maximum temperatures have increased during the 1960s (GOK, 2018). Depending on region and season, maximum temperatures have risen by 0.7-2°C and minimum temperatures by 0.2-1.3°C (GOK, 2018). Western Kenya's temperature rose 0.8–2.9 °C (GOK, 2018). The country's yearly precipitation estimate is 0.2–0.4 percent higher. Major droughts occurred every decade and lesser ones every three to four years (Mutimba et al, 2010). Climate change impacts temperature and precipitation, which hurts agricultural production (Barasa et al., 2015).

Kenya's Vision 2030 development ambitions are increasingly threatened by climate change. Kenya is already highly susceptible to climate-related risks, and in many locations, extreme occurrences and variability of weather are already the norm; rainfall is erratic and unpredictable; droughts have become more frequent throughout the lengthy rainy season and devastating floods during the short rains. Climate change is not natural fluctuation. They listed variance in rainfall patterns, including distribution, length, and amount, as the main sign of climate change. Most farmers noted an increase in temperature (Ishaya & Abaje, 2018).

Bungoma County produces 97 million litres of milk annually, mostly in Tongaren, Kimilili, and Mt.Elgon. The Bungoma County livestock sector includes dairy, poultry, beef pig, sheep and goat, beekeeper, rabbit, developing livestock, and donkey production (Bungoma County, 2018). Livestock products stabilize rural poor food security for daily life (Van jink & Wilkes, 2015). Bungoma County generates 270,900 litres of milk daily from 129,000 exotic breeds, 30% of which are lactating. Zebu breeds contribute 75,795 litres. Bungoma County wants to develop milk markets in neighboring counties (Bungoma County, 2018). Owing to inadequate yields, smallholder open grazing farmers only sold 48% of their milk, keeping the balance for household consumption and calves. Due to milk processors' limited collection days/times and impassable access routes, producers have to find alternative markets for their milk. Enhancing formal milk selling by dairy processors and primary dairy cooperative societies with adequate collecting centers and chilling facilities will boost commercialization of the sub-sector, improving milk quality, job opportunities, household income, and food security.

In 2013 and 2017, agriculture produced 70% of jobs in Bungoma County, western Kenya (Bungoma County, 2018). Climate change hinders small-scale dairy farming. According to Bungoma County Government (2018) integrated report, climate change has already affected agriculture and ecosystems in the area, with variable weather patterns and decreases in indigenous flora and fauna. Climate change will also cause greater temperatures, water scarcity, changes in rainfall patterns, environmental pressures like El Nino, and more extreme weather events including storms, droughts, and floods.

Agriculture such as dairy farming is highly sensitive to climate change and variability, and rain-fed agriculture systems, in particular, are especially susceptible to unpredictable weather. Agricultural production is intricately linked to animal feed provision and hence, small holder dairy herd productivity as discussed by Volenzo and Odiyo (2020). It is, therefore, important to evaluate the coping mechanisms employed by smallholder dairy cattle farmers in response to the effects of climate change in Bungoma County, Kenya which strives to reduce poverty levels and prevalent food insecurity situation in the current climate.

1.1 Statement of the Problem

Extreme weather caused by climate change and fluctuation threatens small-holder dairy agricultural productivity. According to the Agriculture Sector Development Support Programme (ASDSP) (2019) study, warming and drying may reduce dairy product production by 10–20% by 2050. Nevertheless, some areas may lose more (Bungoma County Government, 2018). The top sub-Counties of Tongaren, Kimilili, and Mt. Elgon produce 97 million litres of milk annually (Bungoma County Government, 2018). Bungoma County has a food insecurity rate of 43% and a poverty index of 52.9%, compared to the national index of 46%. Instead of the prescribed three meals, many County families eat one (Nicholl, 2019).

Due to rising population and urbanization, the dairy business in Bungoma has enormous potential to boost household income, especially for smallholder farmers, and create local jobs. Dairy farming, especially, is important in Bungoma County, where 31% of household income comes from dairy sales. Climate change and variance have raised dairy cattle herd production costs for Bungoma County smallholder dairy farmers. Bungoma County's livestock losses were caused by sickness and shortage of pastures/fodder (Barasa et al., 2015). In another article, the Ricardian model is applied to African livestock data and reveals that livestock is climate-sensitive. Climate change (CC) threatens Sub-Saharan Africa (SSA) the most (Bryan et al.., 2013; IPCC, 2014).

East African dairy herd productivity is low due to poor use of production methods and environmental variables. Mapiye et al. (2016) noted that poor feed availability in sub-Saharan Africa reduced dairy animal productivity. It is because of the above that the current study sought to evaluate the relationship between climate change and variability on smallholder dairy productivity in Bungoma County.

1.2 Research Objective

The overall objective of this study was to examine the coping mechanisms employed by smallholder dairy cattle farmers in response to the effects of climate change in Bungoma County, Kenya.

II. LITERATURE REVIEW

2.1. Theoretical Review

2.1.1. Sustainable Livelihoods Framework (SLF)

The research was founded on the Sustainable Livelihoods Framework (SLF). The theory, created by the UK Department for International Development (DFID), has been extensively utilized in climate change adaptation research because to its comprehensive examination of community assets, vulnerabilities, transformative structures, and livelihood strategies (Scoones, 2015). This paradigm is based on the premise that rural households employ a blend of resources—natural, financial, human, social, and physical capital—to maintain their livelihoods, especially when confronted with shocks such as climate variability (Chambers & Conway, 1992; Department for International Development [DFID], 2000). In Bungoma County, where farmers encounter unpredictable weather, forage shortages, disease outbreaks, and diminishing milk production, the SLF allows researchers to pinpoint the precise adaptive strategies—such as feed conservation, breed diversification, migration, and social networks—that farmers employ to mitigate climate-related risks.

Furthermore, it enables the examination of how institutional support, including access to extension services, market opportunities, and local knowledge networks, either boosts or limits these coping methods (Nhemachena & Hassan, 2021; Makate et al., 2022). The efficacy of SLF resides in its practical applicability to rural development and climate change, as it not only evaluates outcomes but also informs policy suggestions by connecting household behavior to wider socio-economic and ecological systems. Consequently, utilizing the Sustainable Livelihoods Framework in this study offers a whole perspective for comprehending and addressing the intricate relationship between vulnerability and adaptation in smallholder dairy farming amid climatic stress.

2.2 Empirical Review

Climate change, encompassing extreme weather, will affect animal production and transportation, leading to production and operational losses, as well as heightened mortality and morbidity expenses. Heat stress-related fatalities could incur costs of £34 million by 2080 (Moran et al., 2018). China's climate has seen warming, accompanied with complex precipitation variability and an increase in the frequency of extreme events (IPCC, 2016; IPCC, 2017). Literature indicates that rainfall in Africa's Sahel has decreased by 20-30%, and the 20th century had the most severe long-term drought globally (IPCC, 2016). Africa's reliance on rain-fed agriculture and smallholders' incapacity to adapt to climate change hinder the achievement of food security. Floods and droughts have intensified in East Africa (IPCC, 2017).

The frequency of hot days and nights in Kenya has increased by 10°C since the 1960s, as reported in the literature (Mutimba et al., 2010; GoK, 2018). National precipitation forecasts indicate an annual increase of 0.2–0.4%. The literature indicates that significant droughts transpire every decade, while minor droughts occur every three to four years (Mutimba et al., 2010). Since 1993, Kenya has proclaimed six disasters related to drought and flooding. Agriculture depends on climate factors such as temperature and precipitation; thus, climate fluctuation adversely affects production (Otolo & Wakhungu, 2013).

Under the UNFCCC, each nation is required to establish a comprehensive climate response strategy that incorporates all climate change measures across energy, transportation, industry, agriculture, forestry, and waste management. Most affluent nations, responsible for the majority of greenhouse gas emissions, have not met this criterion (Wambugu, et al., 2011). The productivity of Kenyan smallholder dairy farming is contingent upon climatic suitability and stability; hence, adaptation techniques at both national and local levels are essential for sustaining productivity.

Climate drives most Kenyan economic activity (GOK, 2018), and climate change and variability threaten national development. Climate change is shown by extreme weather, unpredictable rainfall, rising temperatures, and (GOK, 2018). Since 1960, minimum and maximum temperatures have increased (Wabwoba, 2018). Depending on region and season, maximum temperatures have risen by 0.7-2°C and minimum temperatures by 0.2-1.3°C. The most noticeable change is increasing variability in year-to-year rainfall with an overall drop in March-May long rains (L.R) rainfall. L.R. has longer droughts. Nonetheless, the September–February short rains (S.R) season sees greater rain (GOK, 2018). This shows that the S.R (October to December) season is extending into the hot and dry January and February. Western Kenya's temperature rose 0.8–2.9 °C (GOK, 2018).

As fodder production depends on rainfall, small-holder dairy producers are subject to weather fluctuation and climate change. Droughts require knowledge, resources, and skillful management in normal and catastrophic situations (United Nations International Strategy for Disaster Reduction [UNISDR], 2019). Yet, low/lack of fodder conservation in times of above-normal rainfall exposes farmers to detrimental effects during extreme and frequent drought episodes/cycles. Extreme weather impacts on fodder, dairy animal health, and livestock productivity have been widely examined in ASAL countries. Bungoma County, Kenya, has moderate rainfall but little study. Extreme weather in the country necessitates an assessment of climate change and variable effects on important economic participants such local smallholder dairy productivity. This study sets out to identify indigenous coping strategies, and stakeholder contributions for enhanced sustainability of smallholder dairy production in Bungoma Country.

Kenya has a long history of non-commercial dairy production from indigenous animals (zebu). Kenya's commercial dairy sector began in 1920 when European settlers brought purebred dairy animals. Commercial dairy farming had two phases. First, European-owned large-scale dairy farming on the Kenyan Highlands, and second, African smallholdings from the 1950s (Ishaya & Abaje, 2018).

Smallholder risk management sometimes involves animals (Van Der Lee et al., 2016). Cattle goods are perishable and produced in remote locations. To maximize their worth, they need a more efficient marketing and processing system from manufacturing to consumption. As most African livestock producers are tiny, resource-poor, and unable to connect with markets, processors, and customers, marketing and processing are even more important (Koyi & Wakhungu, 2018). With few exceptions, livestock and livestock product marketing remains unstructured, archaic, and fragmented following decades of planned economic development.

Climatic change has forced rural communities to develop indigenous coping strategies: Indigenous knowledge is learned through centuries of practical experiences to mitigate climate change and other environmental stress impacts. These extensive knowledge systems and behaviors can solve various climate change coping and adaption methods. Many indigenous peoples are detecting climate change and its challenges on their own. Indigenous communities have adapted to harsh weather. In summary, indigenous climate change adaptation strategies may include: shifting to other livelihoods less risky to climate change; adjusting cropping patterns; planting early mature crops like the "Amazon Stick" (Cassava); practicing multi-cropping; relocating to higher ground; and praying for help (Bynoe, 2021).

Irrigated farmland may mitigate climatic variability in underdeveloped nations. Eakin et al. (2014) describes this for Mexico, although market uncertainty and climatic risk may make households making this change more vulnerable. In South Asia, drought and flood solutions include raising livestock production relative to crops and selecting crop varieties, but various case studies highlight the relevance of livelihood diversification in villages and towns, both reactively and proactively (Macdonald et al., 2014). These and other research demonstrate the role of information and networks or social capital in mitigating climate change and variability (Winkels & Adger, 2012).

III. METHODOLOGY

The study adopted a correlational research design to explore the impact of climate change on dairy cattle production among smallholder farmers in Bungoma County, Kenya, a region selected for its agricultural potential, high poverty rates, and underperforming dairy sector. The correlational approach involved recording of variables within their natural environment, and the strength and direction of the relationship is measured. Such design is especially helpful in cases where it will be unfeasible, unjustifiable or unethical to control variables. It enabled the researcher to find regularities, tendencies, possible trends of probable dependency to have useful information to formulate subsequent investigations in it or even policy formulation. It can however help show one whether there are any relationships in variables but cannot prove cause and effect associations. The research focused on three sub-counties—Mt. Elgon, Kimilili, and Tongaren—deemed representative of the county's nine sub-counties. A multistage random sampling technique was used to select 415 respondents from a target population of 1,200 farmers, proportionally allocated based on sub-county size and farmer population. In addition, 3 key informants from NGOs, FBOs, and government departments were selected through purposive sampling. Data was gathered through observation, questionnaires and key informants. Quantitative data were analyzed using SPSS through descriptive statistics such as frequencies and percentages, while qualitative data were examined using thematic analysis to identify patterns and deeper insights, following Fowler and Floyd's analytical framework.

IV. FINDINGS & DISCUSSION

4.1 Socio-demographic Characteristics of Smallholder Dairy Cattle Farm Households

The study looked into four (4) aspects of social characteristics namely age, level of education and occupation in Tongaren, Kimilili and Mt. Elgon sub-counties in Bungoma County. The demographics were key in determining their relation with dairy cattle farming practices and their impact on climate and milk production.

4.1.1 Age Distribution for Small Holder Dairy Farmers in Bungoma County

The section gives the age distribution among smallholder dairy farm household heads as recorded in Figure 1.

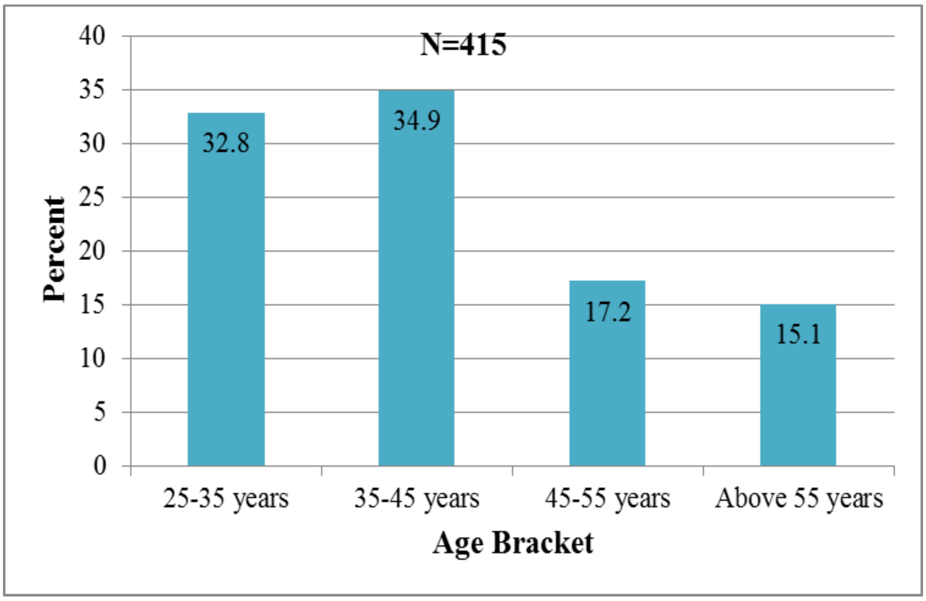

Figure 1
Age for Small Holder Household Respondents for Dairy Farmers in Bungoma County, Kenya

According to the findings 32.8% were age group 25-35 years, 34.9% indicated that they were in age group between 35- 45 years, 17.2% indicated that they were in age group between 45-55 years while 15.1% were in age group of above 55 years. This indicates that the majority of the smallholders for household heads were in age group of 25-45 years. These findings agree with Markovic and Markovic (2012) who found out that dairy farming is unattractive to young people in Montenegro. Kigathi (2016) revealed that majority of the dairy farmers were old and mature people who owned land to practice dairy farming. The studies also revealed that majority of young people were only hired to work on these dairy farms and generally in the various action points of the dairy value chain.

4.1.2 Level of Education for Small Holder Dairy Farmers in Bungoma County

The study further interrogated the respondents to establish their level of education. The small holder dairy farmers were asked to state their highest level of educational qualification. The results were recorded in Figure 2.

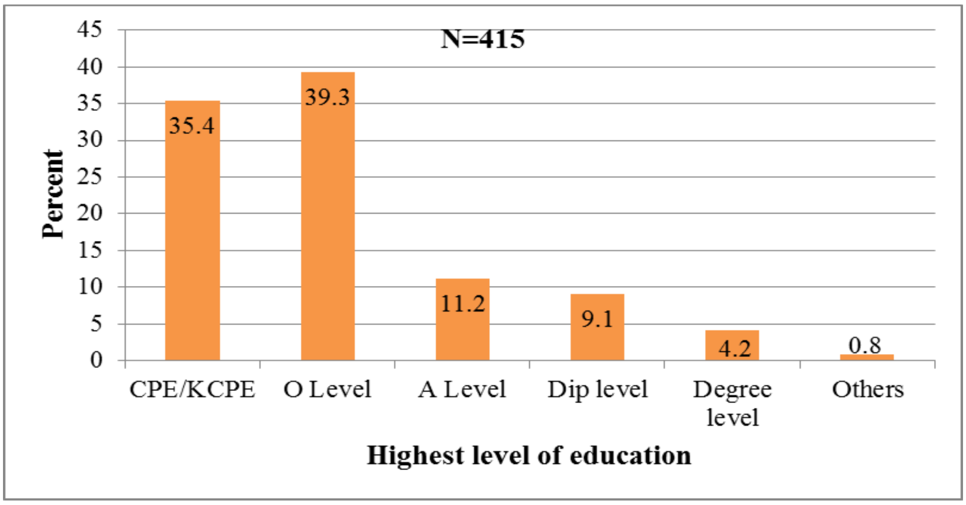

Figure 2
Educational level of the Small Holder Dairy Farmers in Bungoma County, Kenya

The small holder dairy farmers were asked to state their highest level of educational qualification. The results were recorded. The results shows that 35.4% had attained CPE/KCPE level of education, 39.3% had attained Ordinary level of education, 11.2% had attained Advanced level of education, 9.1% had attained diploma level, 4.3% had attained degree level of education while 0.8% had attained other levels of education. Other levels of education included CPA and other certificates. The dairy value chain relies on education from production to consumption. An education-based value chain is the only way dairy farmers can determine the optimal technology for their business. Milk carriers needed skills to preserve hygiene and quality and provide safe products to consumers. Agro-vets who supply inputs should have dairy training to help farmers use them.

College, graduate, and postgraduate players dominated capacity building institutions, livestock officers, dairy cooperative officers, and financial institution responders. This group needed certification. Retired civil servants and teachers were farmers with degrees and diplomas. Some farmers, sellers, and transporters had primary and secondary schooling. The survey indicated that vendors and carriers thought their work required experience rather than education. Dairy value chain education is linked (Kaneene et al., 2016). Mvurungu (2013) found that some farmers had primary and secondary education, but others were illiterate, which hindered dairy technology uptake in Tanzania. In another study, Wambugu et al. (2011) found that 8% of dairy farmers in former western, coastal, and central provinces had no formal education and 5% had a university degree.

4.3 Awareness of Climate Change Coping Mechanisms by Smallholder Dairy Farmers in Bungoma County, Kenya

This study sought to establish the awareness of the existence of coping mechanisms in response to the effects of climate change in Bungoma County. In this regard the farmers were asked to state whether they were aware of strategies used to respond to climate change.

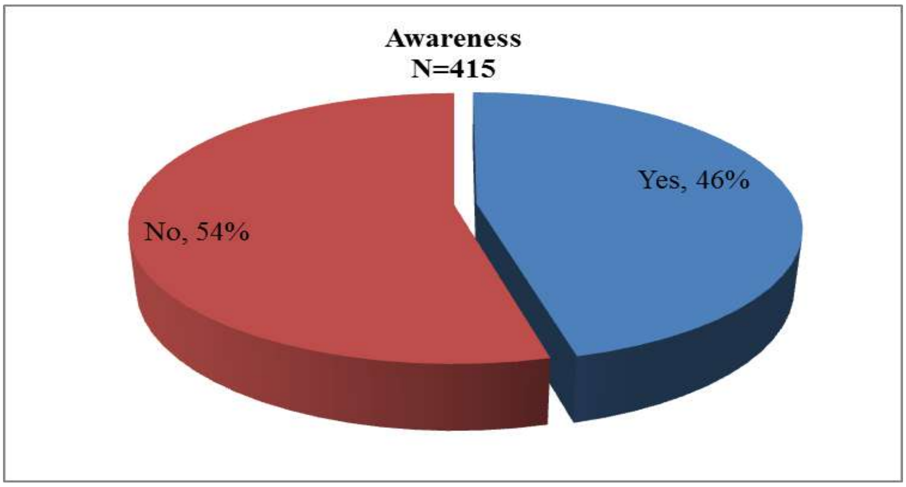

Figure 3
Awareness of Coping Mechanisms by Smallholder Dairy Cattle Farmers in Bungoma County

From the results in (46.0%) were aware while 54.0% were not aware of climate change coping strategies adopted by smallholder farmers in Bungoma. A Chi- Square test conducted on availability of water for livestock indicated that there was a highly significant ($p<0.000$) variation in the responses. A high level of awareness on effects of climate change and variability has not been translated in adaptation strategy awareness. The views form the questionnaires correspond with those given by the participants who took part in the focused group discussions and key informant interviews most of who agreed that they were much aware of various strategies used to respond to effects of climate change in Bungoma.

4.4 Types of Coping Mechanisms Used by Smallholder Dairy in Management of Cattle Farmers in Bungoma County

On being asked to give their views about the type of coping mechanisms used to respond to the effects of climate change, the farmers who participated in the study gave various responses as detailed below.

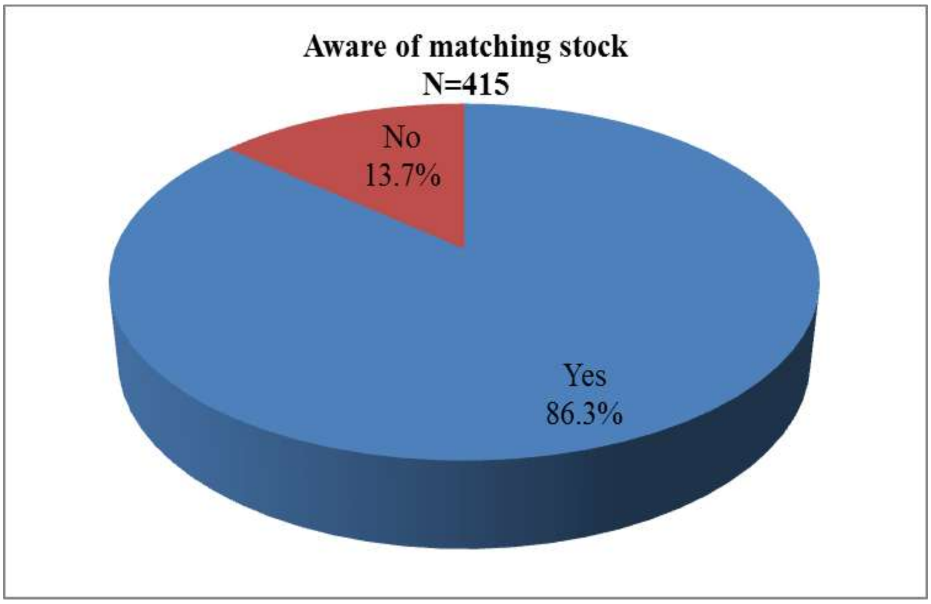

Figure 4
Matching stock rates farmer awareness in Bungoma County. Kenya

When asked if they were aware of the stock match rate as a strategy adopted in response to the effects of climate change the results indicated that the majority (86.3%) were aware while the remaining 13.7% were not aware of matching stock rates. A Chi- Square test conducted on stock match rate indicated that there was a highly significant ($p<0.000$) variation in the responses. This has the implication that most of the smallholder farmer had knowledge of ensuring that to achieve high returns in dairy farming, the size of the livestock stock should march the amount of available resources including pasture and water. These views correspond with finding by Batima et al, (2015) who argues that adaptations in field-based livestock include additional care to continuously match stock rates with pasture production.

The study also sought to shed light on the farmers' awareness regarding the practice of altering acreage under forage as a coping strategy.

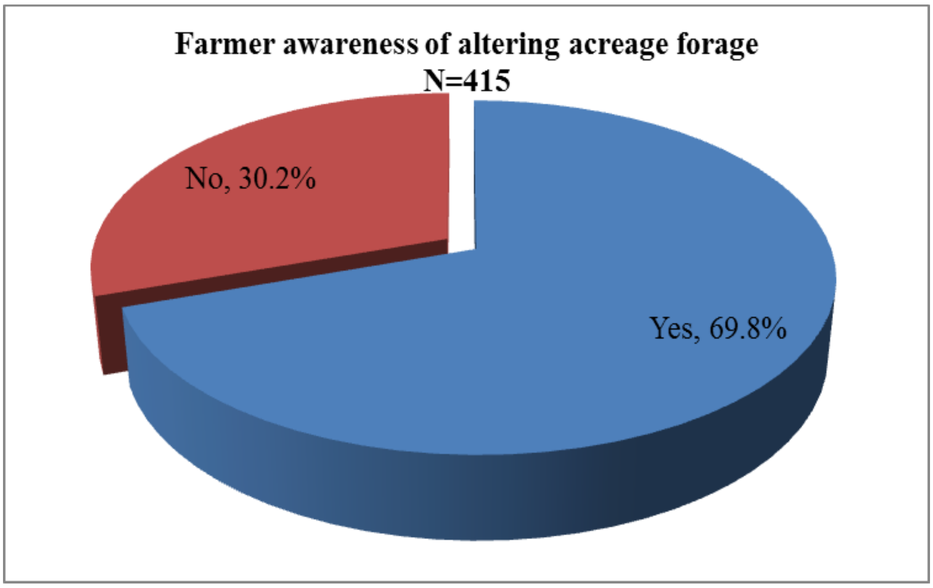

Figure 5
Farmer Awareness of Altering Acreage Forage in Bungoma County, Kenya

From the results in Figure 6.4, 69.8% were aware of altering acreage forage while 30.2% were not aware of altering acreage under forage as a recommended technique for coping with the effects of climate change among smallholder dairy cattle farmers in Bungoma County. A Chi- Square test conducted on practice of altering acreage under forage indicated that there was a highly significant ($p<0.000$) variation in the responses. This strategy specifies it if properly applied may cushion farmers against harsh extreme weather effects by boosting smallholder dairy cattle productivity. This practice will enable farmers save enough grazing land for pasture.

However, most farmers are faced with competing land use choices i.e. cash crops and food crop, and livestock grazing. Land scarcity, coupled with rampant family land subdivision during succession, has reduced land parcels into un-economical size of holdings provide source of the information. Hence considering this strategy as a coping mechanism against climate change effects may not be found appealing to most farmers. In spite the farmers' knowledge of this technique, its effectiveness as an adaptation strategy needs further examination.

The study further attempted to establish whether the farmers were knowledgeable of the practice of alternating napier with other grasses in order improve the nutrition value of fodder and found out the results presented.

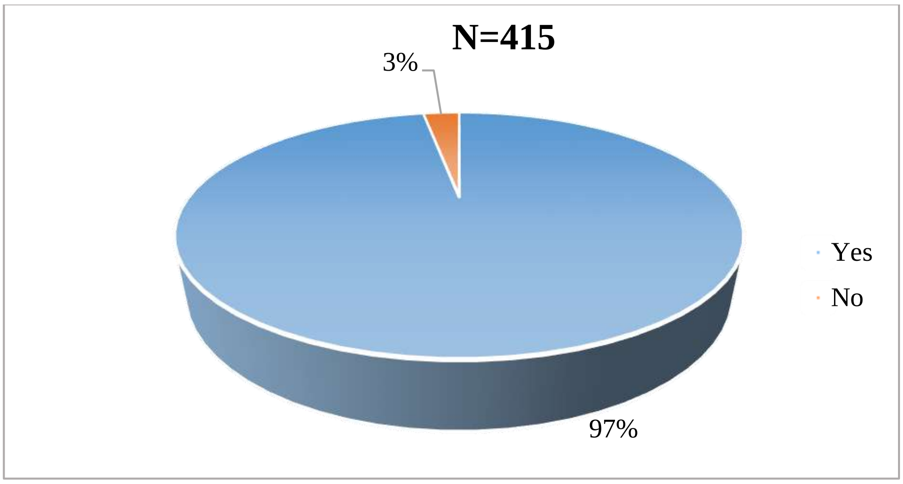

Figure 6
Farmer Awareness on Fodder Farming in Bungoma County.

From the results in Figure 6, the majority (97%) were aware while the minority (3%) were not aware of alternating nippier and other grasses as a way of improving animal feeds. Most of the farmers are practicing this with as high as 97% of adaptation. A Chi- Square test conducted on farmer awareness on fodder farming indicated that there was a highly significant ($p<0.000$) variation in the responses. This finding corresponds the views by most the participants in the key informant interviews and Focus group discussions who remarked that "alternating nippier with other grasses such legume grass has greatly helped improve milk production since this practice ensures that the nutrients not contained in the nippier grass are obtained from other grasses".

4.5 Altering Animal Breeds, Types of Breeding and Veterinary Services

Respondents were also asked on whether farmers were aware of altering animal breeds.

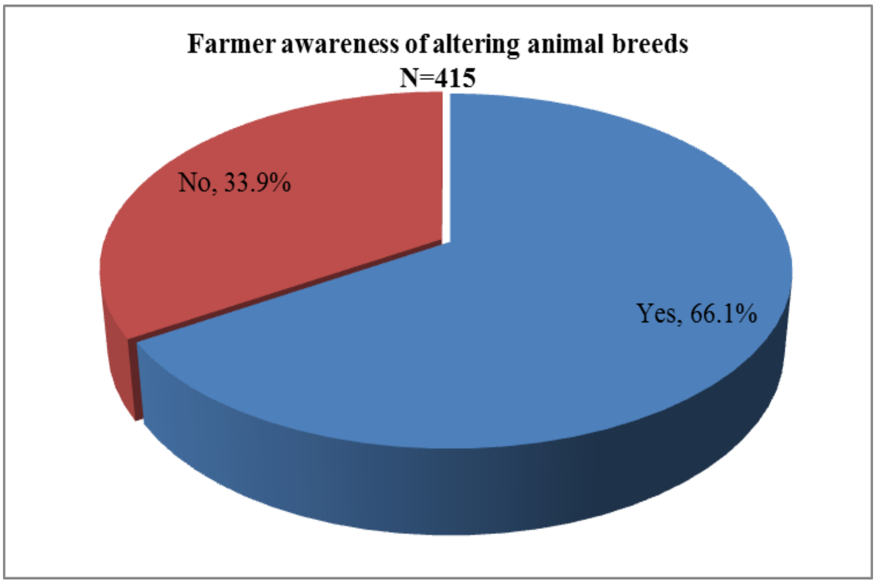

Figure 7
Farmer Awareness of Animal Breeds in Bungoma County, Kenya

Their responses were recorded. From the results, 66.1% were aware while 33.9% were not aware of cattle breeds. This refers to the deliberate attempt of smallholder dairy cattle farmers switching to rearing more climate change resilient cattle breeds. Most of smallholder dairy farmers are practicing this as a climate change coping strategy (Van Dijk & Wilkes, 2015). The farmers attending Focus group discussions acknowledged that local indigenous cattle are quite resilient to climate change effects and are easy to maintain. However, their milk productivity is extremely low in comparison to the exotic breed like Fresians. They further observed that though the milk yields of Friesian cows are very high, their adaptability to climate change effects are extremely low (Rowlinson, 2018). In addition, the cost of maintaining them are very high in comparison to the local breeds.

The small scale dairy farmers were asked to state the type of breeding practiced. Seasonal breeding is a remarkable adaptive feature, which allows animals to coordinate physiological functions throughout the year.

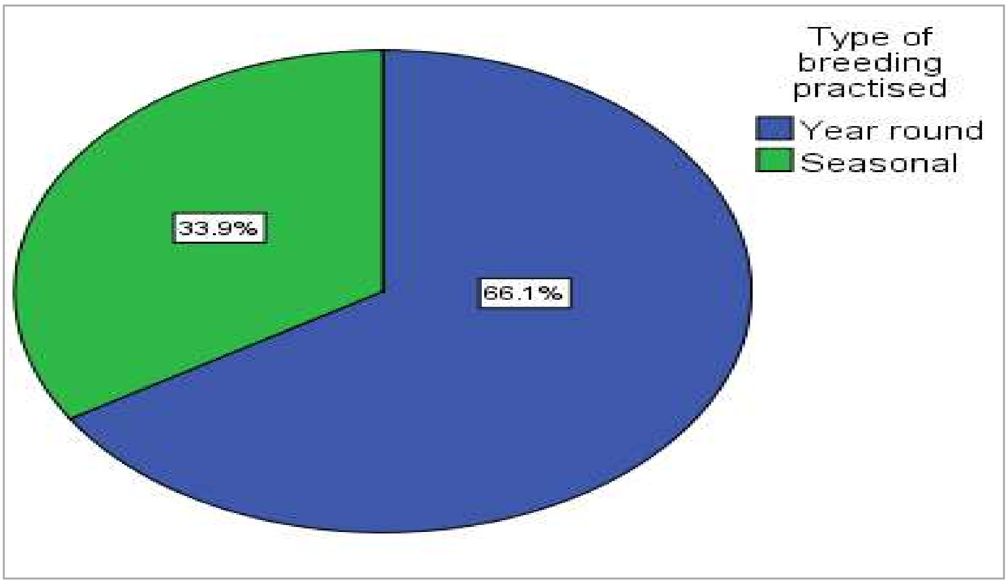

Figure 8
Types of Breeding Practiced in Bungoma County, Kenya

From the results, 33.9% practiced seasonal breeding while 66.1% did it all year round. Most of the cattle farmers 66.1% practised year all round breeding. This could be due to unpredictability of breeding cycle that may have been influenced by climate change. Respondents were asked whether veterinary services were involved in breeding. The responses were summarized.

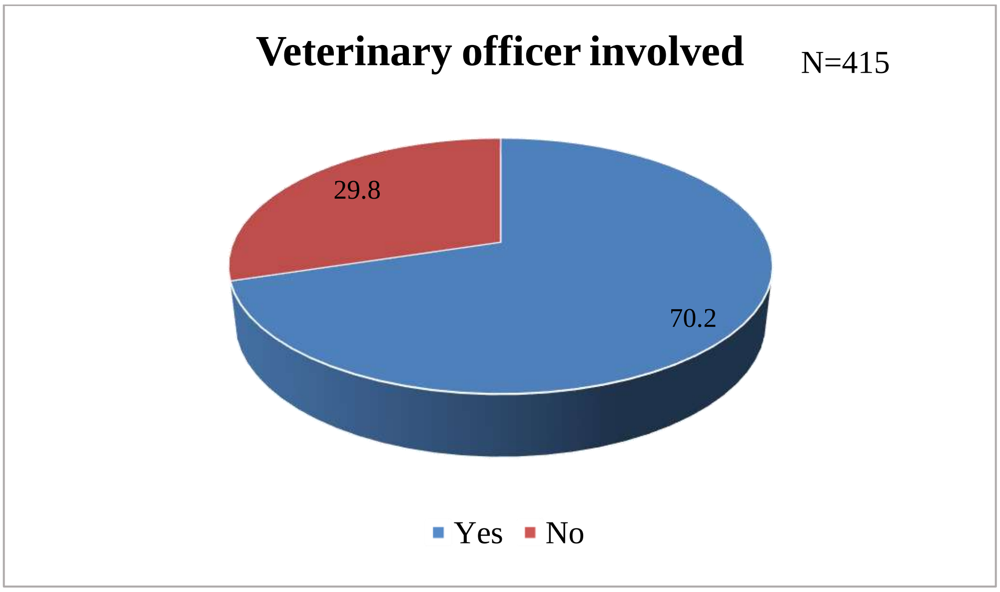

Figure 9
Veterinary Officers Involved in Breeding in Bungoma County, Kenya

The results indicated that 70.2% involved veterinary officers while 29.8% did not. According to services (Heffernan et al.., 2005), in most developing countries, the poor have not been the primary clients of veterinary Indeed, the prevailing wisdom has been either that livestock were insignificant to the livelihoods of the poor or such small numbers were kept that the provision of services was economically infeasible. For those who did not, they were asked the reason why. This was summarized in Table 1.

Table 1

Reason for not Seeking Veterinary Services for the Dairy Farmers

Reason	Frequency	Percentage	
Expensive	52	35.9	Chi square X^2=85.48 df=5 p=0.000
Vets are not readily available	35	24.1	
Lack of money	24	16.6	
Bulls are always available	20	13.8	
Has no problem with breeding	14	9.7	
Total	**145**	**100**	

Major reasons given for not involving the Veterinary were that it was expensive; Veterinary officers were not easily available, lack of money, availability of bulls and having no problems in breeding in this order. The small farmer was perceived to have less knowledge of and participation in disease control programmes and much lower participation in farmers' associations. Chi square test indicated that there is a significant relationship between Veterinary services and timely breeding of cattle as shown by a calculated χ_5^2 = 467.481 which is greater than the critical χ_5^2= 386.053. In Africa, the small farmer was reported to be further removed from service providers (Gosling & Arnell, 2016). The animal health needs of small farmers were perceived to be higher in all regions, they were seen to keep a wider range of species, and they experience more animal health problems and have much higher dependence on state veterinary services than larger farmers. The reasons given for the type of breeding were summarized in Table 2.

Table 2

Reasons for the Type of Breeding in Bungoma County

Reason for type of breeding	Frequency	Percent	
AI has improved quality breeds	55	18.0	Chi square X^2=46.73 df=9 p=0.000
Bulls are cheap and easily available	45	14.8	
AI calves are very strong and healthy	43	14.1	
Affordable	34	11.1	
AI does not transmit disease	32	10.5	
AI its expensive	28	9.2	
AI dairy cattle produce high quality milk	25	8.2	
AI is not reliable	25	8.2	
AI is accurate	18	5.9	
Total	**305**	**100**	

Ranking of reasons given by farmers for their choice of breeding were that AI has improved quality breeds; secondly that bulls were cheap and easily available, and thirdly that AI calves were very strong and healthy and the service was affordable, AI does not transmit diseases, AI its expensive, AI dairy cattle produce high quality milk and that AI is not reliable. Chi square test indicated that there is a significant relationship between Veterinary services and timely breeding of cattle as shown by a calculated χ_9^2 = 74.481 which is greater than the critical χ_9^2= 46.73. Focus group discussions indicated that AI services were expensive to small holder farmers and sometimes not easily available. A response confirmed by Bungoma County Government (2018) Respondents were asked to indicate whether bulls slept separately from cows. The responses were recorded in Figure 10.

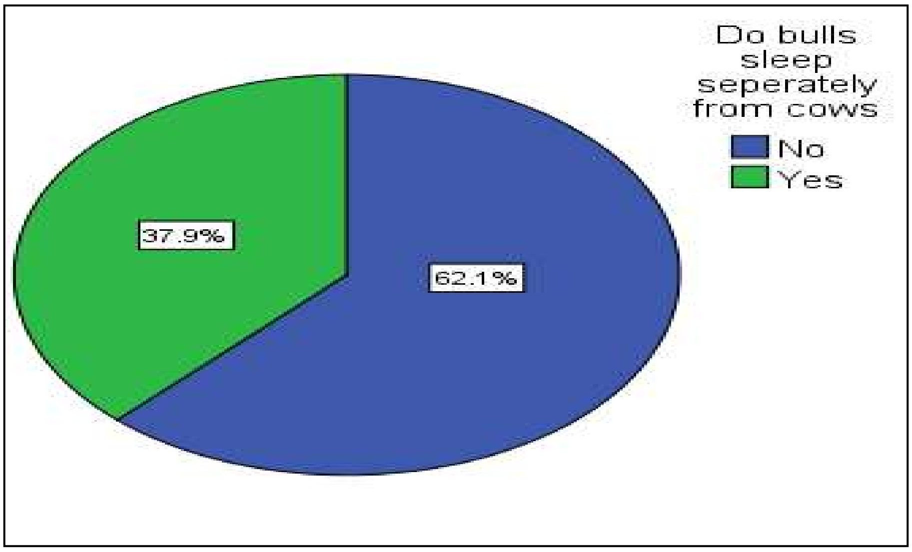

Figure 10
Bulls Sleep Separately from Cows in Bungoma County

From the results, 62.1% indicated they did not sleep separately and only 37.9% indicated that they slept separately. A Chi- Square test conducted on bulls sleep separately from cows indicated that there was a highly significant ($p<0.000$) variation in the responses. This is consistent with their choice of breeding practice that was influenced by unpredictability of breeding cycle. The timing of breeding is regarded crucial as it facilitates planning for enough good food is necessary all year round for a good conception rate. This also includes management tasks such as dehorning, vaccination and castration must be done all year round (Van Dijk & Wilkes, 2015). When asked whether the farmers were aware of timely breeding of their cattle the study found the results presented.

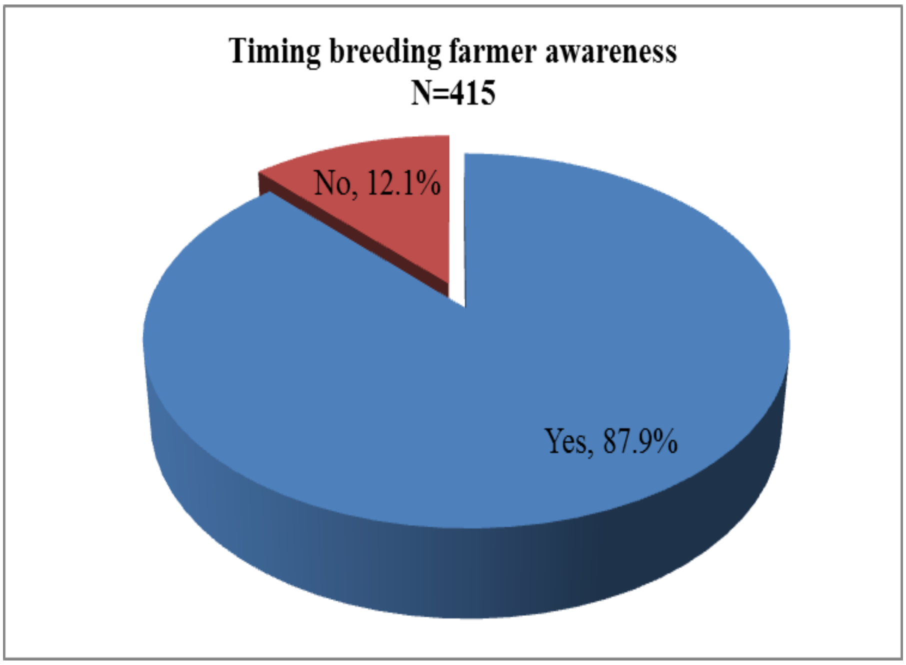

Figure 11
Timely Breeding of Cattle in Bungoma County

From the results, 87.9 % indicated to be aware of timely breeding while 12.1% were not aware of this practice. The high level awareness and the knowledge on the importance of timing the breeding season for the cattle is a positive starting point to instill breeding strategies for climate change adaptation. Timely breeding enables the farmer to only allow breeding at the most suited time when pasture and water resources are available and accessible to them. Furthermore, Sbardella et al. (2020), points out that treatments for improving the timing of ovulation, enhanced removal of impaired follicles, induction of ovulation of healthy follicles, embryo transfer, and progesterone supplementation before and after artificial insemination may be needed to improve fertility of heat-stressed dairy cows.

4.7 Farmer Awareness of Crop and Livestock Integration

To further establish the farmer's knowledge about certain best practices in agriculture, they were asked to state whether they knew the practice of integrating crops and animals with the results being presented.

Findings showed that the majority (95.1%) reported that they were aware while the remaining minority (4.9%) said not to be aware of crop and livestock integration. A Chi- Square test conducted on farmer awareness of crop and livestock integration indicated that there was a highly significant (p<0.000) variation in the responses. There was a unanimous agreement among those who took part in the key informant interviews and Focus group discussions most who echoed by saying that "mixed farming as it is popularly known is an old age ways farming which has been used by our great grand- fathers to ensure to ensure soil fertility and enough fodder for the livestock at the same time. According to the respondents, keeping livestock along- side cultivation of crops such as sweet potatoes, beans, maize among others helps replenish soil fertility which also helps increase fodder production from maize stock and potato vines.

The small scale dairy farmers were also asked to indicate whether they were aware of feeding fodder trees with the information. Findings indicated that majority (80.6%) of the small scale dairy farmers agreed that they were knowledgeable about using fodder trees as animal feeds while the remaining 19.4% of the respondents reported not aware of the use of tree fodder as a source of food to livestock in Bungoma County. A Chi- Square test conducted on farmer awareness of feeding fodder trees indicated that there was a highly significant (p<0.000) variation in the responses. Key informant interviews stated that this strategy was popular among farmers though there was a need to increase variety of trees that mature early and highly adaptive to climate change effects.

4.8 Dynamics in Numbers of Dairy Animals in Bungoma County, Kenya

The study sought to establish smallholder dairy farmers' knowledge on the use of altering cattle numbers; diversification to other livestock raring as measures to cope with adverse climate change effects. To sample their responses, farmers were asked to state current number of dairy animals kept and the following information was gathered; the results were as recorded in Table 3.

Table 3

Current Number of Dairy Cattle Owned per Household in Bungoma County

Number of dairy animals	Frequency	Per cent	
1-2	138	36.7	Chi square X^2=57.24 df=4 p=0.000
2-5	160	42.6	
5-10	62	16.5	
Above 10	16	4.3	
Total	**376**	**100.0**	

From the results, majority of farmers 79.3% currently had less than five dairy cows. Key informant interviews confirmed that smallholder dairy farmers are keeping less than five cows due to decreasing gracing land sizes. This could be explained by observed declines of grazing land resulting from competing land uses, couple with declining agricultural farmer production and by extension paucity of farmer crop waste availability for cattle feed. These among other factors of land sub-division for shared inheritance. This finding concurs with Kaneene et al. (2016) that cows are by far the most common dairy animal, with farmers in developing countries usually keeping them in herds of two or three animals.

From the results, majority owned less than 5 dairy cattle. A comparison of results indicated that there was a slight increase in numbers of dairy animals kept over the last 5 years. This slight increase in numbers of dairy animals may be due increasing demand and prices of milk in the county. In additional, the revived Kitinda Dairy milk processing plant could have provided a ready market for milk. The small-scale farmers were asked to state the change in the number of dairy animals over the last five years. The responses were recorded.
Statistical analysis of the same are as indicated in Table 4.

Table 4

Number of Dairy Cattle Owned 5 years Ago in Bungoma County

Number of dairy animals	Frequency	Per cent	
None	1	0.3	Chi square X^2=85.74 df=5 p=0.000
1-2	173	46.1	
2-5	134	35.7	
5-10	63	16.8	
Above 10	4	1.1	
Total	**375**	**100.0**	

From the results, 12.8% indicated that it significantly increased, 39.2% said it has slightly increased, 17.8% indicated that it has not changed while 30.3% said it had decreased. Many 39.2% observed a slight increase in the number of cow kept per household. Respondents were asked to state the number of grade cattle they have kept from 2015 to 2019 keep. The summary of the sums and mean scores is given in Table 5

Table 5
Descriptive Statistics on Number of Grade Cattle in Bungoma County

Year	N	Minimum	Maximum	Sum	Mean	Std. Error
2015	196	0	4	53	0.27	0.0378
2017	205	0	6	116	0.57	0.0706
2019	238	0	8	267	1.12	0.1024

The data shows that there was a general increase in the number of grade cows over the years. The county's population growth presents an ever increasing demand for dairy products. It was also observed that smallholder farmers were fetching good prices of milk from the local consumers and milk venders. In mixed farming scenario, many farmers are looking at cattle as a security against crop failure occasioned by extreme weather. This observation is shared by key informant interviews stakeholders in the dairy sector who observed that milk sales offer an alternative income for vulnerable smallholder dairy cattle farmers in the County. The small scale dairy cattle farmers were asked to give the reasons for the change in the number of grade cattle. The responses were summarized in Table 6.

Table 6
Reason for Change in Number of Grade Cattle in Bungoma County

Reason	Frequency	Percent	
High milk production	240	65.9	Chi square X^2=46.85 df=9 p=0.000
High quality calves	34	9.3	
Labour expenses	24	6.6	
Death due to disease outbreak	23	6.3	
high maintenance cost	15	4.1	
Easy to manage	13	3.6	
Limited space	8	2.2	
They died out of sickness	4	1.1	
Lack of space	3	0.8	
Total	**364**	**100**	

Reasons given for the increase or decrease in the number of grade cows were: High milk production, high quality calves, labour expenses, death due to disease outbreak, high maintenance cost, easy to manage, limited space, death out of sickness and lack of space. It is evident that smallholder dairy cattle farmers put a premium on milk production capability of grade cows. 65.9% of farmers indicated that high milk productivity was the main reason of keeping grade cows. Chi square test indicated that there is a significant relationship on the change in number of grade cattle as shown by a calculated χ_4^2 = 46.85 which is greater than the critical χ_4^2= 74.53. The Production and productivity of the current livestock herd is too low due to inferior genetics of the cattle in the County, Bungoma County Government (2018). Focus group discussions concurred with this view, but further expressed fears of their in ability to cope with extreme climate change effects as a major concern. This perhaps points at the need for selective breeding strategies to provide smallholder dairy farmers with alternative high milk yielding cattle, with high resilience to climate change effects. Respondents were asked to state the reasons for the changes in the number of crossbreeds and the results recorded in Table 7.

Table 7
Reason for Change in Number of Cross Breeds in Bungoma County

Reason for increase	Frequency	Percent	
Adapts to climate change	164	41.4	Chi square X^2=75.46 df=7 p=0.000
High milk production	72	18.2	
Affordable	71	17.9	
consumes less food and cheap to maintain	34	8.6	
For security since the local breeds are target to theft.	31	7.8	
calves produced are of a high quality	16	4.0	
Available for breeding	8	2.0	
Total	**396**	**100**	

From the results, reasons for increased cross breeds were: adapts to climate change, high milk production, affordable, consumes less food and cheap to maintain, for security since the local breeds are target to theft, calves produced are of a high quality and they are also available for breeding. Chi square test indicated that there is a significant relationship on change in number of cross breeds as shown by a calculated χ^2_7 = 75.46 which is greater than the critical χ^2_7= 84.53. Focus group discussions confirmed the facts and they further added that cross matures fairly early and fetch good prices on the market. As coping mechanism, this is also the most widely adaptation to recurrent climate change effects. Respondents were asked to state the number of local cattle they had from 2015 to 2019. The data shows that there was a general increase in the number of local cattle over the years. The summary of the sums and mean scores is given in Table 8.

Table 8

Descriptive Statistics on Number of Local (Indigenous) Cattle in Bungoma County

Year	N	Minimum	Maximum	Sum	Mean	Std. Error
2015	202	0	4	73	0.36	0.633
2017	216	0	4	129	0.60	0.863
2019	227	0	999	1213	5.34	66.259

The small scale dairy cattle farmers were asked to state the reasons for the changes in the number of local cattle and the results recorded in Table 9

Table 9

Reason for Change in Number of Local Cattle for Bungoma County

Reason	Frequency	Percent
Adaptability to harsh climatic changes	119	29.5
Cheap to maintain	98	24.3
Low purchasing price	41	10.2
Disease resistant	35	8.7
Readily available and cheap to purchase	31	7.7
For work purposes i.e. transport, ploughing	26	6.5
Relatively low produce of milk	22	5.5
Calves mature fast	20	5.0
Good quality milk	11	2.7
Total	**403**	**100.0**

The reasons indicated for the changing numbers were as follows: adapts to harsh climatic changes, cheap to maintain, low purchasing price, disease resistant, readily available and cheap to purchase, for work purposes e.g. transport & ploughing, relatively low produce of milk, calves mature fast and good quality milk.

In summary, this study looked at various climate change and variability coping mechanisms adapted in Bungoma County. Major among these coping strategies, diversification has been widely impressed as an effective adaptation. Farmers have opted to diversify to other on- farm alternatives for reasons cited in the above discussions. These findings resonate with other researches as follows; diversifying an existing farm business entails incorporation of alternative enterprises. Diversification is practiced for purposes of increasing income and food availability (Shahbaz et al., 2017).

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

Smallholder dairy farmers have evolved a number of climate change coping mechanisms; Key among these is reverting to rearing indigenous zebu and cross breed cows that are more resilient to the adverse effects. Integration of dairy and crop farming, use of farm waste as animal feeds, altering acreage, matching stock rates are among the coping mechanisms adapted by smallholder dairy cattle herd farmers. Diversifying to other forms of livestock and income generating activities e.g. chicken, goats, sheep, pigs and beekeeping.

5.2 Recommendation

Climate change and variability effects are on great increase and quickly eroding the gains of dairy technologies adapted in the recent times in the county to boost smallholder dairy cattle production in the county. Both Policy formulation and investment adaptations by the county government to address to minimize losses and damages incurred by smallholder dairy cattle farmers, occasioned by increased frequency of extreme rainfall over the three sites.

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