Adaptation strategies for enhancing sustainable smallholder dairy cattle productivity under the regime of climate change in Bungoma County, Kenya

ABSTRACT

The study evaluated adaptation strategies for enhancing sustainable dairy cattle herd productivity under the present of climate change scenario. The study was conducted in three selected Sub Counties of Bungoma County that is Tongaren, Mt. Elgon, and Kimilili, Sub Counties with estimated total population of 900 smallholders. A cross-sectional, correction and evaluation research designs was used to provide an accurate portrayal of the characteristics of the respondents. A sample size of 415 respondents was used and served with questionnaires to solicit their responses. A review of empirical reports, interviews of key stakeholders, NGOs, professionals in the Kenya Metrological Department as well as ministry of agriculture was used to compliment data gathered through questionnaires. Quantitative data was analyzed using Microsoft Excel and SPSS software. From the results farmers use the following adaptation strategies as a matter of priority of strategies to enhance productivity; - growing of early maturing and drought resistant crops varieties. Making silage and preserving of farm residues for dry spells. Farmers are collaborating with veterinary officers during breeding so as to improve on the quality of cows kept. 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.

(Key Words: Adaptation strategies, smallholder dairy cattle productivity, climate change, Bungoma County)

1.1 Introduction

"The phenomena of climate change and variability are posing concerns to governments and policymakers throughout the world. The consequences of this change have been felt in most sectors of the world such as agriculture, economic sector, forestry, livestock and fishery" (Wambugu, *et al*., 2011). "Over the past 150 years, the global mean surface temperature has increased by 0.76°C, according to the Intergovernmental Panel on Climate Change" (IPCC, 2014). "Other regional differences in observed changes worth pointing out include trends in relative sea level, which is rising on average globally" (Church *et al.*, 2014), but "displays large regional variations in magnitude, or even sign, due to a combination of influences ranging from El Niño/La Niña cycles to local tectonic activity" (Nicholls *et al.,* 2013). "General conclusions about ongoing and future risks of sea-level change very difficult to draw across diverse regional groupings such as small islands" (IPCC, 2014). "Under the Paris Agreement, 92 countries have included the livestock sector in their nationally determined commitments (NDCs) as a means to achieve their national reduction targets" (Wilkes, 2017).

“There are also regional variations in another ongoing effect of rising CO2 concentration ocean acidification, with a greater pH decrease at high latitudes consistent with the generally lower buffer capacities of the high latitude oceans compared to lower latitudes” (Rhein et *al.*, 2014). “Calcifying organisms are expected to show responses to these trends in future, but key uncertainties remain at organismal to ecosystem levels” (IPCC, 2014).

“Global warming has caused greater climatic volatility such as changes in precipitation patterns and increased frequency and intensity of extreme weather events and has led to a rise in mean global sea levels. These occurrences result in perpetual flooding, displacements of populations, destruction of property and crop failure. A report of results from a study that assessed the ability of farmers in 10 African countries (Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa and Zambia) to detect and adapt to climate change. Results from all these studies have shown that farmers indeed perceive a change in climate over time and take some actions to adapt to such changes” (Lema & Majule, 2019).

“In Kenya, climate change and variabilty are evidenced by irregular and un-predicrainfall, intense downpours, rising temperature and generally extreme and harsh weather” (GOK, 2018). “Since the 1960s both minimum and maximum temperatures have been on an increase or warming trend” (GOK, 2018). “The maximum temperature has generally risen by O.7-2°C and the minimum by 0.2-1.3 ° C depending on region and season” (GOK, 2018). “Western Kenya has had an increase in temperature of 0.8 -2.9 °C” (GOK, 2018). “Total annual precipitation projection in the country suggest an increase of approximately 0.2- 0.4 per cent per year” (NCCRS, 2010). “The country experienced major droughts every decade and minor ones every three to four years” (Mutimba *et al*, 2010; NCCRS, 2010; KMD, 2018). “The change in climate has a mainly adversarial impact upon agricultural production because it affects climatic factors such as temperature and precipitation” (Muchemi 2015; Barasa *et al*., 2015).

“Besides individual household characteristics, production and marketing of milk by smallholders are strongly influenced by patterns of human population densities, climate, rainfall and access to urban centres and services” (KDB, 2018). “Climate change is becoming one of the most serious challenges to Kenya's achievement of its development goals as described under Vision 2030. Kenya is already highly susceptible to climate-related hazards, and in many areas, extreme events and variability of weather are now the norm; rainfall is irregular and unpredictable; while droughts have become more frequent during the long rainy season and severe floods during the short rains. The climate is changing and that this change is different from natural variability. They identified variation in rainfall patterns reflected by a change in distribution, duration, and amount of rains as the key indicator of climate change; participants also cited temperature change, but less often, with most farmers referring to an increase in temperature” (Ishaya & Abaje, 2018).

“In Bungoma County in western Kenya, the agriculture sector is provided up to 70 per cent of jobs between 2013 and 2017” (Bungoma County Government, 2018). However, climate change presents many challenges, for the development of small-scale dairy farming. According to Bungoma County Government (2018) integrated report, “climate change has already begun to

impact agriculture and ecosystems in the county, with erratic and unpredictable weather patterns and declines in indigenous flora and fauna, has been observed. Multiple severe impacts are also likely to result from climate change in the future, including higher temperatures, water scarcity, changes in rainfall patterns, environmental stresses like the El Nino phenomenon, and an increase in extreme weather events, like 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 (2013). "It is, therefore, important to evaluate the impact of climate change on smallholder dairy herd productivity in Bungoma County which strives to reduce poverty levels and prevalent food insecurity situation in the current climate". Volenzo (2013)

1.2 Statement of the Problem

"Small holder dairy farming faces a high risk of reduced productivity resulting from extreme weather occasioned by climate change and weather variability. Overall, dairy products yields may fall by 10 to 20% to 2050 because of warming and drying, but there are places where yield losses may be much more severe as indicated in the Agricultural Sector Development Support Programme (ASDSP) Report" (Bungoma County Government, 2014). "The annual milk production is estimated at 97 Million litres, and is mainly produced in the upper sub-Counties of this County mainly Tongaren, Kimilili and Mt. Elgon" (Bungoma County Government, 2018). "Bungoma County is food insecure and also records a poverty index of 52.9% compared to the National index of 46%, while the food insecurity stands at 43%, KNBS (2010). Many families in the County take one meal a day, in contrast to the recommended three meals per day" (UNICEF, 2019).

"With the fast-growing demand for milk and other dairy products resulting from increasing population and urbanisation, the dairy industry in Bungoma has great potential to enhance the generation of household income mainly among smallholder farmers as well as to create employment opportunities for the local population. Livestock and in particularly dairy farming is critical in the county with income generated from the sale of dairy products and livestock accounting for about 31% of the total household income Bungoma County Government (2018). Among other challenges facing the smallholder dairy in Bungoma County are climate change and variation related that have contributed to the high cost of dairy cattle herd production". (UNICEF, 2019).

"The main climate-related factors that resulted in the loss of livestock were increased infestation by diseases and lack of pastures/fodder in Bungoma County" (Barasa, *et al.,* 2015). "In a separate article, the Ricardian model is applied to African livestock data" (Seo & Mendelsohn, 2017) and shows that "livestock is sensitive to climate. Sub-Saharan Africa (SSA) has been identified as one of the regions that are most vulnerable to the impacts of climate change (CC)" (Bryan & Notenbaert, 2013; IPCC, 2014).

The low dairy herd productivity in East Africa is attributed to limited use of production technologies and inadequate exploitation of the existing environmental influences. Mapiye *et al.* (2016) alluded that "the low quantity and quality of feed resources affected the productivity of dairy animals in sub-Saharan Africa. 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".

1.3 Research Objectives

The overall objective of this study was to evaluate adaptations strategies for enhancing sustainable smallholder dairy cattle productivity under the regime of climate change in Bungoma County, Kenya

LITERATURE REVIEW

2.1 Climate Change and Livestock Adaptation Strategies

"Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. However, the expanding human population, urbanization, environmental degradation and increased consumption of animal source foods have rendered some of those coping mechanisms ineffective" (Sidahmed, 2018). "In addition, changes brought about by global warming are likely to happen at such a speed that they will exceed the capacity of spontaneous adaptation of both human communities and animal species. The following have been identified by several experts as ways to increase adaptation in the livestock sector: Production adjustments". (FAO, 2018; Thornton, et al., 2018; Sidahmed, 2018)

"Changes in livestock practices could include: (i) diversification, intensification and/or integration of pasture management, livestock and crop production; (ii) changing land use and irrigation; (iii) altering the timing of operations; (iv) conservation of nature and ecosystems; (v) modifying stock routings and distances; (vi) introducing mixed livestock farming systems, such as stall-fed systems and pasture grazing". (FAO, 2018; Thornton, et al., 2018; Sidahmed, 2018)

Breeding strategies: "Many local breeds are already adapted to harsh living conditions. However, developing countries are usually characterized by a lack of technology in livestock breeding and agricultural programmes that might otherwise help to speed adaptation. Adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases" (Hoffmann, 2018). "Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds" (Wakhungu, 2012). If climate change is faster than natural selection, the risk to the survival and adaptation of the new breed is greater.

Market responses: "The agriculture market could be enhanced by, for example, the promotion of interregional trade and credit schemes; institutional and policy changes, Removing or introducing subsidies, insurance systems, income diversification practices and establishing livestock early warning systems – as in the case of IFAD-supported interventions in Ethiopia,

and other forecasting and crisis-preparedness systems – could benefit adaptation efforts". (Wakhungu, 2012)

Science and technology development: "Working towards a better understanding of the impacts of climate change on livestock, developing new breeds and genetic types, improving animal health and enhancing water and soil management would support adaptation measures in the long term". (Wakhungu, 2012)

Capacity building for livestock keepers: "There is a need to improve the capacity of livestock producers and herders to understand and deal with climate change increasing their awareness of global changes" (Wakhungu, 2012). "In addition, training in agro-ecological technologies and practices for the production and conservation of fodder improves the supply of animal feed and reduces malnutrition and mortality in herds". (Wakhungu, 2012)

Livestock management systems: "Efficient and affordable adaptation practices need to be developed for the rural poor who are unable to afford expensive adaptation technologies. These could include (i) provision of shade and water to reduce heat stress from increased temperature. Given current high energy prices, providing natural (low cost) shade instead of high cost air conditioning is more suifor rural poor producers; (ii) reduction of livestock numbers – a lower number of more productive animals leads to more efficient production and lower GHG emissions from livestock production" (Batima, 2016); (iii) "changes in livestock/herd composition (selection of large animals rather than small); (iv) improved management of water resources through the introduction of simple techniques for localized irrigation (e.g. drip and sprinkler irrigation), accompanied by infrastructure to harvest and store rainwater, such as tanks connected to the roofs of houses and small surface and underground dams". (Batima, 2016)

2.2 Indigenous Coping Mechanisms for Climate Change and Variability

Climate change has challenged different farming communities to evolve indigenous coping strategies discussed as follows: "Indigenous knowledge is unique to a given culture and environment as they are acquired through generations of empirical experiences to ameliorate the anticipated adverse consequences associated with climate change and from other impacts or consequences related to environmental stresses. These rich knowledge systems and practices can be tapped to provide solution to many coping and adaptation measures to climate change. Many indigenous peoples are taking their own initiatives in coping with climate change in the form of identifying the changes that are occurring in climatic patterns and the ensuing challenges. In some cases, indigenous communities have developed specific adaptation strategies to extreme variations of weather, such as: Crop diversification to minimize risk of harvest failures—varieties of crops with different susceptibilities to droughts, floods, pest etc. or varieties adapted to different locations such as riverbanks, high mountains, and close to primary forest etc; Change of hunting and gathering periods to adapt to changing animal migration and fruiting periods; Increasing food preservation and improving preservation methods and techniques; Introduction of food banking and seed banking along with creation of exchange networks among the communities; Changes in food habits—improving forest conservation and reverting to gathering food in the forests during bad harvest; Introduction of multi-cropping, double cropping and relay cropping systems as appropriate by many communities; Altering land use and settlement

patterns; Other measures such as conservation of forests and watershed, including restoration of ecosystems; awareness raising and solidarity actions to ensure or to address the concerns of indigenous peoples. It is therefore essential to recognize both the vulnerability and contributions of indigenous peoples in designing culturally appropriate adaptation and mitigation development plan as defined by the communities"(AIPP & IWGIA, 2011)

In summary, indigenous climate change adaptation strategies may take different approaches, largely due socio-economic and environmental situation of a given people; according to (Bynoe, 2011) may take the form of:

Shifting to other livelihoods less risky to climate change; Adjusting cropping patterns; Planting early mature crops like the "Amazon Stick" (Cassava);Practising multi-cropping; Relocating to higher round; and Asking God for help.

Shifting to irrigated farming is sometimes seen as a mitigation strategy in the face of climate variability across the developing world. Eakin (2013) describes "this for Mexico, but notes that the interaction of market uncertainty with climatic risk may in fact increase the vulnerability of households making this shift". "In South Asia, agricultural strategies such as increasing livestock production relative to crops, and selection of crop varieties, are responses to both drought and floods, but several case studies show the importance of livelihood diversification, in the villages and in towns, and both responsively to disaster and proactively" (Moench, *et al*. 2014). "These and other studies also show the importance of information and networks or social capital in mitigation with climate change and variability" (Winkels, *et al*. 2012).

3.0 METHODOLOGY

The study used evaluation research design where the variables such as culture, industrial process and land ownership were accessed. The selected research design allowed for collection of data in the form of questionnaires and interviews. Ethnographic were used where Interviews, questionnaires and Focus Group Discussions (FGD) were the main sources of primary data in this study. The interview questions were unstructured while those for the questionnaires were both structured (with set responses) and open ended (in which the respondents gave their own answers) as described in Goodman and Marshall (2018). The structured questions were fixed and identical to all respondents, which made it possible to compare and contrast between sets of data as guided by Sax, (2013). Some primary data were also collected from the respondents by the use of interviews guides developed to obtain face-to-face responses from the sampled population unit. The unstructured questions in the interview schedule supplemented the structured questions (Goodman & Marshall, 2018)

Secondary information was sourced from published and unpublished sources with literature on the impact of climate change on farming as and with specific focus on smallholder farmers in Bungoma County. These included textbooks, journals, government policy documents, government annual reports on the topic, seminar papers, conference proceedings, business journals, newspapers and periodicals and other relevant literature. Historical metrological data

obtained from KNMD was analyzed. Data on climate and weather entailed the temperature and the rainfall. Data on temperature was measured using degree Celsius o C while rainfall was measured using mm for the period 2004 to 2018. The Mann Kendall Trend Test was be used to analyze data collected over time for consistently increasing or decreasing trends.

The researcher strived to honour all guarantees of privacy, confidentiality and anonymity (giving false names for confidentiality) in performing with the research. The researcher also endeavoured to link result interpretation with the obtained data and use equitable standards of methods, which aim at the accuracy and did not exploit the sources of data in any way in the process of the research that may compromise the integrity of the study (Goodman, & Marshall, 2018). In addition to this, the researcher obtained NACOSTI permit to conduct the research.

4.0 RESULTS AND DISCUSSION

4.1 Adaptation strategies to curb effects of climate change

Respondents were asked to give strategies used to curb the effects of climate change, the results were summarized in Table 1

Table 1: Adaptation strategies for effects of climate change for smallholder dairy farmers in Bungoma County

Strategies	Frequency	Percentage	Rank
Planting different varieties of crops	354	94.1	1
Feed preservation	336	89.4	2
Soil fertility water management	253	67.3	3
Staggering time of planting	243	64.6	4
Rearing different breeds of livestock	197	52.4	5
Use of weeds alternatives	163	43.4	6
Using feeding fodder trees	93	24.7	7
Use of weather forecasting to plan	85	22.6	8
Feed conservation alternatives	66	17.6	9
Feeding concentrates alternatives	61	16.2	10
Irrigating pasture farmer awareness	61	16.2	11
Planting fodder for sale	58	15.4	12
Use of sugarcane tops	53	14.1	13
Use of maize stover	46	12.4	14
No adaptation method used	3	0.8	15

Source: Researcher (2019)

From the findings in Table 1, 94.1% indicated that they were planting different varieties of crops as an adaptation strategy to curb climate change. Also, 89.4% indicated, feed preservation, 67.3% indicated soil fertility water management, 64.6% indicated staggering time of planting, 52.4% indicated rearing different breeds of livestock, 43.4% indicated use of weeds alternatives, 24.7% indicated using feeding fodder trees, by observation the most adopted fodder trees the farmer had planted Calliandra and Sesbania sesban trees. 22.6% indicated use of weather forecasting to plan, 17.6% indicated feed conservation alternatives, 16.2% indicated feeding concentrates alternatives, 16.2% indicated irrigating pasture farmer awareness, 15.4% indicated planting fodder for sale, 14.1% indicated use of sugarcane tops, 12.4% indicated use of maize stover and 0.8% indicated that they didn't have any adaptation method used to cur climate change.

4.3 Challenges facing adaptation to climate change and variability by smallholder dairy farmers in Bungoma County

The challenges faced in trying to cope with the effects of climate change were analyzed and the results were recorded in Table 2

Table 2: Challenges in adaptation to the effects of climate change by smallholder dairy farmers in Bungoma County

Strategy	Frequency	Percentage	Rank
Lack of money to acquire modern techniques	327	87.0	1
Lack current knowledge on adaptation method	276	73.4	2
lack of improved seeds	256	68.1	3
Lack of access to irrigation water	250	66.5	4
Digging boreholes	250	65.1	5
lack of information on weather incidence	239	63.6	6
Afforestation	172	44.8	7
Rain water harvesting/ storage	105	27.3	8
Making hay/silage	94	24.5	9
Buy feeds	52	13.5	10
Soil conservation e.g. mulching	47	12.4	11

Source: Researcher (2019)

According to the results Table 2, 87.0% indicated lack of money to acquire modern techniques, 73.4% indicated lack current knowledge on adaptation method, 68.1% indicated lack of improved seeds, 66.5% indicated lack of access to irrigation water, 65.1% indicated digging boreholes, 63.6% indicated lack of information on weather incidence, 44.8% indicated

afforestation, 27.3% indicated rain water harvesting/storage, 24.5% indicated making hay/silage, 13.5% indicated buying feeds and 12.4% indicated soil conservation, for instance mulching.

4.4 Effectiveness of adaptation strategies

Respondents were asked to indicate how the adaptation strategies had been effective in assisting farmers deal with the effects of climate change. The responses were summarized in Table 3.

Table 3: Effectiveness of adaptation strategies for Bungoma County

Effectiveness	Frequency	Percent	Tongaren	Kimilili	Mt. Elgon
Improved milk production	186	23.3	1	1	1
Best quality cows are being reared	130	16.3	2	3	2
AI improves the breed quality	87	10.9	3	2	4
Availability of water supply to dairy animals	80	10	4	4	3
Ensured availability for feeds	74	9.3	5	5	5
Availability of food	68	8.5	6	7	6
Pests and diseases controlled through inter cropping	65	8.2	7	6	7
Improved soil fertility	59	7.4	8	8	8
Soil erosion has reduced	48	6	9	9	9

Source: Researcher (2019)

From the findings Table 3, 23.3% of the respondents indicated that the practice of adaptation strategies improved milk production, 16.3% indicated that best quality cows are being reared and 10.9% indicated that AI improves the breed quality. Similarly, 10.0% indicated practicing adaptation strategies avails water supply to dairy animals, 9.3% indicated that adaptation strategies ensures availability for feeds, 8.5% of the respondents indicated that the adaptation strategies ensures availability of food, 8.2% of the respondents indicated that pests and diseases get controlled through inter cropping, 7.4% indicated that improved soil fertility is achieved and 6.0% indicated that soil erosion has reduced.

4.5 Recommendations Adaptation of climate change

The farmers gave recommendations on what can be done to enhance fight on climate change and they were summarized in Table 4.

Table 4: Recommendations on what can be done to enhance adaptation of climate change for Bungoma County

Recommendation	Frequency	Percent	Tongaren	Kimilili	Mt. Elgon
Afforestation/ Stop deforestation	257	66.9	1	1	1

Improved extension services/ Increase the number of vet officers	242	63	2	2	3
Avail credit facilities for farmers	209	54.4	3	4	2
Awareness to be given to farmers on the importance of trees	195	50.8	4	6	4
Lower cost of far inputs e.g. fertilizers	182	47.4	5	5	5
Build water tanks	168	43.8	6	6	6
Build dams for irrigation.	94	24.5	7	7	7
Preserve water catchment areas	85	22.1	8	9	9
Establish a weather station	67	17.4	9	10	8
Education to farmers on better way to improve farming	54	14.1	10	8	10
Doing dipping/ spraying of their animals at their own home	38	9.9	11	11	11
farmers to plant cover crops	31	8.1	12	13	12
Giving cross breed for dairy cattle from well-wishers and government	20	5.2	13	12	13
Improve water supply systems	16	4.2	14	14	14

Source: Researcher (2019)

According to the findings Table 4, 66.9% recommended forestation/stop deforestation, 63.0% recommended improved extension services/increase the number of vet officers, 54.4% recommended availing credit facilities for farmers, 50.8% recommended awareness to be given to farmers on the importance of trees, 47.4% recommended lower cost of far inputs such as fertilizers, 43.8% recommended building of water tanks, 24.5% recommended building of dams for irrigation, 22.1% recommended preservation of water catchment areas, 17.4% recommended establishment of a weather station, 14.1% recommended education to farmers on better way to improve farming, 9.9% recommended doing dipping/ spraying of their animals at their own home, 8.1% of the respondents recommended farmers to plant cover crops, 5.2% recommended giving cross breed for dairy cattle from well-wishers and government and 4.2% recommended improving of water supply systems.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In general, climate change and variability effects have adversely affected smallholder dairy herd cattle productivity in Bungoma County both directly and indirectly resulting to food aggravated insecurity and declining livelihoods. 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

Based on the results and findings of the study, the following recommendations were made; Dairy farmers should be empowered to adapt and mitigate against the effects of climate change and variability that has exacerbated frequent drought and emergence of new vectors and livestock diseases. As a response to the effects of climate variability and change, dairy farmers should invest in fodder development and conservation technologies in order to sustain their dairy herd productivity; Adapt integrated farming system to minimise adverse effects climate change on dairy productivity; advocate and promote climate smart agriculture among dairy farmers to advert serious impact of climate change.

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