Climate change and the African livestock sector: emerging adaptation measures from UNFCCC national communications

Introduction

Agriculture dominates African economies and can contribute to about 25.9% of the Gross Domestic Product (GDP) (Rasch *et al*., 2016). The sector contributes significantly to employment and food security of rural communities. It provides almost 50% of household food requirements and incomes (Rust & Rust, 2013). However, the sector is vulnerable to climate change. Climate risks and impacts on national economies and peoples' livelihoods in Africa are widely acknowledged (Thornton *et al*., 2007). Adaptation is one of the key intervention options in dealing with negative climate change impacts (Adger *et al*., 2003). Climate change adaptation refers to the ability to adjust in human or natural systems in response to the changing climate condition (IPCC, 2001). This study focuses on climate change adaptation in the livestock sector and pays attention to a wide spectrum of adaptation measures that are emerging across the African continent as reported periodically in the UNFCCC National Communications. This study refers to adaptation measures in the livestock sector ranging from dairy cattle, beef cattle, sheep, goats, pigs, horses and poultry, which contribute almost 92% of the income in Africa (Thornton *et al*., 2007). There is therefore an urgent need to adopt effective measures to deal with the fragile nature of the livestock sector to climate change (Gill & Smith, 2008).

Climate change impact on livestock seem to be under researched as more work has been done on the impact of climate change on crops (Yin *et al*., 2016c; Zinyengere *et al*., 2016; Berg *et al*., 2013; Liu *et al*., 2013; Zinyengere *et al*., 2013; Waha *et al*., 2013; Muller, 2013. The impacts of the changing climate on livestock production systems can either be direct or indirect. Direct impacts arise from changes in humidity, air temperature, wind speed as well as extreme weather events like floods, droughts, extreme frost, wildfires and hail storm leading to reduced wool and milk production as well as growth and reproduction (Houghton, 2001). A change in feed resources is another evident impact as climate change affects the health, pastures, the ecological buffer capacity and their sustainability as well as vectors and parasites distribution (Thornton *et al*., 2007). Rangelands and forages are negatively impacted resulting in the reduced quantity of stovers and grains during dry season feeding (Ibid). As such, farmers find it difficult to manage feed shortages in the dry seasons and/or during periods of extended droughts. Furthermore, increased temperatures affect the digestibility and degradation of plant species (Steinfeld *et al*., 2006).

Although not a focus of this paper, livestock production is also one of the major contributors to methane and other greenhouse gases (GHGs) that cause global warming resulting in climate change (Aydinalp and Cresser, 2008). Steinfeld *et al*. (2006) estimated a global increase in meat demand to 2050. This increase will push famers to increase their livestock production and by default increase GHG emissions. Therefore, livestock farmers have a huge

task to meet the growing meat demand and at the same time reducing GHG emissions. In addition to methane, livestock production generates carbon dioxide (CO2) and nitrous oxide (N2O).

Coming back to the focus of the paper, Parsons *et al*. (2001), point out that increased temperatures often lead to heat stress and reduced livestock feed intake level thereby affecting dairy milk yields. Valtorta (2002) estimates a 10%-14% reduction in milk production by 2020 as a result of climate change. A question then arises: what adaptation measures in the livestock exist in response to climate change in African countries?

This paper is structured as follows: the first section is the introduction addressing the problem of the study. The second section presents the literature review. The third section explains the method and materials used. The fourth section presents the emerging findings and discusses the audited adaptation measures from selected United Nations Framework Convention on Climate change (UNFCCC) National Communications. The concluding section presents the authors position and suggestions emanating from the study.

Climate change's impacts on livestock

Climate change is expected to affect both the quantity and quality of the animal feeds, increase heat and water stress, accelerate the prevalence of livestock diseases and vectors, as well as accelerate biodiversity and livelihoods loss (Thornton *et al*., 2009). The quality and quantity of feeds is affected through altering legumes and grass composition. The quality of herbage is impacted through changing concentrations of water-soluble carbohydrates at given dry matter yields (Hopkins and Del Prado, 2007). At the same time, an increase in mean temperatures lead to considerable modifications in rangeland species, composition, patterns and biome distribution (Hanson *et al*., 1993). This modification changes species competition dynamics and the compositions of mixed grasslands resulting in changes to livestock productivity. However, a study by Thornton *et al*. (2007) indicate favourable growth of forbs and legumes over grasses with increase in temperatures. The authors argued that increased temperatures often lead to lignification of plant tissues that cause reduced plant digestibility. The formation of lignin plant cell walls can ultimately reduce nutrient availability for animals.

Although livestock management practices are not a new thing, this review study builds on old initiatives and strategies for improved livestock management. These practices have been going as a response to population, global demands, innovations and research. Typical examples are the livestock coping strategies spearheaded by pastoralists in East Africa, who moved 85% of their livestock to other areas looking for greener pastures (Musembi *et al*., 1986). Moreover, Holtzman (1996); Little (1992) assert that in coping with the changing climate in East Africa region, livestock herders practiced pastoral diversification through indulging in non-pastoral income-generating activities for example, involved in trading

initiatives (selling firewood, milk, livestock and other products) and selling and gathering wild products and fruits (medicinal plants, firewood, gum arabica). The long seasoned droughts of 1987/88, 1992 and 1996, and the floods of 1992/93 affected Somali, Kenya and Ethiopia herders including movement of seasonal herds (de Waal 1997). The pastoralists engage in various coping strategies such as migrating livestock better grazing areas or pastures, increase livestock sales to generate income during drought periods, livestock slaughtering and migration for male herders in search of employment in other areas (Little 1992a).

A typical example of livestock migration as a coping strategy to the impacts of climate change was practiced by the Maasai of the Serengeti and Ngorongoro Crater in Tanzania (Kijazi *et al*., 1997). During periods of standing droughts and reduced productivity of rangelands the Maasai travelled long distances in search for greener pastures (Gichohi *et al*., 1996). The Maasai have historically coped with climate change and variability through moving their livestock over large pieces of land. Over 65% of the Maasai population is living below the poverty datum line (GoK (Government of Kenya) 2003). The only way to keep their livelihoods is through extended migration patterns. Their household options revolve around livestock for their food security and raising livestock as cultural and capital asset and gain (Thornton *et al.,* 2006).

Without addressing the negative impacts of climate change on livestock production, food insecurity will remain and become more pronounced in the future. Previous research identified heat stress and humid conditions as major stumbling block in livestock production. Heat stress is often associated with mortality, reduced growth and reproduction (SCA, 1990). Sirohi and Michaelowa (2007) assert that reduced feed intake, behavioural and metabolic changes in livestock are due to increased heat. The need to improve livestock breeding as a means of climate change adaptation to increase resistance to high temperatures and diseases is highlighted by Mader and Davis (2004) who asserted that locally adapted livestock may be tolerant to disease and excessive heat. King *et al*. (2006), point out that the changing climate may result in reduced livestock feed intake leading to a decrease in animal fertility, general fitness and longevity; aspects supported by Aydinalp and Cresser (2008). Moreover, Marcoux (1998) points out the significance of gender mainstreaming and how poverty and gender determine adaptive responses options to the changing climate among livestock holders. A gendered approach to understanding the impact of climate change is not new in the development and climate research (Meinzen-Dick *et al*., 2014).

Increased temperatures may also necessitate the spread of pathogens or parasites that are harmful to livestock including animal herders (Harvell *et al*., 2002). WHO (1996) supports this claim and pointed out that parasites and pathogens are sensitive to temperature, moist or dry conditions resulting in pathogens multiplying or decreasing in numbers. Reilly *et al*. (1996), maintain that there is limited documentation on appropriate intervention measures in dealing with the impact of climate change in the livestock sector. Appropriate intervention measures such as the livestock diversification and use of indigenous knowledge are among adaptation measures that can be employed for sustainable livestock production. This is a view

supported by (Romanini *et al*., 2008:1) who acknowledged that "we need studies that look at climate change adaptation in livestock production to be able to develop sound policies". The observation on indigenous knowledge emerged as an adaptation measure in Gbetibouo's (2009) work who studies small scale famers and climate change adaptation in the Limpopo River Basin in South Africa. In Africa, livestock sometimes rely on their indigenous knowledge systems (IKS) as an adaptation measure for the changing climate (Nyong *et al*., 2007). Indigenous or traditional knowledge refers to the knowledge accumulated across generations (Agrawal, 2003). IKS have shown potential in boosting livestock production through employing locally and appropriate adaptation measures in the livestock sector (Joshua *et al.*, 2012). Liu *et al*. (2008) highlighted the need for suitable adaptation options for example, improved irrigation, livestock breeding and farmer access to extension services and markets to ensure sustainable livestock production.

As highlighted earlier, changes in rainfall and temperature may increase vectors of livestock disease (midges, flies, ticks, mosquitoes and tsetse). Romanini *et al*. (2008) emphasize that climate change may lead to ecosystems modification, biodiversity loss, species being exposed to pathogens and vectors that can affect livestock and human beings. Thornton *et al*. (2006b) identify rangeland-based arid–semi-arid (LGA) and mixed rain-fed arid–semi-arid (MRA) systems as most vulnerable to climate change in Africa. The authors found that current adaptation practices may not be able to reduce the negative effect of future climate on livestock. Patz *et al.* (2005a), consider livestock diversification and intensification and integrated pasture management as effective adaptation measures. The authors concluded that investment in research towards improved livestock breeding is potentially useful for adapting to future climates. To keep livestock production sustainable, it is imperative to adopt appropriate intervention measures that can ensure continuous genetic breeding and improvement to produce efficient livestock under climate change. For example, locally adapted livestock can be resistant to drought, disease, heat, produces high milk yield and high reproduction rates. To achieve this, it is crucial to relate livestock breeds and genes with the surrounding environment to understand well suited animal species that can adapt to the changing climatic conditions (Seré *et al*., 2008).

Such initiatives are being championed by regional economic communities (REC) such as IGAD, SADC, AU and the UN in the African continent. The RECs are spearheading livestock breeding initiatives at regional level and also replicated at national level, either as policies, action plans or strategies. Livestock breeding initiatives are promoted in the region and also common among Maasai pastoralists. Keeping livestock breeds that can grow faster, able to thrive in poor quality browse during drought conditions, reproduce faster and can be sold easier. IGAD and AU recommend indigenous breeds for example, the *Zebu East African cattle*, black headed Maasai and the sheep east African goat (GoK, 2001). Breeding and raising adapted indigenous livestock breed is a common coping strategy being practiced by the pastoralists in the Arid and Semi-Arid Lands (ASALs). For example, Uganda and Tanzania, over 96 percent of their livestock are indigenous and raised in drylands (Nassef *et al*, 2009). The same is also being practiced in India, with an estimated the estimated 157

million indigenous cattle reported in 2003 and 22 million of cross breeds (Aruna and Arand, 2010).

Materials and methods

In order to address the research question outlined in the introduction, we reviewed adaptations measures in National Communications to the UNFCCC from 21 African countries. The countries were purposefully sampled and details regarding National Communications selected are shown in Table 1. The countries were sampled based on the following criteria: Firstly, those with the most updated national communications as posted on the UNFCCC website and repository. In this case, it could be either the second or third National Communication report submitted to the UNFCCC. The reason for considering the second or third National communications was to gather the latest available data from the selected countries. Secondly, the National Communications selected were those from English speaking countries as the authors can only read and understand English.

Table 1: Sample countries and National Communications chosen

Country	*National Communication 2*	*National Communication 3*
Botswana	✓	
Egypt	✓	
Eritrea	✓	
Gambia	✓	
Ghana		✓
Guinea-Bissau	✓	
Kenya	✓	
Lesotho	✓	
Malawi	✓	
Mauritius	✓	
Namibia		✓
Nigeria	✓	
Rwanda	✓	
Sierra Leone	✓	
South Africa	✓	
Sudan	✓	
Swaziland	✓	
Seychelles	✓	
Uganda	✓	
Zambia	✓	
Zimbabwe	✓	

Source: Authors, 2016

On auditing, 95 categories of adaptation interventions emerged, which were further organised into eight thematic areas. The eight thematic areas and the number of categories in each of the themes are presented in Table 2.

Table 2: Adaptation themes and number of categories identified

Theme	Number of Category
Carrying capacity and policies	23
Integrated pasture management	17
Capacity building, extension, training, awareness and information sharing	14
Livestock breeding, diversification and intensification	14
Disease, vectors and parasites management	8
Technology, Innovation, Research and Development	7
Alternative livelihood	5
Water supply	3
Total	***95***

Source: Authors, 2016

Following Sandig and Selting (1997); Sandelowski and Barroso (2003b) the methodology also employed the literature survey approach through thematic analysis and content analysis on the impacts of climate change on livestock and a review of the submitted adaptation measures. The study employed content analysis to systematically code and categorize large texts from the national communication reports in determining first patterns and trends of the used words, their relationships, frequency, structures and communication discourses (Gbrich, 2007). Content analysis purposely describes documents' characteristics through investigating who says what, with what effect and to whom (Bloor & Wood, 2006). On other hand, thematic analysis identifies, analyses and reports themes within data Braun & Clarke (2006: 79) which in this case from the retrieved national communications. In this study, both approaches enables the authors to familiarise with the data retrieved from national communication reports, code interesting data features systematically, search for themes, name and define the themes, organising and creating categories and description of research themes through formulating sub-categories and finally analysing results through conceptual systems (Elo & Kyngäs, 2008: 110). In addition, the grounded theory approach by Charmaz (1983) was largely employed. The study used grounded theory approach to derive meaning from the retrieved information. A number of advantages have been observed when using the grounded theory approach namely: its ability to provide for intuitive appeal, creativity in formulating new ideas, capability to develop concepts through logic comparison and frequent memo writing (Glaser, 1978), as well as systematic data collection and analysis (Hussein et al., 2014). The grounded theory was derived inductively through systematic collection and analysis of data (Strauss and Corbin, 1990) pertaining to the submitted National Communications reports. The adaptation themes and categories of the analysis emerged from the National Communications reports. The emerged themes captured the essence of measures and experience drawn from varied country submissions and contexts instituted to make the livestock sector climate compatible in as far as adaptation is concerned. The retrieved themes were then examined and interpreted to give meaning and draw conclusions through coding, conceptualizing, categorizing, and theorizing.

Coding entails reviewing the information sentence by sentence to identify anchors (words or phrases) that allow the key points of the data to come forward. Conceptualizing groups codes

with similar content (where new concepts are core parameters of the data and codes can be seen as dimensions of these concepts). Categorizing develops categories that broadly group the concepts and constitute the basic elements to be generated into a hypothesis or a theory. Theorizing constructs system of explanations for the main concerns of the subject of the research.

Emerging Findings and Discussions

This section highlights the key findings and discussions from the study. We present and discuss findings of adaptation measures instituted by countries in the livestock sector. Although the adaptation measures revealed from the national communications below are not from all the identified countries and regions, some are still applicable across the African continent as these are generic. Such measures include: de-stocking during droughts and livestock diversification. Details regarding the emerging findings and discussion on the actual adaptation measures are presented each in turn as per the themes identified in Table 1.

Carrying-capacity and policies

Carrying capacity is expressed as an ecological concept showing the relationship between a natural environment and population it rely on for its sustenance. The concept supposes restriction on the number or size of individuals that can be assisted at any given consumption level without environmental degradation. Therefore, carrying capacity prescribes long-term environmental sustainability. Under this theme, the following adaptation categories emerged: moving livestock to higher carrying capacity grazing areas, culling, and one cow per household, changes of livestock composition, livestock loaning and relocating. The South African government developed a policy that advised and legislated stocking rates of livestock with the aim of reducing rangelands stress from continuous grazing (South Africa, DEA, 2011). Policy shifts informed by research have proved to be effective in preventing degradation of grazing areas stocking rates. The government is carrying out science-based studies on current and future carrying capacities projections (Ibid).

In Malawi, the government embarked on a culling programme to reduce livestock grazing densities in the Shire Valley agro-ecology. The programme focuses only to animals with a short and fast growing cycle season (Government of Malawi, 2011). In Zimbabwe, the government developed agricultural production policies and practices that recognize the need to reduce carrying capacity of rangelands. The objective of the practices is to have fewer animals sustained within rangelands (Zimbabwe, Ministry of Environment and Natural Resources Management, 2013). Moreover, the government of Zambia developed policies on rangelands with an objective to improve the grazing management practices such as maintaining optimum livestock numbers. Other measures include strategies on improving the management of manure to reduce excess build up and release of methane (Zambia, Ministry of Lands, Natural Resources and Environmental Protection, 2014).

The government of Namibia launched policies in 2014 for farmers to employ adaptation measures in rangelands. The policies encourage timely pruning and thinning of unwanted shrubs, afforestation and reforestation and soil erosion control. The government also formulated and operationalized policies for the Eradication of Trans-boundary Animal Diseases in the Northern Communal Areas (NCA). These policies include the National Rangeland Management Policy and Strategy (NRMPS) (2012) and the National Policy on Climate Change (2011). The mentioned policies lay down the importance of sustainable livestock production, natural resources management and appropriate adaptation measures in the changing climate (Government of Namibia, 2015). Similarly, the government of Guinea-Bissau formulated and approve the Agricultural Development Policy Charter and its Action Plan in 1988 and later updated in 2002. In addition, the government developed the Medium Term National Investment Program (PNIMP) and the National Program for Food Security (PNSA). These policies aim to enhance sustainable livestock production through provision of extension services to farmers and dissemination of improved technologies and innovations. Such innovations include developing short cycle livestock breeds, early warning systems and insurance against disasters (Government of Guinea-Bissau, 2011). The policies promote adaptation measures towards effective diversification, strengthening institutions, protecting natural resources, investing in research and development and technological advances.

Integrated pasture management

Integrated pasture management (IPM) is an adaptive management approach with appropriate practices that can contribute significantly to farm/ranch operation sustainability. The practice provides and an address various aspects of grazing rotation strategies, management options and sustainable pasture integration. It includes options such as improved pasture fertility, rotational grazing systems, plant community modifications through grazing, pasture maintenance, controlling weeds and invasive species and formulate an integrated management plan (Azadi *et al*., 2009a, b). This is one of the crucial adaptation themes that emerged from the auditing exercise. The main adaptation categories include: controlled grazing, rented grazing on nearby boundaries, promoting pasture water supply and controlling weed infestations in grasslands. The government of Eritrea has been financing agencies implementing programs on pasture development. A typical example is the International Fund for Agricultural Development (IFAD) Gash-Barka Agricultural and Livestock Development programme. The objective of the programme was to apply more conservative attitude of shortening the pasture grazing hours in a day. The programme introduced long-term resting of pastures to give grass time to recuperate and to improve organic matter to the soil (Eritrea, Ministry of Land, Water and Environment, 2012).

The Gambia launched a regional project on Sustainable Management of Endemic Ruminant Livestock in West Africa. The project advocated for improved livestock production (meat, milk, and income) within a supportive pasture management. The project reiterated the need for livestock to be under the tree shade in most times of the day and graze early in the mornings and late afternoons. In addition, the project promoted pasture water supply,

controlled rangeland burning and weed infestations in grasslands (Gambia, Ministry of Forestry and the Environment, 2012).

In Lesotho, the Department of Range Resources Management was finalizing the National Range Resources Policy in 2013. The key policy areas include sustainable pasture management through the use of rented grazing areas to the nearby South Africa boundaries. The other policy areas include relocating livestock to better forage quality areas. The government is promoting the establishment of a healthy grass on rangelands, on land of limited agricultural value and promoting livestock mixed grazing (Lesotho, Ministry of Energy, Meteorology and Water Affairs, 2013). The government of Rwanda is promoting integrated pasture management through so many initiatives such as developing and exploiting modern pastures. The government is improving the conditions of pastures for livestock feeding and watering and exercising livestock controlling numbers per each household. Such measures are carried out through government support to professionals in the livestock sector, supporting animal husbandry (dairies) and veterinary research (Rwanda, Ministry of Natural Resources, 2012).

The Government of Namibia prevents rangeland degradation through its anti-soil erosion programme that involves all stakeholders including the communities. The programme is administered through the Ministry of Agriculture and Ministry of Environment (Government of Namibia, 2015). The proper management of pastures is aiding carbon sequestration. Healthy grass sward on rangelands and land of limited agricultural value generally serve as a good adaptation option of maximizing soil carbon sequestration. Reduced rangeland degradation leads to reduced soil erosion, increase in soil carbon and water infiltration rates. Long-term resting of rangeland may also lead to addition of organic material to the soil. The addition of organic matter in the soil improves soil physical, chemical, and biological characteristics and enhances recycling of nutrients.

Capacity building, extension, training, awareness and information sharing

UNESCO (2006) defined capacity building as increasing an organizational or individuals' capabilities to undertake core functions, resolve challenges, and deal objectively with developmental needs. This is supported by Horton (2002) who defined capacity building as improving a person's ability, institutions and team to perform and achieve aims over time. In this case, agricultural extension services play a significant role in addressing farmer decision-making and learning. These services ranges from changes in farming systems, trying out new technological practices and challenges solving such as food insecurity, environmental management, marketing of products and poverty reduction (Rangnekar, 2006). Under this theme, many countries reiterated the need to build capacity, mutual trust and information sharing between farmers, herdsmen and government. The adaptation categories that emerged include: promoting training, information and awareness raising, improve the capacity of livestock producers and herders, institutional capacity building and early warning systems. Nigeria is facilitating initiatives towards building trust and mutual relationship between

farmers and herdsmen. The government is further promoting science-related adaptation strategies. The initiative aims to improve climate forecast prediction to provide crucial early warning climate-related information to farmers and herdsmen. Other adaption measures including developing modelling tools to evaluate climate change impacts on export and domestic meat production (Nigeria, Ministry of Environment, 2014).

Similar initiatives are echoed by the South African government through its information sharing platform created between the government and farmers. The government is reducing the impacts of climate change in livestock through the continuous provision of reliable information. Such approaches aim to provide answers on when, where, what, how much and what appropriate adaptation measures farmers can employ for sustainable livestock production (South Africa, DEA, 2011). The government is providing trainings to farmers to improve their understanding of local rangelands changes, suitable grass species and fire dynamics. Moreover, the government is facilitating a reliable communications between farmers through reliable operational networks (Ibid).

The same initiatives are spearheaded by Lesotho. The government is undertaking programmes to improve the capacity of herders and livestock producers to understand and raise awareness on global climate change issues. Livestock farmers are receiving training on improved technologies, innovations and practices for fodder conservation and production. The training aims to boost the animal feed supply and reduces fodder shortage, including reduced mortality in livestock herds (Lesotho, Ministry of Energy, Meteorology and Water Affairs, 2013).

Livestock Breeding, Diversification and Intensification

Livestock breeding best describes the use of adaptive traits of indigenous animal genetic resources to the disease environments and climatic prevalent conditions (Baker and Rege, 1994). Such breeding initiatives will be addressing and improving livestock diversification and intensification objectives. The idea is to maintain adaptive traits while improving productivity traits. The adapted breeds will be able to withstand adverse climatic conditions such as long-standing droughts and have short-breeding cycle. Key adaptation measures that emerged under this theme are: investing in locally adapted livestock breeds, breeding short cycle and cross-breeding with heat and disease tolerant breeds, shifting to more prolific species and fast growing low input of livestock such as goats, rabbits, pigs and chickens and proper matching of breeds to the environment. Countries are carrying out livestock breeding initiatives as a way of adapting to the changing climate. A good example is the breeding programme that the government of Malawi initiated since the 1991/92 drought season in Ngabu in the Shire Valley, and in Likasi region. The government spearheads the breeding of heat tolerant and low input cost livestock. The adapted livestock ranges from goats, rabbits, pigs and chickens as well as Brahman crosses and Malawi Zebu cattle (Government of Malawi, 2011). Such genetic improvements in livestock in the country often lead to increased meat and milk production during dry periods. Other realized benefits include improved

livestock health, fast growing animal breeds, low input cost cattle and short-cycle intensive. The animals are able to survive, grow and reproduce in conditions of poor nutrition, parasites infestations and diseases prevalence. Government of Egypt is working towards enhancing its existing low productivity of buffalos' and cattle breeds including and strengthening livestock feeding programs that are adapted to adverse climatic conditions (Government of Egypt, 2010).

Similarly, the government of Swaziland, through the Ministry of Tourism and Environment established a programme of redistributing livestock according to the suitability of agro-ecological zones. The programme selects animals that are able to withstand the changing climatic conditions. For example, the beef and dairy cattle in lower Middleveld and Lowveld can tolerate high and low temperatures (Swaziland, Ministry of Tourism and Environmental Affairs, 2012). The distribution of animals according to their suitable agro-ecological zones led to an increase in livestock feed intake, milk production and reproduction rates.

The government of Lesotho is breeding locally adapted livestock, including improving local genetics through crossbreeding. In this regards, Lesotho is developing disease resistant and drought tolerant livestock breeds based on cross-breeding practices. For example, the indigenous African (Sanga), Nguni, Tuli and Mashona are common breeds (Lesotho, Ministry of Energy, Meteorology and Water Affairs, 2013). Lesotho's department of Livestock Services in the Ministry of Agriculture and Food Security also formed the Wool and Mohair Growers Associations. The main objective of the association is to improve both the quantity and quality of wool and mohair through genetic breeding of wool sheep. The produced wool and mohair are exported generating income and some used locally for tapestries and knitwear. The generated income from wool production helps to boost the local economy of Lesotho. Genetic breeding and upgrading of sheep increased the quantities of wool and mohair between 1999 and 2008 by 6.3 and 7.2% per year and was expected to continue increasing (Ibid).

In Eritrea, extensive animal movement is practiced in most of the pastoral systems as an adaptation measure. The government established grazing patterns of wet and dry season and grazing camps. The grazing camps form the animals' permanent villages during the rainy season and they graze scattered over large areas as water and feed is available in most of the rangelands. However, agro-pastoralists tend to migrate to wet season areas in search of greener pastures and water for their livestock during severe droughts (Eritrea, Ministry of Land, Water and Environment, 2011).

In Gambia, the government developed the National Agricultural Investment Programme (GNAIP) that looks at controlling animal stocking rates as adaptive management practices. Other management practices employed include the promotion of crop and livestock integration and intensive feed gardens, diversification of the production system and stock herds of various breeds (Gambia, Ministry of Fisheries and Water Resources, 2012). Controlling animal stocking rates and rotating grazing areas is crucial for the health of rangelands and provides high income returns from livestock sale. The high profit gains obtained from the sale of animals help to boost the local economy and other economic

demands. Maintaining greener rangelands can help to improve pastures' aesthetic beauty and recreational opportunities vital for ecotourism development. Livestock farmers are able to generate income from eco-tourism activities. Rangelands resources are able to produce medicinal plants harvested for traditional healing and medicinal purposes. Other medicinal plants are exported, generating huge profits and income that can help to improve the local economy and livelihoods of communities.

Disease, vectors and parasites management

Vectors and parasites are established as disease-causing agents to livestock globally (Colwell, 2011). The incidence of vector-borne diseases and parasites are on the increase in Africa and elsewhere (Nicholson, 2010). Hence, the urgent need for appropriate intervention approaches towards a sustainable diseases management such as African tick bite fever, Blue tongue disease and rift valley fever, anthrax, foot and mouth etc. In this regard, the Government of Botswana is designing and developing animal disease health surveillance programme. Such programs are being carried out in most of its rangelands in Central–Bobonong where there is high prevalence of foot and mouth and anthrax diseases (Botswana, Ministry of Environment, Wildlife and Tourism, 2012). The Zimbabwe and Sudan governments are rolling a disease surveillance mechanism including vaccination against epidemic and strategic supplementary feeding in most of its ranging regions. The programme is aiming at controlling the outbreak of livestock disease such as anthrax (Zimbabwe, Ministry of Environment and Natural Resources Management, 2012; Sudan, Government of Sudan, 2013).

Namibia launched a $7 million dollar grant in controlling livestock diseases in the Zambezi region. The region is susceptible to animal diseases such as foot-and-mouth. The government is minimising animal movement, carrying out vaccination and quarantine programs in a way of curbing the spread of diseases. The animal isolation program forms part of the formal marketing of livestock in the Caprivi region (Government of Namibia, 2015). Animal disease health surveillance and quarantine programme implemented in the above mentioned countries help to control livestock mortality from diseases and subsequently improve animal health. The programme can improve the chances of animal survival through controlling the spread of diseases makes it possible to increase milk and meat production.

Technology, Innovation, Research and Development

Facilitating the diffusion of improved technologies and innovation is an important climate change adaptation measure in livestock production. However, there are various challenges faced by farmers in Africa trying to adopt technology and innovations. Such challenges include: complexity of the new technology to comprehend, financial constraints, farmer's opinions and beliefs towards the technology, farmer's perception of the relevance of the new technology, level of motivation of the farmers; and attitude of the farmer's towards change and risk management. Adaptation measures that emerged under this category are: financing and farmer-training on new technology use and practices in fodder production and conservation, and applying modern agriculture through animal traction. Namibia is carrying out adaptation studies in the livestock sector to improve the marketing and export

opportunities. The government is promoting livestock production through creating new marketing openings and infrastructure, particularly in the Zambezi region. In addition, camps such as Katima and Kopano are being rebuilt through a $7 million Namibia dollar grant. In addition, the government through its Vision 2030, National Development Plan 4 and the Country Strategy Paper 2014-2018, continues to pursue technological priorities in water harvesting and use of well adapted indigenous livestock breeds (Government of Namibia, 2015). Technological priorities foster all year round food production through improved technologies and well adapted indigenous livestock breeds.

The government of Lesotho is finalizing its National Range Resources Policy whose key policy areas include rangeland monitoring and research. The department of Range Resources Management promotes research in sustainable rangeland management through forming group grazing arrangement where villages are given grazing areas, to carry out research activities to improve their grazing areas. The research based evidence is utilized to support veterinary and animal husbandry. New livestock breeds and genetic types are developed through research adapted to heat, parasites infestations and diseases prevalence, mature and reproduce faster (Lesotho, Ministry of Energy, Meteorology and Water Affairs, 2013). In Malawi, research is being carried out at Ngabu in the Shire Valley and Likasi in Lilongwe to improve feeds and feeding systems in adapting to climate change. The research is investigating pasture species such as *Kikuyu, Rhodes grass* and *Star grass* that are drought resistant, heat tolerant, short-cycle breeds of cattle, such as *Brahman crosses*, and the *Malawi Zebu* cattle. Although not coming out from the audits, floods, wild fires and extreme frost are climate change impacts that require appropriate adaptation measures at the farm level and need further research. Small livestock, in particular, is prone to these extreme weather events (Government of Malawi, 2011).

Alternative livelihoods

Alternative livelihood often depicts minimal reliance on primary productivity of land, and yet generates greater income return per investment of local resources and local economies diversification, compared to biological productivity-dependent and traditional livelihood (Méndez 1993). However, alternative livelihoods may require one to invest capital and trade-related infrastructure, which depend on effective governance and enabling policies. Such attributes ranges from implementation of innovations to achieve livelihoods sustainability based on productivity of land. The introduction of vegetable gardens at household level, livelihood diversification and village poultry farming are adaptation categories under this theme. The government of Nigeria is championing breeding edible insects as substitute of livestock products such as moth - *Cirinaforda.* The insect is widely consumed in West Africa (Nigeria, Ministry of Environment, 2014). In addition, mushroom production is substituting beef and is produced at a very low cost. The government is sensitizing people on the benefits and significance of consuming other products other than meat (Ibid). Eritrea is promoting diversified sedentary livelihoods options for pastoralists along with expanding their access to income generating activities besides keeping livestock (Eritrea, Ministry of Land, Water and Environment, 2012). Diversifying livelihoods improves both meat and milk production systems.

Water Supply

Sub-Saharan Arica's population depend on rain-fed agriculture for their livelihoods (e.g., Botswana, 76 %; Kenya, 85 %; Zimbabwe, 70 - 80 % and Malawi, 90 %; of the population). An approximately 39% of sub-Saharan Africa population (roughly 261 million people) live in semi-arid lands and therefore the need to employ effective adaptation measures for improved water availability (UNDP/UNSO, 1997). In this regard, countries outlined various adaptation categories that emerged under this theme, which include: promoting pasture water supply, improved irrigation and water harvesting techniques. The government of Nigeria supports the expansion of small-scale water harvesting practices for livestock in the dry areas. It built water harvesting structures and boreholes for livestock watering in the Sudano-Sahelian areas known for its long dry seasons (Nigeria, Ministry of Environment, 2014). In Lesotho the government is undertaking improved water resources management through harvesting and store water in containers attached to houses as well as surface artificial dams (Lesotho, Ministry of Energy, Meteorology and Water Affairs, 2013). Improved water supply enables livestock watering during dry periods, improved all year-round household food security and healthy green pastures all year round. Borehole drilling remains one of the traditional adaptation measures across the continent as deep boreholes feature prominently in Botswana, Namibia and other areas prone to prolonged drought

Conclusion

This study reviewed adaptation measures contained in the UNFCCC's National Communications from 21 selected African countries. The results indicate that there are a number of adaptation measures instituted by countries in the livestock sector to make it compatible to the changing climate. Although the adaptation measures revealed are from selected countries and regions, some are still applicable across the African continent as these are generic. For example, de-stocking during droughts and livestock diversification. For this study, although 21 countries are mentioned, only 16 countries emphasized adaptation measures in the livestock sector. The remaining 5 countries either mentioned agriculture sector or refer only to fisheries and crop sector. Key adaptation measures that emerged are: livestock breeding; disease, vectors and parasites management; livestock diversification and intensification; integrated pasture management and capacity building, extension, training, awareness and information sharing. Countries reported benefits from the implemented adaptation measures that include increased milk and meat production even during dry periods, improved all year-round household food security, improved animal health, enhanced water supply and soil management, healthy green pastures all year round, low input costs, increased profit margins, reduced rangelands degradation, improved capacity of livestock producers and herders, diversified livelihoods options, improved marketing, and export opportunities.

Early warning systems through modelling: models can provide information on pasture productivity and the ability to resolve changes in intra-annual precipitation patterns. The

information generated by models can be critical to decision-makers and livestock holders in making sustainable long-term decision-making regarding the management of arid and semi-arid grazing systems. Generated models can provide crucial information to livestock managers and government with the relevant information required to make appropriate intervention regarding the changing climate. For example, when and what is the best time to de-stock or move their livestock to other areas with greener pastures.

Employing adaptation measures can increase livestock productivity, for example, increased dairy milk yield, eggs and many other livestock products. These products can be very essential to the livelihoods of communities and increasing household's nutritional status. Increased trade with other countries can book countries' economies and the Gross Domestic Product (GPD). Technological developments such as development and promotion of adapted livestock breeds helps in boosting the livestock productivity even during drought conditions and other extreme weather events such as heat stress. Other measures can be promoted which are useful that include: micro-level adaptation options, including farm production adjustments such as diversification and intensification of livestock production; income-related responses such as credit schemes and livestock insurance schemes. institutional changes can be realized, including policy modifications for example, promoting subsidies, other income stabilization options, policies for insurance programs and livestock support; markets improvements (mostly local) livestock markets, and supporting inter-regional trade in livestock products. The adaptation measures may influence the development of continental agricultural research institutions and improved collaboration in the region. Owing to the importance of information produced by research institutions, government will be in a position to support research and expand to other areas.

However, for adaptation to be successful, it needs changes to behaviour. Policies, strategies and programs alone can't effectively improve adaptive capacity. There is need to understand the context and processes of decision-making about adaptation. Therefore, adaptation can be challenged by social, institutional, political and economic environment where people operate. There is need to exercise collaborative learning processes in supporting adaptation in the livestock sector to cope with the ever changing climate.

However, countries reported challenges that can hinder or slow down the adoption of adaptation measures such as financial constraints, unfavourable policies, limited knowledge, and slow diffusion of technology and innovation. Finally, the study shows that adaptation should be part of the bigger and ongoing climate change agenda in the livestock sector. Decision and policy makers, private sectors, relevant stakeholders and government officials and scientist should play a key role in ensuring that adaptation measures reach farmers, herders at grassroots level. In addition, governments should create an enabling environment (policies) in climate change adaptation to improve food security.

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