academicresearchJournals

Vol. 5(2), pp. 98-106, March 2017
DOI: 10.14662/ARJASR2016.056

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Effect of Climate Change on Nutritional Supply to Livestock Production

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Accepted 28 February 2017

The aim of this paper is to review the effects of climate change on nutritional supply and related parameters that have roles in reducing livestock production and productivity. Climate change can cause long-term changes in the environment in turn affect feed production and generally the production of farm animals. The main effects of climate change on livestock nutrition are through its effects in feed resources availability. Livestock development in low income countries needs to operate within the overall development objectives of reducing rural poverty, promoting rural growth and enhancing sustainable resource use. It will be our task as nutritionists to use improved feed crop varieties in a highly focused and professional manner when formulating diets. Therefore, climate researchers, meteorologists, plant breeders, crop producers, animal nutritionists, biologists, geneticists, livestock producers, animal housing technicians, doctors, etc. should all work together in the frames of a carefully structured and coordinated project to achieve the objectives of climate change adaptation, designing future directions in livestock production and mitigation strategies. Generally, negative impacts of climate change on livestock nutrition are continuing directly or indirectly and in different ways and livestock production and productivity is declining from time to time. For the demand-led and changing livestock systems, the focus of research that can benefit the resource poor needs to attend to what is changing? Now the task is given, and its accomplishment to minimize the effects of the existing changes depends only on us.

Key words*:* Climate change, livestock production, nutrition

Cite this article as: Abebe K (2017). Effect of Climate Change on Nutritional Supply to Livestock Production. Acad. Res. J. Agri. Sci. Res. 5(2): 98-106

INTRODUCTION

Almost 80% of African agricultural land is grazing land. African farmers depend on livestock for income, food and animal products Nin *et al*. (2007), and are known to keep cattle as an insurance policy for when droughts ruin annual crops (Fafchamps *et al*., 1998). African animals are exposed to the outside elements and depend largely on natural forage for nutrition. There is consequently every reason to expect that animal husbandry on farms in Africa will be sensitive to climate. Climate can affect livestock both directly and indirectly (Adams *et al*., 1999; McDermott *et al*., 2001). Direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance such as growth, milk production, wool production and reproduction.

In the developing world, livestock production is rapidly changed in response to a variety of environments. Globally, human population is expected to increase from around 6.5 billion today to 9.2 billion by 2050. From thus more than 1 billion of this incensement will occur in Africa. Rapid urbanization is expected to continue in developing countries and the global demand for livestock products will continue to increase significantly in the coming decades (Delgado *et al*., 1999). The potential impact of the drivers of change on livestock systems and the resource-poor people who depend on them for their livelihoods is considerable. These impacts will be influenced by both supply-side shifts in natural resource use as well as market-led demand changes. Given the complexity of livestock and in most cases crop-livestock systems in developing countries, a mix of technological, policy and institutional innovations will be required. On the technology side, improvements will be linked to a combination of feed and nutrition, genetics and breeding, health and environmental management options with different appropriate systems.

At the same time, the significant climate changes are changing the physical and biological systems that have already occurred in all continents mostly observed in oceans (Rosenzweig *et al*., 2008). Smallholder, subsistence farmers, pastoralists and artisanal fisher folk will suffer in localized climatic change due snow-pack decrease, particularly in the Indo-Gangetic Plain and Sea-Level Rise (IPCC, 2007). Furthermore, changes in frequency and severity of extreme climate events have significant consequences for food production and food security (IPCC, 2007).

Investigators stated that on the future about 1.3 billion poor people, at least 90% of them are located in Asia and sub Saharan Africa and climate change will have major impacts on more than 600 million livestock dependant people. About 60% of these poor people are dependent on livestock for some part of their livelihoods (Thomas and Rangnekar, 2004). According to the reviewed results, the impacts are included the productivity of rain fed crops and forage, water availability and, distribution of important human, livestock and crop diseases. Major changes anticipated in livestock species, crops grown, feed resources and feeding strategies. Climate change could be particularly damaging countries which are dependent on rain fed agriculture and under heavy pressure from food insecurity and often famine caused by natural disasters (Deressa, 2006).

As reported by Smit *et al*. (1996) climate affects animal production in ways like the impact of changes in livestock feed-grain availability and price; impacts on livestock pastures and forage crop production and quality; changes in the distribution of livestock diseases and pests; and direct effects of weather and extreme events on animal health, growth and reproduction. Therefore, the objective of this paper is to review and summarize the issues related to climate change, effects on livestock nutrition and production.

CLIMATE CHANGE AND AGRICULTURE

The research on climate change and its implications is at present in the focus of much scientific interest. In addition to comprehensive research efforts there is an increasing need for incorporating the fact and impacts of climate change both in the area of regular education and of agricultural extension services. Since neither the present status of climate change nor its expected future development are unequivocal facts particularly in consequence of the expected influence of the international treaties on climate protection the continuous monitoring of the process, of changes and their influence are necessary both from the meteorological and from the user side (Babinszky *et al*., 2011).

Babinszky *et al*. (2011) also reported that interactions existing among the available biological, biometrical (yields) and meteorological data can be explored by using various statistical methods. The expected changes are entered into the equation as independent parameters and these can provide a basis for drawing conclusions for the future. By the practical application of the results of plant and animal growth simulation models (relying on a background of advanced computer technology), and of open-field small plot trials (open top chambers, in which for example the effects of atmospheric carbon dioxide can be studied) and climate chamber animal trials the stability of food production and sustainable agricultural production can be ensured even beside changing environmental conditions.

Livestock Production

Climate Change

Climate change refers to long term or permanent sift in climate of an area. It has the potential to affect agriculture through changes in temperature, rainfall (timing and quantity), CO_2, solar radiation and the interaction of these elements (Chrispeels, M.J.; Sadave, D.E., 1994 and Fraser, E., 2009). Agriculture can both mitigate and worsen global warming. Some of the increase in CO_2 in the atmosphere comes from the decomposition of organic matter in the soil, and much of the methane emitted into the atmosphere is caused by the decomposition of organic matter in wet soils such as rice paddies. Further, wet or anaerobic soils also lose nitrogen through de-nitrification, releasing the green house gas nitric oxide. Changes in management can reduce the release of these greenhouse gases, to sequester some the CO_2 in the atmosphere (Bardy, N.C. and R.R.Weil., 2002).

In the tropics and subtropics in general, crop yields may fall by 10 to 20% by 2050 because of warming and drying, but there are places where yield losses may be much more severe (Thornton *et al*., 2007).

The challenges for development are already considerable, and there is now general concern that climate change and increasing climate variability will compound these challenges. Developing countries are generally considered the most vulnerable to the effects of climate change than more developed countries, largely because of their often limited capacity to adapt (Thomas and Twyman, 2005). It is still the case that there is only limited knowledge about the interactions of climate with other drivers of change in agricultural systems and on broader development trends. One approach to making sense of the interactions of broad development drivers, with the added burdens of climate change, is scenario building and analysis (MEA, 2005; ILRI-FAO, 2006).

Causes of climate change

Climate change is caused by accumulation of Green House Gases (GHG) in the atmosphere which leads to global warming. Based on IPCC report some of the GHGs in the atmosphere include carbon dioxide (CO_2), methane (CH_4) and nitric oxide (N_2O). At global scale, the main cause of greenhouse gas (GHG) emissions is from carbon dioxide (70%), primarily from burning of fossil fuel (petroleum) imported from industrialized countries, while the other sources for GHG are methane and nitrous oxide caused by deforestation and agricultural activities, particularly the use of pesticides.

There are historical accounts of many centuries ago indicating that climate variability and change are not recent phenomena in Ethiopia. For example, from 1540 to 1800 AD, 26 major famines and droughts, accompanied by the spread of human and livestock, diseases had been recorded. Similarly, the great Ethiopian famine (1889-1892) is known for its epidemics and famine (Pankhurst, 1985; McKee 2008).

In the arid and semi-arid areas, drought is part of a normal cycle, and pastoralists have developed some strategies to cope with it, such as mobility, livestock species diversity, reciprocity in use of resources, territorial fluidity and social safety nets. However, according to many applied research findings, the vulnerability of pastoralists to drought is very complex and diverse. It is claimed that drought as such is not making pastoralists vulnerable but rather the increasing marginalization of their drought response mechanisms (Devereux, 2006).

Restriction on mobility of people and animals, intensification of conflicts and stricter control of cross-border trade and defective tenure policy are some of the threats (Mebratu, 2009; Yohannes and Waters-Bayer, 2002). Some authors underlined that the prolonged droughts, combined with environmental degradation and increasing sedentarisation, have led to deterioration of pastoral livelihoods (e.g. Ayelew, 2001). Others consider the frequency of drought as a crisis of pastoralism and predict that this way of life and production will not be viable; they therefore recommend sedentarisation of pastoral communities (e.g. Devereux, 2006).

Impacts of Climate Change on Livestock Nutrition and their Production

Feed resources

One of the most significant effects of climate change on livestock production is changing the animal feed resources. Although indirect effects on feed resources can have an important impact on livestock productivity, carrying capacity of rangelands, buffering ability of ecosystems and their sustainability, prices of stovers and grains, trade in feeds, changes in feeding options, greenhouse gas emissions and grazing management. Increased temperature increase lignifications of plant tissues and reduce the digestibility and degradation of plant species. This leads to reduced nutrient availability for animals and reduced livestock production, which may have impacts on food security and reduced the production of milk and meat for smallholders (Minson, 1990).

As stated by Easterling and Apps (2005) lack of appropriate physiological models that related to climate and animal physiology is limited the confidence that can be placed in predictions of impacts. It is clear, however, that warming will alter the heat exchange between animal and environment in feed intake, mortality, growth, reproduction, maintenance and productions (SCA, 1990). Sirohi and Michaelowa (2007) cited from Hahn (1999) in giving the thermal comfort zone for temperate-region adult cattle is ranged 5-15^{0}C.

Shortage of water has become globally significant over the last 40 years and accelerating conditions for 1-2 billion people (MEA, 2005). Population growth, economic development and climate change impacts the global water availability in the future. Today’s food production and environmental trends continue into the future, they will lead to crises in many parts of the world (Comprehensive Assessment, 2007).

Livestock diseases and vectors

The complexity of climate change is associated with so many factors like vectors (McDermott *et al*., 2001). Tsetse are very sensitive to environmental change, either due to climate or direct human impacts on habitat but the impacts vary in major species groups. Forest and riverine species are much more sensitive to climatic factors that savannah species while riverine species are much more adaptable to increasing human population densities than the other groups. Sleeping sickness, particularly the gambiense type, will continue, as now, to be a major problem, if concerted control efforts are not implemented. The impacts of changes in ecosystems on infectious diseases is depend on change in ecosystems, the type of land-use, disease specific transmission dynamics, and risky and susceptibility of the populations (Patz *et al*., 2005). According to Baylis and Githeko (2006) discussed that climate change may affect infectious diseases on their pathogens and higher temperatures may increase the rate of development of pathogens or parasites. Climate change-driven alterations to livestock husbandry in Africa, if they occur, could have many indirect and unpredictable impacts on infectious animal disease in the continent (Baylis and Githeko, 2006).

Biodiversity

The loss of genetic and cultural diversity in agriculture is as a result of the forces of globalization (Ehrenfeld, 2005). Animal and plant genetic resources are the ultimate nonrenewable resource; once gone, they are gone for good (Sere *et al*., 2008).

The relationships between livestock populations and the environment are complex and appear to be viewed very differently from mainstream of developed and developing countries perspectives. A recent FAO report, *Livestock's Long Shadow,* focused on the effects of livestock on the environment (Steinfeld *et al*., 2006). The "long shadow" refers to the negative effects of livestock production and marketing chains on almost all aspects of the environment; livestock production is associated with carbon dioxide, methane and nitrous oxide emissions, water depletion and soil erosion as key examples.

Land use and systems change

Report of Thornton *et al*. (2007) indicated that as temperature increases and rainfall increases or decreases (depending on location) and becomes more variable, the niches for different crops and grassland species change. For example, transitions from one crop to another, or between crops and rangelands, can occur. As temperate areas become warmer, substitution for crop species more suited for warmer climates can occur (for instance, maize in parts of Asia in places where only wheat would grow in the past). In parts of East Africa, reductions in the length of growing period are likely to lead to maize being substituted by crop species more suited to drier environments such as sorghum and millet.

Changes in species composition

Composition of species in rangelands and some managed grasslands is an important determinant factor of livestock productivity. As temperature and CO_2 levels change due to climate change, the optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes. For example, in the temperate regions and subtropics, where grasslands often contain C3 and C4 species, some species are more prominent than others in the summer, while the balance of the mix reverts in winter. Small changes in temperature alter this balance significantly and often result in changes in livestock productivity; an implication of this is that significant changes in management of the grazing system may be required to attain the production levels desired. It has also been suggested recently that the proportion of browse in rangelands will increase in the future as a result of increased growth and competition of browse species due to increased CO_2 levels (Morgan *et al*., 2007). This will have significant impacts on the types of animal species that could graze these rangelands and may alter the dietary patters of the communities' dependent from them. Legume species will also benefit from increases in CO_2 and in tropical grasslands, the mix between legumes and grasses could be altered.

Impact of Climate Change on Feed Crop Production

Most of the relevant data in literature suggests the necessity of distinguishing between the potential and the actual vegetation periods. A consequence of the higher daily mean temperatures is that the potential vegetation period will be longer. At the same time the higher temperature leads to accelerated growth and this in turn shortens the crop lifecycle, and thus the duration of the actual vegetation period is also shortened. Under such circumstances it is reasonable to either grow varieties having a longer growth season (these usually produce higher yields than varieties with a shorter growth season, and can also be stored better), or to grow after crops (Babinszky *et al.,* 2011). In this latter case the same area can be harvested twice within the same year.

Livestock Feeding Strategies in Response to Climate Change

As reported by Babinszky *et al*. (2011) climatic conditions determine the energy and nutrient metabolism of farm animals. According to relevant data climate change leads to a higher mean ambient temperature, and it may even result in extreme weather in certain parts of the World. This calls for a discussion of feeding strategies in response to climate change, including nutritional manipulation and feeding during cold and heat stress.

Livestock feeding strategies during cold stress

Animals consume more feed at low ambient temperatures in order to compensate for the increased energy requirement used in thermoregulation. From the aspect of energy requirements a cold environment is essentially the equivalent of reduced energy supply, and thus higher feed intakes and higher energy intakes can meet the extra demand of thermo-genesis. When the increased feed intake is prevented by the limitations of the animal's gastro-intestinal system, any means of boosting the dietary energy of the feed may be suitable for maintaining growth, and egg and milk production. Although increasing the dietary energy in a thermo-neutral environment is associated with the improvement of feed conversion (the amount of feed required to produce 1 kg of product), in cold ambient temperatures, however, feed conversion may become worse or in the best case does not change with the feeding of high energy density diets due to the higher use of maintenance i.e. non-productive energy. The body attempts to compensate for the excessive heat loss suffered in cold temperatures by a higher rate of heat production, and one component of this is to increase the use of maintenance energy. Heat, however, is also generated in the course of digesting and converting the dietary nutrients (the thermic effect of diet), which helps to maintain body temperature in conditions below the lower critical temperature; accordingly the feeding of diets with a high thermic effect will help the animals cope with the too cold environment. Thus for example, when high fiber diets are fermented by the colon bacteria a relatively high portion of energy is lost as heat; and the oxidation of proteins or amino acids as a form of energy producing process also produces lot of heat. Therefore, feeds containing a high percentage of fermentable fibers or excess protein increase the heat production of the animals. In practical feeding, however, protein overfeeding is not recommended either from the economical or the environmental point of view.

Livestock feeding strategies during heat stress

Since heat production after ingestion of the diet is high, farm animals reduce their feeding activity at high ambient temperatures, which bears significant consequences on their nutrient intake. The practice of feeding the daily ration in several smaller portions or during the cooler parts of the day follows from the above. Based on the previous sections other potential feeding strategies can be applied at the time of heat stress, which (i) reduce the heat production by the animals; (ii) compensate for the lower nutrient supply; and (iii) alleviate heat stress induced metabolic changes. It should be noted, however, that during severe heat stress these methods should be used in combination in order to maintain the production performance of the farm animals and the quality of their products.

RESPONSES TO CLIMATE CHANGE IMPACTS ON LIVESTOCK PRODUCTION

If the European Union target of stabilizing climate temperature increases to 2^oC above pre-industrial levels is to be met, this is likely to require stabilization of the CO_2 concentration below 450 ppm. This is certainly possible, and some see this as an economically attractive goal (Stern, 2006). There is a great variety of possible adaptive responses including:-

- ✓ Micro-level adaptation options including farm production adjustments such as diversification and intensification of crop and livestock production; changing land use and irrigation; and altering the timing of operations.
- ✓ Income-related responses that are potentially effective adaptation measures to climate change, such as more drought-tolerant crops, livestock and flood insurance schemes, credit schemes and income diversification opportunities.
- ✓ Institutional changes, including pricing policy adjustments such as the removal or putting in place of subsidies, the development of income stabilization options, agricultural policy including agricultural support and insurance programs; improvements in (particularly local) agricultural markets and the promotion of inter-regional trade in agriculture.
- ✓ Technological developments, such as the development and promotion of new crop varieties and livestock feeds, improvements in water and soil management, and improved animal health technology (Kurukulasuriya and Rosenthal, 2003).

When dealing with issues of climate change, it is important to understand the different terms used as "packages" in understanding the system. Accordingly, "climate variability" is the fluctuation in climatic parameters from the normal or baseline values, whereas "climate change" is a change in the long-term mean value of a particular climate parameter (Abebe, 2008).

> "Vulnerability" is defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2007).

According to Burton *et al.* (1993), the term "adaptation measures" covers eight categories; bearing losses (doing nothing), sharing losses, modifying the threat and thus preventing effects, changing use, changing location, accessing new research based technologies, disseminating knowledge through education to change behavior, and restoration. Others have classified the different forms of adaptation as anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC, 2001).

Mitigation Options

Mitigation potential is using improved crop and grazing land management to increase soil carbon storage, and improved livestock and manure management to reduce methane emissions (Steinfeld *et al*., 2006). Considerable amounts of carbon can be sequestered from improved management in grasslands. Such management would include conversion of cropland to grassland, reduction in grazing intensity and biomass burning, improving degraded lands and reducing erosion and changes in species mix. In terms of methane mitigation in pastoral systems, probably the only effective way is reducing livestock numbers. Mitigation options which provide multiple environmental benefits should be favored when considering ways in which the livestock sector can reduce its influence on climate change. For example, pasture and grassland-based livestock systems can simultaneously contribute to carbon sequestration, biodiversity protection, water storage, as well as to the prevention of fires, floods and erosion. In addition, mitigation options will need to consider regional and local specificities and some assessed for their impact on animal health and welfare (Animal Science Report, 2007).

FUTURE DIRECTIONS OF DEVELOPMENT OF LIVESTOCK PRODUCTION

Developed countries are facing the trend of increased production of food and decreasing consumers on the market by permanent decrease of prices. Based on existing situation in livestock production, as well as previous domestic and international practice, a quick and efficient transformation of livestock production is necessary in order to be competitive on the international market (Aleksic *et al*., 2005; Aleksic *et al*., 2007). It is necessary to improve the production potential of certain species and breeds of domestic animals using genetic-selection measures as the future direction of the globe. By application of new technologies in livestock production and processing a higher level of production and improved quality of livestock products will be ensured. By the introduction of new technologies the efficiency and competitiveness of this production will be improved on the global market (Petrovic *et al*., 2004).

Future livestock production will be based on private farm production with market orientation. By specializing production higher profitability will be ensured, and in this way competitiveness on foreign market. It is necessary to associate market oriented producers into associations which would contribute to more rational utilization of available assets. Specialized farms for production of milk have objective to produce high quality milk which is in compliance with standards in regard to % of milk fat, % of milk proteins and especially bacteriological safety of milk. On specialized farms a system of certification and registration should be introduced since in this way the value of product is increased (Petrovic *et al*., 2002, 2003).

CONCULISSION

Livestock systems in developing countries are characterized by rapid change as a result of factors like population growth, increases in the demand for livestock products as income rise and urbanization. Climate change is adding to the considerable and existing development challenges. Climate can affect livestock both directly and indirectly. Direct effects by air temperature, humidity, wind speed and other climate factors influence animal performance such as growth, milk production, wool production and reproduction. In addition to direct effects it also affects the quantity and quality of feedstuffs like pasture, forage and grain, and the severity and distribution of livestock diseases and parasites. Changes in feed resources availability are one of the most obvious and significant effects of climate change on livestock production. Species composition in rangelands and some managed grasslands is an important determinant factor of livestock productivity.

Climate changes have severe impacts in many parts of the tropics and Sub-tropics. Despite, the importance of livestock to poor people and the magnitude of the changes are likely to be failed livestock systems. But little is known about the interactions of climate and increasing climate variability with other drivers of change in livestock systems and development trends. Effective adaptation and adoption of new technologies, which contribute both to mitigation and the long term viability of farming, will require investments and planning efforts capacity of individual farms. Public authorities will have a role to play in supporting and facilitating climate change adaptation policies. In order to continue, livestock industries need to anticipate these changes, be prepared for uncertainty and develop adaption strategies.

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