Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.7, No.8, 2017

Impacts of Climate Change on Livestock Production: A Review

Shambel Bekele
Department of Agricultural Economics, College of Agriculture, Wolaita Sodo University, Box 138, Ethiopia

Abstract
This review was conducted to assess the effect of climate change on livestock production. The climate change especially global warming may highly influence production performance of farm animals throughout the world. Among the environmental variable that affect animals heat stress seems to be the intriguing factor making animal production challenging in many geographical locations in the world. changes in climatic factors such as temperature, precipitation and the frequency and severity of extreme events like droughts directly affected livestock yields. All animals have a range of ambient environmental temperature termed as thermo neutral zone and temperature above or below this thermo neutral range of the animal create stress condition in animals. A thermal environment is a major factor that affects milk production in dairy cow especially on animals of high genetic merit. Milk yield decline by 0.2kgper unit increase thermal humidity index (THI) when it exceeded 72.The increase in milk yield increase sensitivity of animals to thermal stress and decline the threshold temperature at which milk losses occur. The mid lactating dairy cows were the most heat sensitive compared to their early and late lactating counterparts. In addition mid lactating dairy cows showed a higher decline in milk production (-38%) when the animals were exposed to heat. Animals can adapt the hot environment, however the response mechanism are helpful for survival but are detrimental to productive and reproductive performances. Reproduction is normally luxurious phenomenon and appropriate when the animal is in right homeostasis. Heat stress due to high ambient temperature accompanied with excess humidity cause infertility in most of the farm species and adverse effect on reproductive performance of farm animals. Climate change has a direct impact on the growth of palatable grass species and the regeneration of fodder species in pasture and forest fodder is decreasing because of less rainfall leading to a shortage in diversity and quality of livestock fodder. This has led to a decrease in livestock population which has further affected production of milk, milk products and meat. The drought also affected livestock by drying wetlands, pasture land, water resources, streams and decreasing availability of drinking water for livestock. Temperature increase led to outbreak of new born diseases and scarcity of fodder led to change in livestock pattern Changes in rainfall and temperature regimes may affect both the distribution and abundance of disease causing vectors, as can changes in the frequency of extreme events. Higher temperature resulting from climate change may increase the rate of development of certain pathogen or parasites that have one or more life cycle stages outside their animal host. This may shorten generation times and possible increase the total number of generations per year leading to higher pathogen or parasite population size. Therefore to adapt climate change farmers from developing countries implement different adaptation strategies such as breeding locally adapted livestock species, diversifying livestock types, proper resource management practices and alternative feed production technologies.

1. INTRODUCTION

World population is expected to grow from 5.5 billion now to about 8 billion in the year 2020. As a result of this, the importance of livestock production can be expected to increase over the next decades (World Bank, 2002). Extensive livestock production is practiced in arid and semi-arid areas all over the world (McCarthy, 2001). Livestock is the sole source of livelihood for at least 20 million pastoral families and an important source of income for at least 200 million stalk holder farmer families in Asia, Africa and Latin America (World Bank, 2002). Extensive livestock production still provides a livelihood for a large number of people in marginal areas of sub-Saharan Africa. Yet, few advances of any sort have been made over the last three decades, and these areas remain characterized by low productivity and extreme vulnerability to climatic fluctuations (McCarthy, 2001).

The relationship between the livestock sector and climate change is much more complex and generally overlooked (Reilly et al., 1996; McCarthy et al., 2001; Seo and Mendelsohn, 2007) yet livestock plays a crucial role in poverty reduction and rural development in Africa (Nin et al., 2007; Seo and Mendelsohn, 2008; IUCN, 2010). Livestock production in African rural communities largely depends on natural resources specifically pasture and water (Seo and Mendelsohn, 2008; IUCN, 2010). Climate change will therefore affect livestock production directly, through impacts on livestock performance and indirectly through impacts on the environment (Adams et al., 1999; McCarthy et al., 2001; Calvosa et al., 2010).

Ethiopia is a country of more than 1.1 million square kilometers, located in the Horn of Africa. With more than 80 million inhabitants, Ethiopia is the second-most populous nation in Africa after Nigeria. The country has a sustained record of strong economic growth, which, during the last decade, contributed significantly to the sustainable development agenda: GDP has nearly tripled since 1992 with a corresponding reduction in head count poverty from 56 percent in 1992 to 29.5 percent in 2011 (MoFED, 2012). Ethiopia has

witnessed double digit growth (i.e., 11.2% growth in real GDP) (MoFED, 2010). This growth performance effectively surpasses the 7% annual rate required for attaining the MDG of halving poverty by 2015 (ADBG, 2010).

The livestock population in Ethiopia that reaches more than 80 million heads is the largest in Africa and the 10th in the world. It constitutes a large component of the Ethiopian agricultural sector and is well integrated with the farming systems found in the highlands and provides the sole means of subsistence for the nomadic pastoralists in the lowlands (FDRE, 2001). In pastoral and agro-pastoral systems, livestock are key assets for people, providing multiple economic, social, and risk management functions. The impacts that climate change will bring about are expected to exacerbate the vulnerability of livestock systems and to reinforce existing factors that are simultaneously affecting livestock production systems such as rapid population and economic growth, increased demand for food (including livestock) and products, increased conflict over scarce resources (i.e. land tenure, water, bio fuels etc). For rural communities, losing livestock assets might lead to the collapse into chronic poverty with long-term effects on their livelihood (IFAD, 2011).

2. Livestock Production and Climate Change

Livestock systems directly support the livelihoods of at least 600 million smallholder farmers, mostly in sub-Saharan Africa and South Asia (Thornton, 2010). It is a rapidly-growing agricultural subsector, and its share of agricultural GDP is 33 percent and rising, driven by population growth, urbanization and increasing incomes in developing countries. Demand for all livestock products is expected to nearly double in sub-Saharan Africa and South Asia by 2050 (Alexandratos and Bruinsma, 2012). On the other hand, changes in climate over the last 30 years have already reduced global agricultural production in the range 1-5 % per decade. Unlike for cropping systems, there is currently only limited evidence for recent impacts on livestock systems (Porter et al., 2014). For future impacts, projections indicate widespread negative impacts on forage quality and thus on livestock productivity in both high and low latitudes. In much of Africa, where many millions of smallholder farmers on livestock-based systems, this will have cascading impacts on incomes and food security. The negative effects of increased temperature on feed intake, reproduction and performance across the range of livestock species are reasonably well understood (Porter et al., 2014). There is much less certainty concerning the aggregated impacts of climate change on livestock systems with and without adaptation. Livestock are a critically important risk management resource; for about 170 million poor people in sub-Saharan Africa, livestock may be one of their very few assets (Robinson et al., 2010).

Literature is pointing to the fact that climate change does affect livestock production and livestock systems. For instance, Thornton (2010) concludes that the biggest impacts of climate change are going to be seen in livestock and mixed systems in developing countries where people are already highly vulnerable. The need to adapt to climate change and to mitigate greenhouse emissions will undoubtedly add to the costs of production in different places and the projected growth in bio-fuels may have substantial additional impacts on competition for land and on food security. According to Naqvi and Sejian (2011) due to the fact that the livestock production system is sensitive to climate change and at the same time itself a contributor to the phenomenon, climate change has the potential to be an increasingly formidable challenge to the development of the livestock sector, and that responding to the challenge of climate change requires formulation of appropriate adaptation and mitigation options for the sector. In pastoral and agro-pastoral systems, livestock are key assets for people, providing multiple economic, social, and risk management functions. The impacts that climate change will bring about are expected to exacerbate the vulnerability of livestock systems and to reinforce existing factors that are simultaneously affecting livestock production systems such as rapid population and economic growth, increased demand for food (including livestock) and products, increased conflict over scarce resources (i.e. land tenure, water, bio fuels etc). For rural communities, losing livestock assets might lead to the collapse into chronic poverty with long-term effects on their livelihood (IFAD, 2011). In Africa, agriculture is negatively affected by climate change (Deressa *et al*., 2009). A study by Apata *et al.* (2009) concluded that Africa is generally a continent most vulnerable to climate change. This is due to the erratic and unreliable weather which calls for farmers to be aware of the effects that this weather pattern might have on farming in the immediate-term and long-term production periods. It also calls for adaptation measures that should be employed to curb the negative effects of climate change especially on livestock production. Thornton *et al*. (2002) forecasted that climate change was to bring about shortage of water which could reduce livestock feed and pasture yield.

2.1 Effect of Climate change and livestock production in Ethiopia

2.1.1 Milk production

Livestock and climate change have a close relationship (Iqubal, 2013). The spatial distribution and availability of pasture and water are highly dependent on the pattern and availability of rainfall (Aklilu et al., 2013). Changes in the patterns of rainfall and ranges of temperature affect feed availability, grazing ranges, feed quality, weed, pest and disease incidence (Coffey, 2008). Thus, changes in climatic factors such as temperature, precipitation and

the frequency and severity of extreme events like droughts directly affected livestock yields (Adams et al., 1998). Climatic factors or seasonal changes greatly influence the behavior of animals due to neuroendocrine response to climatic elements, consequently affecting production and health of animals (Shelton, 2000; Sejian *et al.,* 2010a; Baumgard *et al.,* 2012). Climate change is a major threat to the viability and sustainability of livestock production systems in many regions of the world (Gaughan *et al.,* 2009). High production animals are subjected to greater influence by climatic factors, particularly those rose under tropical conditions, due to high air temperatures and relative humidity (Gaughan *et al.,* 2008; Martello *et al.,* 2010). Parons et al. (2001) have argued that high temperatures may reduce feed intake, lower milk production, lead to energy deficits that may lower cow fertility, fitness and longevity. Modeling work by Chase (2006) using the Cornell Net Carbohydrate and Protein System model suggested that the maintenance energy requirements of a dairy cow weighing 635kg yielding 36kg of milk per day may be increased by 22% at 32 ^{0}c compared with the energy requirements at 16 ^{0}c. For the same temperature increase, Thornton et al. (2008) predicted a dry matter intake decrease by 18% and milk decrease by 32%

2.1.2 Impact on Feeds Resources

One of the most important effects of climate change on livestock production is changing the animal feed resources. Abate (2009) found that drought and delay in the onset of rain led to poor regeneration of grass, water shortage and heat stress on livestock. It further reports that the drought and delay of rainfall led to increased mortality of livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures. Digambar (2011) reported that as a result of severe drought, there was direct impact on the growth of palatable grass species and that regeneration of fodder species in pasture and forest fodder is decreasing because of less rainfall leading to a shortage in diversity and quality of livestock fodder. This has led to a decrease in livestock population which has further affected production of milk, milk products and meat. The drought also affected livestock by drying wetlands, pasture land, water resources, streams and decreasing availability of drinking water for livestock. Changes in temperature, rainfall regime and CO2 levels will affect grassland productivity and species composition and dynamics, resulting in changes in animal diets and possibly reduced nutrient availability for animals (McKeon et al., 2009; Izaurralde et al., 2011).

2.1.3 Impact on water source

Morton (2007) and Madzwamuse (2010) believed that climate change mostly affected developing countries, in particular among populations referred to as subsistence or smallholder farmers. Furthermore, small farm sizes, low technology and low capitalization are likely to increase vulnerability of livestock production. Water supplies from rivers, lakes and rainfall are threatened by climate change which reduces water availability for livestock production. De Wit and Stankiewicz (2006) calculated that decreases in perennial drainage would significantly affect present surface water access across 25 per cent of Africa by the end of this century.

2.1.4 Effects climate change on Livestock Reproduction

Reproductive functions of livestock are vulnerable to climate changes and both female and males are affected adversely. Heat stress also negatively affects reproductive function (Amundson *et al.,* 2006; Sprott *et al.,* 2001). The climate change scenario due to rise in temperature and higher intensity of radiant heat load will affect reproductive rhythm via hypothalamo- hypophyseal–ovarian axis. The main factor regulating ovarian activity is GnRH from hypothalamus and the gonadotropins i.e. FSH and LH from anterior pituitary gland (Madan and Prakash, 2007).

2.2.5 Climate change and 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 are 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

According to the FAO (2007) among the direct effects of climate change are high temperatures and changes in rainfall patterns, translating in an increased spread of existing vector-borne diseases and macro parasites of animals as well as the emergence and spread of new diseases. In some areas, climate change may also cause new transmission models and these effects will be felt by both developed and developing countries, but developing countries will be most impacted because of their lack of resources, knowledge, veterinarian and extension services and research technology development. Some of the indirect effects will be brought about by changes in feed resources linked to the carrying capacity of rangelands, the buffering abilities of ecosystems, increased desertification processes, increased scarcity of water resources, lower production of grain and so on.

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Zelalem et al. (2009) reported that animal had died during severe droughts. The southern lowlands of Ethiopia are among the country's vulnerable regions to the impacts of climate change. Recurrent droughts, flash floods, diseases, and pests are among the prevalent disaster risks related to climate change in the area. Pastoral communities are the major victims of these disaster risks (Aklilu et al., 2013). According to ONRS (2011), climate change and variability in Ethiopia poses particular risks to poor farmers and pastoralists who have an immediate daily dependence on climate sensitive livelihoods and natural resources. In addition to the physiological effects of higher temperatures on individual animals, loss of animals as a result of droughts and floods, or disease epidemics related to climate change may thus increase. Indirect effects may be felt via ecosystem changes that alter the distribution of animal diseases or the supply of feed. As reported by ANRS (2010) all pastoral regions in Ethiopia are highly prone to the adverse impacts of climate change, while the problem is more prevalent in the North Eastern lowlands of the country

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). Their importance is critical, but the complexity of ecosystems means that it is extremely difficult to assess the impacts of climate change on biodiversity. Given that this change is very rapidly in the future, it makes much sense for any consideration to emphasize conservation as well as mitigation activities on biodiversity aspects (IPCC, 2002). Pastoralists and smallholders are the guardians of much of the world's livestock genetic resources (CGRFA, 2007). According to FAO (2007) and CGRFA (2007) indicated that about 20% of animal genetic resource breeds are now classified as at risk and that almost one breed per month is becoming extinct. Much of this genetic erosion is attributed to global livestock production practices and the increasing marginalization of traditional production systems and associated local breeds. The drivers of these changes in developing countries depend on the system (Seré et al., 2008).

A study conducted in Yabelo, Borana Zone in southern Ethiopia indicated that households have experienced a severe reduction in their assets, with an average reduction of 80% in livestock holdings from their peak holdings over the past ten years mainly by climate change (Stark et al., 2011). Additional study indicated that the decline in the number of livestock species namely cattle, goats, sheep and donkey kept by pastoralists of Moyale and Dillo areas was remarkable in which most of the animals were reported to have died during severe droughts, which occurred in 2005 and 2008 (Zelalem et al., 2009). Again, the decreases in number of livestock in Arba Minch district is directly or indirectly interlinked and related to climate change (Iqubal, 2013). Livestock health problems exacerbated by climate change such as the high prevalence of Trypanosomiasis in the lowlands are among the challenges that affect livestock fertility (Habtamu, 2012). Thus, it is agreed that livestock productivity is highly affected by climate change. Livestock productivity is affected most severely under the Ethiopia dry scenario, in which the ratio between future and baseline productivity falls to a low value of approximately 0.70 in the moisture reliable humid lowland zone, or a 30% decline in productivity. Under each scenario, there is a downward trend in productivity over the 2001 to 2050 period (Robinson et al., 2013).

2.1.6 Indirect Impacts (Live Stock / Human Health)

In addition to the direct impacts of climatic change on many aspects of livestock and livestock systems, there are various indirect impacts that can be expected to impinge on livestock keepers. As with livestock diseases, the changes wrought by climate change on infectious disease burdens may be extremely complex on human health and sensitivity to ecological change (Patz et al, 2005). Impacts of climate change on malaria distribution are likely to be largest in Africa and Asia (Van Lieshout et al., 2004). Effects (via changes in crop, livestock practices) on distribution and impact of malaria in many systems and schistosomiasis and lymphatic filariasis in irrigated systems (Patz *et al*., 2005). MacDonald and Simon (2011) also reported that farmers living in Ethiopia's semi-arid and arid lowlands that have less diversified assets and are heavily reliant on rain-fed agriculture are, along with their livestock, particularly vulnerable to climate change are a victims.

2.2 Adaptations of climate change

Global environmental changes and increase climatic variability demands adaptation options and ways to minimize risks (Getachcew, 2010). Increased impacts of climate change and variability make the rural agrarian people to practice various adaptation and coping strategies. These include mainly indigenous knowledge and wide variety of skills developed outside the formal education over a long period of time among the rural communities (Mongi et al., 2010). Rural producers of arid and semi-arid areas where there is recurrent drought

and unreliable rainfall have learned to cope with the existed situations. However, in the course of widespread poverty, highly unpredictable rainfall pattern and frequent extreme events coupled with increasing population and fragile resources, these coping strategies are becoming insufficient (Getachew, 2010).

Improving local genetics through cross breeding with heat and disease tolerant breeds. If climate change is faster than natural selection the risk of survival and adaptation of the new breed becomes greater (Hoffmann, 2008). 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 *(Ibid)*. 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.

3. Conclusion and recommendation

Livestock production is under threat from the changing climate. This is because the natural pastures which a majority of the livestock owners rely on for feeding their animals are deteriorating in quality and the amount of fodder available. In addition to that, water sources available are not reliable as they sometimes dry up due to high temperatures and shortage of rainfall. Livestock has been lost due to among other factors excessive heat, shortage of water, feed and unknown diseases. Climate change has an impact on livestock production in the world in general and developing country in particular. Therefore to adapt climate change farmers from developing countries implement different adaptation strategies such as breeding locally adapted livestock species, diversifying livestock types, proper resource management practices and alternative feed production technologies. Identifying and strengthening local breeds that have adapted to local climatic stress and feed sources, improving local genetics through cross-breeding with heat and disease tolerant breeds. 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. Providing natural (low cost) shade instead of high cost air conditioning is more suitable for rural poor producers. 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. In addition to this the government of developing countries should come up with appropriate intervention programmes. Such programmes may include construction of larger earth dams and water canals to ensure that there is no shortage of drinking water for the animals.

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