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THREATS AND CHALLENGES OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION: IMPLICATIONS ON ADAPTATION AND MITIGATION STRATEGIES FOCUSING ON ETHIOPIA: A REVIEW

Ibrahim Mehdi

College of Dryland Agriculture and Natural Resources, Department of Animal and Range Sciences, Jigjiga University, Ethiopia;

email: ibromehdi2013@gmail.com

ABSTRACT

Climate change and extreme weather events affect livestock production and the direct impact of anthropogenic climate change has been documented extensively over the past years. Most of the livestock owners in the country perceive there is a climate change impacts on the livestock production, productivity and health. Climate change is characterized as a substantial change in the climate variables such as temperature, precipitation, and wind patterns. Climate change will have far-reaching consequences on livestock production and health particularly in vulnerable parts of the world where it is vital for nutrition and livelihood. The major impacts on livestock production include: the feed shortage, shortage of water, losses of livestock genetic resources, reduced productivity, and decreased mature weight or longer time to reach mature weight. Again, it may cause the loss of body condition, reduced milk production and poor reproductive performance on mature animals. Furthermore, the higher the temperature resulting from the climate change may increase the rate of development of certain pathogens or parasites that have one or more life cycle stages outside their animal host. Moreover, it is found that climate change will affects livestock health through several pathways, which are effects on pathogens, hosts, vectors such as changes in the rainfall and temperature regimes can affect both the distribution and the abundance of diseases vectors, and affects on epidemiology such as altered transmission rates between hosts. There are ways to combat the climate change, namely, mitigation and adaptation. Mitigation strategies are the management practices such as stocking rate, level and type of feed supplementation, the forage types, genetic selection for improved feed efficiency, and feed additives aimed at decreasing climate threats. While an adaptation to climate change is an adjustment made to human, ecological and/or physical system in response to vulnerability. Thus, the review paper was explore the impacts of the climate changes on the livestock production, and systematic documentation of the knowledges available on adaptation and mitigation strategies on the livestock sector.

Keywords: Adaptation, Climate change, Climate threat, Livestock production, Mitigation

1. Introduction

Climate change and food security are two emerging issues faced by almost every nation. Livestock farming has become unsustainable way of meeting the food demands, as well as providing a livelihood, for one billion poor people around the globe. Unfortunately, the stability of livestock production is hampered by climate change [1], with direct effects including an increase in the incidence of heat stress, and indirectly as the non-availability of feed and water for animals. Climate change is likely to pose the new challenges in the livestock production sector, especially among the poor resources farmers. Climate change refers to the long-term shifts in temperatures and weather patterns. Climate change has been a significant variation of the mean state of climate-relevant variables such as temperature, precipitation, and wind over some time, mostly to be taken as over 30 years [2]. Climate change is a major threat facing humanity.

According to Intergovernmental Panel on Climate Change, [2] climate change has led to an increase in the global average air and ocean temperatures, widespread melting of snow and ice and rising global mean sea level. The projected changes in temperature and rainfall patterns as the consequential impacts on water availability, disease, pests, floods and perpetual droughts are likely to have devastating consequences for the agricultural production and the food

security. Intergovernmental Panel on Climate Change predicted that the average global surface temperatures will increase by 2.8°C on average, ranging from 1.8-4.0°C. Such changes have become one of the pressing problems on a wide variety of the socio-economic activities worldwide. The vulnerability to climate changes in developing countries is mainly due to their reliance on rainfed agriculture.

Climate change and variability becomes the biggest threats to agricultural production for the current and future in developing countries. It influences agricultural activities by an increasing temperature that affects agricultural water demand and crop productivity and increases the frequency and intensity of climate shocks, such as the number of hot days per year, heat waves and drought events. Agriculture is a highly climate-sensitive sector, and it is already affected by climate variability. Agriculture is the most vulnerable and sensitive sectors despite the technological advances achieved in the latter half of 20th century. Extensive livestock production is practiced in the arid and semi-arid areas all over the world [3]. 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 stalkholder farmer families in Asia, Africa and Latin America. Extensive livestock production still provides a livelihood for a large number of the people in the marginal areas of sub-

Saharan Africa. Globally, livestock occupy about 26% of the ice-free land with one-third of the cropland being used for feed production [4].

The livestock production generates nearly 40% of the global agricultural gross domestic product (GDP). Livestock provide 33% of the global protein and 17% of the global calories consumed. The production creates substantial employment opportunities for rural households [5, 6]. Moreover, the livestock are a major provider of food, nutritional security, livelihood, and income in developing countries[7]. Due to the population growth and increasing income and urbanization, the demand for the livestock products is growing rapidly. While, the livestock production is facing increasing pressure from climate change, such as increasing temperatures, more variable precipitation patterns, more frequent extreme events, and increasing CO₂ concentrations [8]. The livestock sector will be increasingly challenging with the scarcity of the resources crucial for the production, particularly land and water. The climate change leads to the reduction in livestock productivity directly by depressing animals adaptive response mechanisms, altering the spread and prevalence of diseases, causing heat stress and indirectly by compromising the availability of feed and forage quality. Therefore, this paper attempts to review the available knowledges on the impacts of climate change, adaptation and mitigation strategies on production and productivity of the livestock.

2. Climate Change Impacts on Livestock Production and Productivity

Climate change, exhibiting higher temperatures, increasing precipitation variation, and more frequent extremes. It driven by increasing CO₂ concentrations. Such changes have been alter the livestock and associated feed production. When the temperature rise above thermal comfort zone, extra energy is required to maintain thermoregulation and the production processes become less effective[9]. Climate change could impact the amount and quality of produce, reliability of production, and the natural resource base on which livestock production depends. Climate is an important factor of agricultural productivity. The changing climate is expected to have severe impact on livestock production systems across the world. World demand for animal protein will rise as the population and real incomes increase and eating habits change. Therefore, animal production plays and will continue to play a key role in food supply.

Global climate change is expected to alter temperature, precipitation, atmospheric carbon dioxide (CO₂) levels, and water availability in ways that will affect the productivity of crop and livestock systems[10]. For livestock systems, climate change could affect the costs and returns of production by altering the thermal environment of animals, thereby

affecting animal health, reproduction, and efficiency by which the livestock convert feed into retained products (meat, milk, wool, and egg). Climatic changes could increase thermal stress for animals and thereby reduce animal production and profitability by lowering feed efficiency, milk production, and reproduction rates[11]. Climate changes could impact the economic viability of livestock production systems worldwide. Environmental stress reduces the productivity and health of livestock resulting in significant economic losses. Heat stress affects animal performance and productivity of beef and dairy cows in all phases of production. The outcomes include decreased growth, reduced reproduction, increased susceptibility to diseases, and ultimately delayed initiation of lactation.

2.1 Impact of climate change on livestock growth

It is known that livestock that are exposed to high ambient temperatures augment the efforts to dissipate the body heat, resulting in the increase of the respiration rate, body temperature, and consumption of water and a decline in feed intake[12, 13]. Apart from the feed intake, the feed conversion also significantly decreases after exposure to heat stress[14]. Exposure of the animal to a high environmental temperature stimulates the peripheral thermal receptors to transmit suppressive nerve impulses to the appetite center in the hypothalamus and thereby causes a decrease in a feed intake[12]. The decrease in feed intake could be due to

the adaptive mechanism of animal to produce less body heat. The growth, the increase in the live body mass or cell multiplication, is controlled both genetically and environmentally[12]. Elevated ambient temperature is considered to be one of the environmental factors influencing growth and the livestock average daily weight gain[15, 16]. The reason for the effects of elevated ambient temperature on growth reduction could be due to the decrease in anabolic activity and the increase in tissue catabolism[12]. The increase in tissue catabolism could be attributed to the increase in catecholamines and glucocorticoids after exposure to heat stress in livestock.

2.2 Impact of climate change on livestock feed intake

Reduced feed intake is the response to high environmental temperatures. Ruminants experienced reduced appetite, gut motility and rumination under increased heat stress [17]. For instance, lactating dairy cows exhibit a reduction in feed intake as ambient temperatures rise above 25–26°C and show more rapid declines above 30°C [18]. The reduction in feed intake causes decreased feed conversion efficiency and daily weight gain [19]. All the livestock types, heat-stress decreased feed intake leads to decreased milk, meat, and egg production, which in turn leads to further sectoral losses.

2.3 Impact of climate change on livestock productivity

One of the direct impacts on the livestock is on the milk yield due to neuroendocrine response to climate change. Increase in number and frequency of stressful days will impact yield and production of cattle and buffalo. High-producing dairy cows generate more metabolic heat, thus become more vulnerable to heat stress than low-producing ones. Consequently, when metabolic heat production increases in conjunction with heat stress, milk production declines rapidly. Under heat stress, dairy cows reduce feed dry matter intake and which approximately 35% of the decrease in milk production [20]. As high-producing dairy cows are larger and emit more metabolic heat than lower-producing breeds, the most productive breeds exhibit the more sensitivity to heat stress [6]. As a consequence, milk production declines as heat-stress-caused metabolic heat production increases [17]. In addition to milk production, hot and humid environments also affect milk composition. Ravagnolo et al. [21], and Gorniak [22] have indicated that lactating cows start to suffer from heat stress at a temperature–humidity index of 72 and above, milk protein and milk fat content declines as the index increases.

Meat production has been affected by heat stress for all commercial livestock types[23]. Heat-stressed ruminants exhibit reduced body size, carcass weight, and fat thickness and lower meat quality [24]. Small ruminants, goats and sheep, have been more adapted to a hot and humid environment [25]. However, feedlot cattle have vulnerable due to their being raised

with greater exposure to rough radiant surfaces and fed high-energy diet [26]. Livestock exposed to heat stress increase energy expenditure to maintain thermoneutral conditions at the expense of growth [27]. Heat-stressed broilers exhibit reduced weight gain, feed conversion rates, protein concentration, and breast muscle weight [28].

2.4 Impact of climate change on livestock reproduction

Heat stress affects the reproduction for both sexes. For females, heat stress reduces estrous period and fertility while increasing the incidence of anestrus and embryonic death. For males, there are declines in semen quality, testicular volume, and quantity of fertile sperm. Significant seasonal differences in reproductive performance in both sexes have been reported [29]. Heat stress affects birds may exhibit a difference in performance compared to mammals. Males are reported to be more sensitive to heat-related infertility than females.

2.5 impact of climate change on livestock health

Heat stress can negatively affect the immune functions via cell-mediated and humoral immune responses [30]. As a result, periods of hot weather can cause livestock to be more vulnerable to diseases and raise the incidence of certain diseases (such as mastitis), leading to an increased potential of morbidity and death [31]. Simultaneously, increased temperature and altered precipitation may accelerate the incidence of pathogens and parasites.

This would affect the distribution and abundance of vector-borne pests and introduce the new diseases [32]. Mortality is an important heat stress impact that has significant associated economic loss. Hot and humid weather has been found to be more life threatening to cows and hogs compared to hot but dry conditions, and temperature higher than 37.7°C with over 50% humidity was to be detrimental [33].

2.6 Impact of climate change on quality and quantity of livestock feed resources

Increases in atmospheric CO₂ and temperature are alter forage quantity and quality, with the magnitude dependent on the livestock system [34] location, and species. Precipitation patterns and extreme climate events are also influential, with the main impacts being production variation. In terms of grassland and pasture, increases in average temperature bring significant changes in pasture composition, patterns, and biome distribution. Changes in precipitation patterns and more frequent droughts may lead to shorter pasture growing periods.

Some research has indicated that changes in temperature, CO₂ levels, and nitrogen deposition decrease the primary production in pasture [35], while some argue that higher temperatures favor grasses over forbs and legumes. Forage quality may also increase due to an increase in nonstructural carbohydrates resulting from elevated CO₂ level [36]. However, quality may also decrease since rising temperatures can increase lignin within plant tissues and therefore reduce

digestibility [37]. Lee et al. [38] suggest that increasing temperature reduces forage nutritive values and correspondingly lead to higher methane production. Forages of higher digestibility supply more energy per unit dry matter (DM) consumed.

2.7 impact of climate change on the livestock Water resources

Water resources in particular are the sector which is highly vulnerable to climate change. Climate change and variability have the potential to impact negatively on the water availability and access to and demand for water in most countries. Climate change will have far-reaching consequences for livestock production, mainly arising from its impact on rainfall patterns which later determine the quantity and quality of grassland and rangeland productivity[39]. Overall, the net impact of climate change on water resources and freshwater ecosystems will be negative due to diminished quantity and quality of available water[40]. Increasing heat stress as a result of climate change, significantly increase water requirements for livestock. Climate change can often exacerbate water problems, for instance, where climate change has led to overgrazing in some areas which then suffer rapid runoff and flooding.

Climate change can aggravate water problem in hot semiarid areas leading to overgrazing which ultimately culminate in rapid runoff in these areas leading to flooding. Frequent droughts might be a cause of concern in terms of disease and parasites distribution and transmission, apart from the physical losses to livestock.

As climate change, all water resources will dry up due to extreme temperatures, and livestock production will be severely hampered[41]. Further, the drying of water resources will create a situation where livestock need to walk long distances in search of water, creating an additional stress. Climate change is projected to change water availability and water usage in animal production. Rising temperatures are likely to increase per animal and per land area of the animal water consumption and irrigation water use [42]. Competition for water between livestock, crops, and non-agricultural uses will increase in coming decades, and it requires more efficient production systems to address water scarcity issue [43].

2.8 Impact of Climate Change on Biodiversity

Climate change may continue alarmingly; cheap energy and other resources, including fresh water will diminish and disappear at an accelerating rate; agricultural and farm communities will deteriorate further while we loss more genetic diversity among crops and farm animals; biodiversity will decline faster as terrestrial and aquatic ecosystem are damaged; harmful exotic species will become ever more numerous. FAO, [44] report on animal genetic resources indicates that 20% of the reported breed are now classified as at risk and that almost one breed per month is becoming extinct. For developing regions, the proportion mammalian species at risk is lower (7-10%) but 60 to 70% of mammals are classified as being of unknown risk status.

3. Measures to Combat the Climate Change

The two central ideas in dealing with to combat the climate change, namely, mitigation and adaptation. Mitigation is a response strategy to the global climate change, and it can be explained as measures that reduce the amount of emissions (abatement) or enhance the absorption capacity of the greenhouse gases (sequestration). Mitigation strategies are the management practices (such as stocking rate, level and type of feed supplementation), forage types, genetic selection for improved feed efficiency, and feed additives aimed at decreasing methane emissions. Adaptation to climate change is an adjustment made to human, ecological or physical system in response to vulnerability [45, 46]. On the other hand,[47] revealed that climate change adaptation through the modification or improvement of agricultural practices will be imperative to continue meeting the growing food demands of the modern society.

3.1 Mitigation

The most successful ways to minimize the environmental impact is to increase productivity and thus decrease the GHG emissions per unit of animal protein produced[48]. Electrolyte balance in beef cows and feedlot cattle, but without the effect of climate[49]. The main strategies for reducing GHG emissions involve: improving productive and reproductive indexes (reducing age on slaughter, age at first calving and calving

interval); reducing the quantity of replacement animals; increasing the longevity of reproductive cows; improving the genetic merit of both the animals and the forage plants; utilizing additives and supplements; improving food conversion efficiency; optimizing the supply of good quality water; improving management of both animals and pasture; enhancing animal health (control of parasites, diseases and vaccines); and looking to improve animal well-being[50-54]. Studies show that the first step in the attempt to reduce the effect of cattle production on global warming is to increase productivity by supplying better quality food. All the livestock practice such as genetics, nutrition, reproduction, health and dietary supplements and proper feeding (include grazing) management are that result in the improved feed efficiency. Improved feeding management mainly the composition of feed has some effect on the enteric fermentation and emission of CH₄ from the rumen or the hind gut[55].

3.1.1 Land resource management

Substantial livestock mitigation lies in livestock management and land use. Possible strategies involve adoption of improved pastures, intensification of ruminant diets, changes in ruminant breeds, reductions in stocking rate, and lowering grazing intensity. Havlík et al. [56] indicated that significant emission reduction could be achieved through transitions to more efficient and less land-demanding livestock systems. They also found that mitigation policies targeting land-use-change-related emissions are 5–10 times

more efficient than policies targeting emissions from the livestock only. Another land-use-related mitigation category deals with carbon sequestration, mainly relates to livestock feed-crop production. Carbon sequestering actions include using conservation tillage, selecting to produce higher yielding crops, reducing deforestation, converting cropland to grassland, and improving grass species[3].

3.1.2 Enteric fermentation management

As discussed, enteric fermentation is the main source of ruminant methane emissions. This emission source can be reduced through dietary management and genetics. Knapp et al.[57] found that nutrition and feeding strategies such as improving forage digestibility can reduce enteric methane emission by 2.5–15% per unit of milk produced and more significant reductions achieved if combined with genetic and management approaches. Feed additives and supplements, such as antibiotics, lipids, grain, and ionophores, have also been shown to decrease enteric methane emissions [58].

3.1.3 Livestock manure management

Livestock manure generates both N₂O and CH₄ emissions, and most of these are related to storage and handling methods[3]. Altered manure storage practices can reduce manure GHG emissions. These include shortened storage duration, lowered storage temperature, solid-liquid separation, and less use of water[59]. Anaerobic digestion processes,

in which microorganisms break down manure in the absence of oxygen, produce a mixture of biogas (mainly CH₄ and CO₂) and digestate that can be captured and used as bioenergy to generate heat or electricity. This also indirectly reduces GHG emissions by replacing emission-intensive fossil energy and by changing the composition of emissions from the traditional combination of N₂O and CH₄ into a combination of CO₂ and CH₄ [60]. Anaerobic digestion can lead to an over 30% reduction in GHG emissions compared to traditional manure treatment [61]. Dietary adjustment for animals can also be used to reduce manure emission as it could change the volume and composition of the manure.

3.1.4 Fertilizer management

Fertilizer application in feed crop production contributes N₂O emissions attributable to the livestock sector. Associated mitigation strategies aim at increasing nitrogen application efficiency. Possible measures include the use of time-released nitrogen, precision application, organic fertilizers, plant breeding, genetic modifications, and changes in plant species [62]. Another possible practice related to reducing emission from feed production involves shifts in types of livestock feed. Pikaar et al. [63] analyzed the potential of using microbial proteins (MP) as a feed replacement, finding that it can replace 10–19% of conventional crop-based animal feed protein demand, which leads to a reduction by 7% in agricultural greenhouse gas emission.

3.2 Adaptation

It refers to adjustment in ecological, social, or economic systems to reduce the negative or enhance the positive impacts of climate change. In commonly observed responses to heat stress include: reduced feed intake, shade seeking, increased sweating and panting, increased water intake and drinking frequency, increased standing time and decreased lying time and reduced defecation and urination frequency. Human adaptation strategies involve breeding, production/management system modifications, and institutional and policy changes. Therefore, Successful adaptations may be shown as a better way of coping with consequences of climate change and associated drivers of diseases.

3.2.1 Adaptation related to livestock productivity

Adaptation by housing and managing mental intervention: Adaptation with reference to climate change is referred to as adjustment or preparation of natural, human or livestock systems to the new or the changing environments which moderates harm or uses beneficial opportunities. Adaptation can reduce the current risks of climate change impacts and can be used for addressing emerging risks. To increase milk productivity Dairy cattle production in hot climates may be improved in two ways:

Adapting the animals through selection, breeding and acclimatization

Promoting indigenous breeds for rearing as these are more heat tolerant than cross-bred and exotic breeds. Livestock management, in reality, is the manipulation of the animal environment to promote the most efficient production of meat, milk, egg and wool. Shade for livestock is considered essential to minimize loss in milk production and reproductive efficiency. Shades can improve animal comfort and productivity and should be designed to maximize ventilation and protection from the heat load..

Adapting the animals by providing protective structures and cooling devices

The design and management of the shades for the dairy cattle vary in different areas and climates. A shade space of 60 square feet per animal is considered adequate. The larger space allotments provide more open area for ventilation, which is a critical factor in hot, humid climate. Cattle shades should be designed and orientated in such a way that the animals are exposed to a large proportion of the cool sky. Elimination of direct solar radiation is essential, since the radiated heat load imposed on an animal by the mid day sun several times greater than the metabolic heat generated by the animal.

3.2.2 Adaptation by nutritional intervention

- Take feed to the cows, rather than the cows to feed in hot weather. Walking to feed increases a cow's heat load, so reduce their walking during the hottest time of the day.

- Allow the cattle to grazing at night time in hot weather. So, the night grazing may be practiced for 2-3hrs to fulfill the nutrient requirements partially and have sufficient exercise for the normal physiological function.
- Highly digestible high-energy rations are an effective form of the diet to help the animals to control body temperature by reduction of excess heat. Providing cool drinking water and a low fiber diet renders the comfort to the animals.
- Increase the concentration of minerals and vitamins in the diet to compensate for the reduction in feed intake, particularly sodium, potassium, magnesium and niacin levels in the diet.
- The use of antioxidants such as Vit. E, Vit. A and selenium helps in reducing the impact of heat stress by oxidant balance, resulting in improved reproductive efficiency and animal health.

3.2.3 Adaptation by reproductive intervention

- **Progesterone supplementation** during early pregnancy has proven beneficial in some studies. Supplementation of exogenous progesterone during heat stress has the potential to improve fertility.
- Studies reported that heat synchronization with GnRH and PGF2a also improves fertility.
- The use of embryo transfer technology (ETT) should be considered a potential strategy for minimizing the negative effects of the heat stress on bovine reproduction.

3.2.4 Adaptation related to climate sensitive livestock diseases

- Responses to improve the control of climate sensitive livestock diseases are No-regret options, which enhance community resilience, alleviate poverty and address global inequality. For example, trypanosomosis and ECF are the two most serious and most climate sensitive animal pests.
- Improve surveillance and response capacity: Accurate information on its presence, level, and impacts and the costs for controlling disease is needed to plan disease control. Disease surveillance is an information-based activity that involves collection and analysis of information on disease occurrence. Well-functioning surveillance systems and timely responses may reduce the cost of outbreaks by 95% [64].
- Forecasting and prediction of disease: Satellite data are increasingly being used to aid disease prediction especially for those diseases that occur in epidemics such as RVF, malaria, etc. Prediction however needs to be grounded on disease transmission patterns; thus, a good understanding about the disease and its epidemiology is important.
- Improve animal health service delivery: The last several decades have seen interest in better linking human, animal and environmental health, an approach called “One Health” and Ecohealth.
- Support eradication and control of priority diseases: Some control technologies with potential to improve control of climate sensitive disease include:
 - ★ Multivalent vaccines that can confer immunity to multiple diseases
 - ★ Thermo-tolerant vaccines that do not require a cold-chain
 - ★ Breeding for disease livestock breeds since they with-stand multiple diseases
 - ★ Insecticides e.g pyrethroids, are effective against several multiple vectors
- Improve the resilience of livestock systems: Livestock can play a greater role in adaptation to climate change and variability. In fact livestock husbandry is regarded as a form of adaptation compared to crop agriculture because livestock are mobile and so can be moved to areas with available feed and water. Changes that could be instituted to help livestock farmers adapt better include:
 - ★ Diversification of livestock and livelihoods
 - ★ Integrating livestock farming with agriculture.
 - ★ Identifying and improving breeds that are better adapted to the environment and disease.
 - ★ Farming practices that limit GHG emission such as better management of manure, replacing fertilizers with biological/nitrogen fixing legumes, soil conservation tillage, etc.
- Consider the implications of climate change responses on disease: Land use changes that are implemented in response to climate change and variability be sources of ecosystem disservices, which result in more animal (and human disease). These changes may result in loss of biodiversity (and hence the risk of more disease), nutrient runoff, sedimentation of water ways, greenhouse gas emissions, and pesticide poisoning of humans and other non-target species. Understanding potential changes and monitoring their

occurrence will allow preventive or remedial actions.

4. Conclusion

Climate change is caused increment of weather related disasters and extreme weather events such as droughts, heat waves, storms, desertification and increases in insect infestations. All climate change related hazards and their related disasters have a negative impact on animals. Climate change on livestock production and productivity had its effect in different ways include feed shortage, shortage of water, livestock genetic resources loss, reduced productivity, and decreased mature weight and/or longer time to reach mature weight. Livestock can be affected in two ways by climate change: the quality and amount of forage from grasslands may be affected and there may be a direct effect on livestock due to higher temperatures. Despite, the importance of livestock to poor people and the magnitude of the changes are likely to be failed livestock systems.

This review explored that the impact of climate change and livestock production is a relatively neglected area. Little is known about interactions of climate and increasing climate variability with other drivers of change in livestock systems and development trends. Shortage of feed and water contribute to reduced productivity and reproductive performance of livestock. This includes slow growth rate of animals, loss of body condition, reduced milk

production and poor reproductive performance in mature animals. Draught oxen that are emaciated and in poor body condition cannot provide adequate draught power for plowing, and affects crop cultivation. 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. In order to continue, livestock industries need to anticipate these changes, be prepared for uncertainty and develop adaption strategies now.

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