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Prospects of Climate Change on Livestock Production

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Abstract

It is easy to anticipate that most production of tropical livestock production and productivities are declined when the climate condition is not comfortable. On the other hand, global demand for livestock product is expected to increasing in the future due to human population and the need for animal protein is increasing. Therefore, this review was show the prospect of climate change on livestock production. It is obvious that there is an interaction between livestock production and climate change. Therefore, The potential impacts of climate change on livestock in the future will result in negative changes in production and quality of feed crop and forage, reduced water availability and quality that may affect the hygienic quality of their products, reduced meat, milk and egg production, change in diseases situation in terms of distribution and occurrence, reproduction problem and biodiversity loss.

Keywords: *Climate, Livestock, Prospects.*

INTRODUCTION

Livestock play a major role in the agricultural sector in developing nation, and livestock sector contributes 40% to the agricultural GDP. Global demand for food of animal origin is growing and it is apparent that the livestock sector will need to expand [1]. Livestock are adversely affected by the disadvantageous effects of hot environmental condition [2]. Climate change is also an emerging hotspot issue of the globe nowadays that drives the state of animal genetic resources by distressing the already established systems of animal husbandry [3]. The change of climate and seasonal fluctuation in herbage quality and quality will affect the well-being of livestock, and will lead to decline in production and reproduction efficiency of livestock [4].

Many authors revealed that in the tropics and subtropics, in particular, increasing heat stress is expected to cause intimidate challenges in livestock production by retarding production and fertility, increasing mortality rates; elevated water requirements and deterring feed intakes [5, 6]. Predominantly, high-producing breeds from temperate regions are not well adapted to the effects of extreme temperatures and suffer from heat stress. If animals are introduced into a very hot climate characterized by higher humidity and poor-quality and quantity forage, they suffer from heat stress and do not produce to their full potential unless their management can be acclimatized. Climate change also affects rainfall patterns especially in semi-arid areas leading them to experience erratic rainfall in the coming decades [6].

Erratic rainfall creased due to extreme temperatures projected to deteriorate feed quality as well as quantity by intensifying the degree of lignification of forages and thereby causing animals to suffer from chronic nutritional deficiency which may harm production and health of animals. The spatial and temporal distributions of many infectious diseases especially that are transmitted by vectors can also be affected by climate change and new threats to animal health are likely to emerge [3].

Climate change is a major threat to the sustainability of livestock systems globally. Consequently, adaptation to, and mitigation of the detrimental effects of extreme climates has played a major role in combating the climatic impact on livestock [2].

Currently there is growing interest in understanding the interaction of climate change and agricultural production and it is motivating a significant amount of research [7]. There is still limited research regarding the effect of climate change and future prospects in livestock production. The aim of this paper is to review the prospects of climate change on livestock production.

Objectives

- To address the prospects of climate change on livestock production.

PROSPECTS OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION

Adverse impact of climate change on livestock production and future prospect

Climate change will affect livestock production and consequently food security [8]. Global warming as a result of Climate change may strongly affect production performance of farm animal and impact worldwide on livestock production and reproduction [9]. Specifically, heat stress is a major source of production loss in dairy and beef industry and whereas new knowledge about animal response to the environment continuous to be developed, managing animals to reduce the impact of climate remains a challenge [10].

The potential impacts of climate change on livestock include changes in water availability, animal growth and milk production [11], production and quality of feed crop and forage [12], diseases and reproduction [13] and biodiversity [14]. These listed above effects are mainly due to an increase in atmospheric temperature and carbon dioxide (CO_2) concentration, precipitation variation, and a combination of these factors [15]. The increment in environmental temperature due to climate change also affects most of the critical factors for livestock production, such as water availability, animal production, reproduction and health. Forage quantity and quality are affected by a combination of increases in temperature, CO2 and precipitation variation. Livestock diseases are mainly affected by an increase in temperature and precipitation variation [13].

High ambient temperature decreases fertility even in poultry, rabbits and horses [16]. Exposure of adult New Zealand White rabbits to severe heat stress strongly reduced conception rate. In a recent study [17] reported changes in ovarian follicle development and ovulation, and a reduction in embryo recovery in exercising mares exposed to hot and humid environment.

Those listed effects of climate change on livestock production can be classified in to two as direct and indirect effects

Direct effects of climate change on livestock

Heat stress

The most significant direct impact of climate change on livestock production comes from the heat stress. Heat stress results in a significant financial burden to livestock producers through decrease in milk component and milk production, meat production, reproductive efficiency and animal health. Thus, an increase in air temperature, such as that predicted by various climate change models, could directly affect animal performance [18, 19] Reported that over 50% of the bovine population is located in the tropics and it has been estimated that heat stress may cause economic losses in about 60% of the dairy farms around the world.

According to [20] there is a range of ambient environmental temperatures that are beneficial to physiological functions of animals. In connection with this during the day, livestock keep a body temperature within a range of ±0.5 ^{0}C [21]. Animal have developed phenotypic response to a single source pf stress such as heat called acclimation [22]. Acclimation results in reduced feed intake, increased water intake, and altered physiological functions such as reproductive and productive efficiency and a change in respiration rate [23, 13].

Heat stress decrease feed intake, milk production, the efficiency of feed conversion, and performance [24, 25]. Warm and humid conditions cause heat stress, which affects behavior and metabolic variations on livestock or even mortality. Heat stress impacts on livestock can be categorized into feed nutrient utilization, feed intake, animal production, reproduction, health, and mortality.

Production

One of the major causes of decreased production in the dairy and beef industry is increased temperature [13] and significant economic losses have been related to this. High-producing dairy cows generate more metabolic heat than low-producing dairy cows. Therefore, high-producing dairy cows are more sensitive to heat stress. Consequently, when metabolic heat production increases in conjunction with heat stress, milk production declines [26, 27]. Buffalo exposure to high temperature also reduces milk production because it affects the animal physiological function, such as pulse, respiration rate and rectal temperature [28].

In the case of meat production, beef cattle with high weights, thick coats, and darker colors are more vulnerable to warming [13]. Global warming may reduce body size, carcass weight and fat thickness in ruminant [29]. The same is true in pig production, where larger pig will have more reduction in growth carcass weight and feed intake [13].

Reproduction

Reproduction efficiency of both livestock sexes may be by heat stress. In cattle and pigs, heat stress resulted from climate change could affects oocyte growth and quality, impairment of embryo development as well as decreased pregnancy rate [30]. In males, heat stress adversely affects spermatogenesis perhaps by inhibiting the proliferation of spermatocytes [18]. The fertility of cow may be compromised by increased energy deficits due to reduced feed intake and heat stress [31].

Conception rate of dairy cows may drop 20-27% in summer and heat stressed cows often have poor expression of oestress due to reduced oestradiol secretin from the dominant follicle developed in a low luteinizing hormone environment. Reproductive inefficiency due to heat stress involves changes in ovarian function and embryonic development by reducing the competence of oocyte to be fertilized and the resulting embryo [32]. Heat stress compromises oocyte growth in cows by altering progesterone secretin, the secretin of luteinizing hormone, follicle-stimulating hormone and ovarian dynamics during the oestrus cycle. Heat stress has also been associated with impairment of embryo development and increase in embryonic mortality in cattle. Heat stress during pregnancy slows growth of the fetus and can increase fetal loss. Secretin of the hormones and enzymes regulating reproductive tract function may also be altered by heat stress [18].

Livestock Disease

Increasing temperature may increase exposure and susceptibility of animal to parasite and disease [33, 34] especially vector-borne diseases [35]. However, little effort has been dedicated to understanding the potential impact of climate change on parasite populations and subsequent effects on animal production [33, 35].

Higher temperatures may increase the rate of development of pathogens or parasites that spend some of their life cycle outside their animal host, which may lead to larger populations [36]. Other pathogens are sensitive to high temperature and their survival may decrease with climate warning. Similarly, those pathogens and parasites that are sensitive to moist or dry condition may be affected by changes to precipitation, soil moisture and the frequency of floods. Changes to winds could affect the spread of certain pathogens and vectors [37].

There may be several impact of climate change on the vectors of disease (midges, flies, ticks, mosquitoes and tsetse are all important vectors of livestock disease in the tropics). Changes in rain fall and temperature regimes may affect both the distribution and abundance of disease vectors, as can changes in the frequency of extreme. It has also been shown that the ability of some insect vectors to become or remain infected with viruses (such as bluetongue) varies with temperature [38].

[13], presented several livestock health problems related to climate change. Prolonged high temperature may affect metabolic rate [39], endocrine status [40], oxidative status [41], glucose, protein and lipid metabolism, liver functionality (reduced cholesterol and albumin) [42, 43], non-esterified fatty

acids (NEFA) [43], saliva production, and salivary HCO3- content. In addition, greater energy deficits affect cow fitness and longevity [31].

Climate change may alter transmission rates between hosts not only by affecting the survival of the pathogen or parasite or intermediate vector but also by other means. Future patterns of international trade, local animal transportation and farm size are factors that may be driven in part by climate change and may affect disease transmission. Other indirect effects of climate change may also affect the abundance and/or distribution of the competitors, predators and parasites of vectors, thus influencing patterns of disease. It may also be that changes in ecosystems, driven by climate change and other drivers that affect land-use, could give rise to new mixtures of species, thereby exposing hosts to novel pathogens and vectors and causing the emergence of new diseases [44]. Trypanotolerence, an adaptive trait which has developed over the course of millennia in sub-humid zone of West Africa, could be lost, thus leading to a greater risk of disease in the future [45]. The future infectious disease situation is going to be different from today's [46].

Mortality

There is a strong relationship between drought and animal death. Projected increased temperature and reduced precipitation in such regions as southern Africa will lead to increased loss of domestic herbivores during extreme events in drought-prone areas [47].

Heat-related mortality and morbidity could increase as temperature increase due to climate change [45]. Warm and humid conditions that cause heat stress can affect livestock mortality [48]. Reported that increases in temperature between 1 and 5 C might induce high mortality in grazing cattle. As a mitigation measure, they recommend sprinklers, shade, or similar management practices to cool the animals. [49] Linked livestock mortality to several heat waves between 1994 and 2006 in the United States and northern Europe.

Indirect effects of climate change on livestock production

In addition to the direct impacts of a changing climate on many aspects of livestock and livestock systems, there are various indirect impacts that can be expected to impinge on livestock production in developing countries [50]. Most of the production losses are incurred via indirect impacts of climate change largely through reductions or non-availability of feed and water resources 18. With the likely emerging scenarios that are already evident from impact of the climate change effects, the livestock production systems are likely to face more of negative impact [51].

Effect of climate change on livestock production system.

According to [52] report there are three main categories of livestock production systems. This include: grazing or pastoral systems, mixed crop -livestock systems and industrial livestock systems.

Impact on grazing or pastoral system

Even though they have developed the capability to cope and adapt to climate uncertainty, the increase of climatic variability will exert a strong influence on pastoral systems. But for conditions that deviate many degrees from a "coping range" pastoral system will also became vulnerable if there is no adaptive capacity. Pastoral system will be expressed to climatic effects particularly in Africa, Australia, Central America and Southern Asia. In these areas some studies forecast up to 50% loss of available biomasses [53].

Impacts on mixed crop -livestock systems

According to [54] we can subdivide these systems in two sub-categories: a) rain-fed mixed systems and b) irrigated mixed systems. The rain fed system is located mainly in central and eastern Europe, India, Eastern South America and central Africa and on the border between the United States and Canada. The irrigated mixed system are located primarily in central Europe, Southern and Eastern Asia and in some zones of Oceania, United State of America and Central America.

Climate change can affect crop-livestock systems such as dairy cow farming, beef cattle fattening, dairy sheep and goat farming, mainly acting on forage availability and quality, animal health and productivity. In mixed rain-fed systems the effects will be higher than in irrigated systems [9].

Less productive and better thermo-tolerant dairy cows, could substitute highly selected cows, in many areas. We can predict that global warming could seriously damage either beef or milk production, especially in mixed rain-fed systems [55].

Impacts on industrial livestock systems

The level of severity on different livestock production due to climate change effect is different of different production system based on their nature. The impact of climate change and variability on industrial and landless livestock production systems such as pig and poultry farming will be less severe compared with pastoral and crop-livestock systems, due to the possibilities of controlled environmental parameters, and because of the possibility to manage feeding variables. However, increased capital investment will be needed for improving cooling systems and thermal isolation of buildings. The integrated models used to assess the likely effects of climate changes on animal health and productivity show some weak points [56]. New climate scenarios may induce negative effects even on industrial livestock systems acing on feed resources, because they are completely dependent on the market for animal feeding. Cost variation of grain and their availability t the market will strongly influence profitability and sustainability of enterprises.

The level of dependence on climate estimates how much the animal performance, health, welfare, nutrition and production may be affected by the climatic conditions in a short or in a medium period in each systems are. The main question regarding the influence of climate change on livestock systems are: how much those three livestock systems are dependent on climate, which components of these systems will be mainly affected and what can we do to cope with these effects [13].

Water shortage and quality

In tropical and sup tropical regions an increased need of drinking water, as a consequence of prolonged exposure to high environmental temperature, is often coincident with a reduction of water availability and forage water content and quality. Fibrous forage reduce voluntary feed intake and can increase fermentative heat and the thermoregulatory demand for water [57]. An additional problem may drive from the quality of water available in hot arid or semi-arid areas. In such climatic areas, water is commonly characterized by high concentration of total dissolved solids.

Animals exposed to hot environments drinking an amount of water 2-3 times more than those in thermo-neutral conditions can run many risks. Indeed, altered water pH may affect metabolism, fertility and digestion; the excess if nitrate content can impair both cardiovascular and respiratory system; excess of heavy metals can impair the hygienic and sanitary quality of production and excretory, skeletal and nervous systems of animals.

Likely, all global warming effect on water availability could force the livestock sector to establish a new priority in producing animal products that need less water. For estimating the water requirement per animal product we can compare water consumption of different animal species, referring the total need of water (for feed, drinking, cleaning, etc.) to produce 1 unit of protein. We can assume one unit of protein corresponds to 30 g of proteins, which is about the daily animal protein requirement for humans. To produce 30 g of protein from beef and pork, about 3.7 tons and 0.597 tons of water is needed respectively [58]. This value is about 6 times the amount of water required to produce the same quantity of protein from pigs: i.e. pasture for beef cattle in grazing systems or in rain fed mixed systems vs. irrigated farming producing grain to feed pigs in industrial livestock systems. The total requirements of water to produce world-wide animal products per year is approximately 2800 km^3 of water, which represents the 7.8% of the net precipitation on land masses of the globe (36,000 km^3 =107,000 km3 total precipitation − 71,000 km^3 evapo-transpiration). Will be possible to recuperate a share of available freshwater that we are lacking today? And, where and how will it be more feasible to do this? This will be vital task for the future [13].

Genetic resource problem

Biodiversity refers to a variety of genes, organism and ecosystems found within a specific environment [59] and contributes to human well-being [60]. Population that are decreasing in genetic biodiversity are risk and one of the durect drivers of this biodiversity loss in climate change. Climate change may eliminate 15-37% of all species in the world [61]. Temperature increases have affected species reproduction, migration, mortality, and distribution [52]. The Intergovernmental Panel on Climate Change Fifth Assessment Report states that an increase of 2 to 3 ^oC above pre-industrial levels may result in 20 to 30% of biodiversity loss of plants and animals [62]. Between 20 and 30 % of all plant and animal species assessed could face a high risk of extinction. Local and rare breeds could be lost as a result of the impact of climate change and disease epidemics. [37] Reported that this biodiversity loss is mainly because of the practices used in livestock production that emphasize yield and economic returns and marginalization of traditional production system where other considerations are also important (such as ability to withstand extremes). Biodiversity loss has global health implications and many of the anticipated health risks driven by climate change will be attributable to a loss of genetic diversity [45]. Changes in the distribution and incidence of disease that kill large number of animal or induce culling measures for disease control may pose additional threats to Animal Genetic Resources diversity, but precise effect are again difficult to predict [5].

With increasing milk yield in dairy cattle, growth rates and leanness in pigs or poultry, metabolic heat production has increased and the capacity to tolerate elevated temperatures has declined [63]. In the long term, single-trait selection for yield will therefore result in animals with lower heat tolerance [64]. So by diluting livestock genetics in tropical area specially, through selecting single trait to get optimum production without considering heat stress tolerance in respect to long term climate change there may be loss of genetic resource gradually. But if the level of human intervention to improve productive performance of livestock is negligible, through long term evolution and natural selection the animal will be improved with trait for heat tolerance and reduce trait for milk, meat and egg production and the may be loss of productive animal.

Feed quality and quantity

Impact of climate change on forage quantity and quality depend on the region and length of growing season [15] and an increase in atmospheric CO_2 level and temperature [12]. Climate change can be expected to have several changes or effects on feed sources and grazing systems. Like, Increase of CO_2 concentration will result in herbage growth changes, with greater effect on C_3 species and less on grain yields [12]. Changes in herbage growth brought about by changes in atmospheric CO_2 concentrations and temperature; Temperature increases to 30–35 ^oC could increase herbage growth, with larger effects on C4 species. However, the effects may vary depending on the location, production system used, and plant species [65]. Change in composition of pasture, such as change in the ratio of grass to legumes. Changes in herbage quality, with changing concentration of water –soluble carbohydrate and N at a given dry matter yields. Greater incidence of drought, which may offset any DM yield increases [66]. An increases of 2 ^oC will produces negative impact on pasture and livestock production in arid and semi-arid regions and positive impact in humid temperate regions. The length of growing season is also an important factor for forage quality and quantity because it determines the duration and periods of available forage. A decrease in forage quality can increase methane emission per unit of gross energy consumed [67]. Therefore, if forage quality declines, it may need to be offset by decreasing forage intake and replacing it with grain to prevent elevated methane emission by livestock [15].

Some information exists on the likely impacts of climate change on forage quality, although little seems to be relevant to the tropics. Quality of feed crops and forage may be affected by increased temperatures and dry conditions due to variations in concentrations of water-soluble carbohydrates and nitrogen [68, 15]. Increased temperature increases lignification of plant tissue and therefore reduce the digestibility and the rates of degradation of plant species [69]. This leads to reduced nutrient availability for animal and ultimately to a reduction in livestock production, which may have impacts on food security and incomes through reduction in the production of milk and meat for smallholders. These impact may be as important in rangeland systems in relation to grazing resources as in the mixed systems in which crop residues are a key dry-season feeding resource [47].

CONCLUSION AND RECOMMENDATION

Climate change, particularly global warming, may strongly affect production performances of farm animals and impact worldwide on livestock production. The potential impacts of climate change on livestock in the future will result in negative changes in production and quality of feed crop and forage, water availability, animal growth and milk production, disease, reproduction and animal genetics and biodiversity loss. The effect of Heat stress on livestock can be categorized into feed nutrient utilization, feed intake, animal production, reproduction, health, mortality which cause economic losses in about 60% of the dairy farm around the world and also been associated with impairment of embryo development and increase in embryonic mortality in cattle. Climate change may influence patterns of disease and changes in ecosystems, and facilitates that the future infectious disease situation is going to be different from today. Climate change may eliminate 15% to 37% of all species in the world which is high risk of animal genetic extinction. Global warming effects on water availability could force the livestock sector to stablish a new priority in producing animal products that need less water. Increased temperature increase lignification of plant tissues and therefore reduce the digestibility and the rate of degradation of plant species that leads to increase CH_4 emission from livestock.

Based on the above conclusive statements, the following recommendations are forwarded:

- All animal scientists must collaborate closely with colleagues of other disciplines, like agronomists, meteorologists, biotechnologists, ecologists, etc
- Selecting animals should not only oriented toward productive traits, but also consider robustness and adaptability to heat stress as well as the genetic potential of individual animal in terms of less enteric CH_4 emission.

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