Livestock Management under Changing Climate Scenario in India

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Abstract: Animal agriculture is a major contributor to climate change through various elements like air temperature, humidity, wind velocity, solar radiation and other factors. Heat is the major constraint in tropical and sub tropical climatic conditions which negatively affects production and reproduction of livestock species. Alterations of temperature and humidity profile may alter the productivity, reproductive efficiency and may aggravate the spread of disease and parasites into new regions. The current review have been framed to provide more insight into the effect of climate change on livestock production in India and how to alleviate the expected thorny picture of livestock production system. Climate can affect livestock both directly and indirectly. Livestock production is not only affected by climate change but also contributes to the cause. Greenhouse gas emissions by the livestock sector could be cut by as much as 30 percent through the wider use of existing best practices and technologies. Livestock production system is expected to be exposed to many challenges due to climate change in India. Climate change through raised temperature, humidity and solar radiation may alter the physiology of livestock, reducing production and reproductive efficiency of both male and female and altered morbidity and mortality rates. Options for alleviating heat stress include adjusting animals' diets to minimize diet-induced thermogenesis (low fibre and low protein) or by increasing nutrient concentration in the feed to compensate for lower intake; taking measures to protect the animals from excessive heat load (shading/improving ventilation by using fans) or enhance heat loss from their bodies (Sprinklers/misters); or genetic selection for heat tolerance or bringing in types of animals that already have good heat tolerance. Livestock production and its economic efficiency depend on quantity and quality of feed and water that animals need to survive, produce and reproduce. In production systems where animals are fed on concentrates, rising grain prices (may be driven by climate change) increase the pressure to use animals that efficiently convert grains into meat, eggs or milk. The geographical and seasonal distributions of many infectious diseases, particularly vector borne, as well as those of many parasites and pests of various kinds are affected by climate. Different managemental options for reducing the effect of thermal stress are genetic approach, nutritional adjustments, managemental interventions, adequate water supply, providing feed to the animals during cool period, stocking density, provision of vegetative cover over the surrounding area, adequate ventilation, revival of common property resources (CPRs), intensive fodder production systems, use of unconventional resources as feed, etc.

Keywords: Climate change, climate variability, livestock, challenges, mitigation strategies.

INTRODUCTION

Animal agriculture is a major contributor to climate change, responsible for 18% of greenhouse gas (GHG) emissions (9% CO_2, 37% methane and 65% N_2O) (FAO report, "Livestock long shadow: environmental issues and options", 2006). These issues may lead to a greater increase in intensive production practices at the expense of medium and long term environmental and animal welfare friendly extensive production methods. Livestock systems based on grazing and the mixed farming systems (most prevalent in India) is expected to be affected more by climate change than an industrialized system [1]. This may be attributed to direct effects of high temperature and solar radiation on animals and negative effect of irratic rainfall pattern and frequent droughts which affect crops and pasture growth. Climate elements include air temperature, humidity, wind velocity, solar radiation and other factors. Heat is the major constraint in tropical and sub tropical climatic conditions which negatively affects production and reproduction of livestock species. The heat stress causes a chain reaction of physiological, behavioural and anatomical changes leading to reduction in growth, productive and reproductive functions. In addition, there is a decrease in activity, increase in respiration, body temperature, increased peripheral blood flow and alterations in endocrine functions.

Fundamentally, the animal production is affected by climate change in four ways, a). through changes in livestock feed-grain availability and price; b). impacts on livestock pastures and forage crop production and quality; c). changes in the distribution of livestock diseases and pests; and the direct effects of weather on animal health, growth and reproduction [2].

Alterations of temperature and humidity profile may aggravate the spread of disease and parasites into new regions, produce an increase in the incidence of disease, ultimately reducing animal productivity [3]. Some of the other indirect effects are brought about by changes in feed resources linked to the carrying

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E-ISSN: 2310-0796/13

capacity of rangelands, increased desertification processes, increased scarcity of water resources, lower production of grain, etc. Vulnerability studies suggest few districts of the India are highly vulnerable to the climate change [4]. In the event of climate change, the biggest challenge will be how to balance huge number of livestock or the productivity per head, at the same time improving the sustainability of the livestock sector. The efficiency of water utilization and optimization of nutrient footprint will be another challenge.

The current review have been framed to provide more insight into the effect of climate change on livestock production in India and how to alleviate the expected thorny picture of livestock production system.

EFFECT OF CLIMATE VARIABILITY AND CHANGE ON LIVESTOCK STATUS

Climate can affect livestock both directly and indirectly [5, 6]. Direct effects from air temperature, humidity, wind speed and other climate factors, influence animal performance such as growth, milk production, wool production and reproduction. Climate can also affect the quantity and quality of feedstuffs such as pasture, forage and grain, and the severity and distribution of livestock diseases and parasites. Indian livestock productivity has been severely affected by vector-borne livestock diseases which are known to be climate sensitive [7]. The direct effects of climate change could translate into the increased spread of existing vector-borne diseases and parasites, accompanied by the emergence and circulation of new diseases.

The impacts of climate change also depend on the rainfall which generally affects crop and grassland productivity, ultimately affecting livestock net income [8]. There are three plausible explanations. First, farmers shift to crops as rainfall increases; second, grassland shifts to forests as rain increases, reducing the quality and quantity of natural grazing for most animals; and third, increases in precipitation increase the incidence of certain animal diseases [8].

HEAT STRESS AND LIVESTOCK

Climatic factors, such as high ambient temperature, high relative humidity (RH), high solar radiation, and low wind speed can induce a heat stress response in heat-susceptible animals. The heat load may, for at least part of the year (seasonal), induce physiological and behavioral changes that contribute to a decrease in production and reproduction, and could impair immune function [9]. Biologically, animals are able to minimize adverse effects of a high heat load by invoking physiological mechanisms, such as an increased respiration rate, an increased sweating rate, changes in endocrine function, and a reduced metabolic rate [10]. When the physiological mechanisms fail to alleviate the effect of heat load, the body temperature may increase to a point at which animal well-being is compromised. The loss in body weight during hot conditions is essentially a result of reduced dry matter intake and an increase in maintenance requirements caused by the increased physiological functions [11].

Under heat stress, a number of physiological and behavioral responses vary in intensity and duration in relation to the animal genetic makeup and environmental factors. Climatic, environmental, nutritional, physical, social or physiological stressors are likely to reduce welfare and performance of animals [12]. Adaptation to heat stress requires the physiological integration of many organs and systems viz. endocrine, cardiorespiratory and immune system [13].

Heat stress reduces libido, fertility and embryonic survival in animals. Primary effect of environmental stress in neonates is increased disease incidence associated with reduced immunoglobulin content in plasma. Heat stress in late gestation reduces fetal growth and alters endocrine status of the dam. Carryover effects of heat stress during late gestation on postpartum lactation and reproduction are also detectable [14]. Thermal stress lowers feed intake of animal which in turn reduces their productivity in terms of milk yield, body weight and reproductive performance [15]. High ambient temperature can adversely affect the structure and physiology of cells causing impaired transcription, RNA processing, translation, oxidative metabolism, membrane structure and function [16].

The global warming and rise in temperature during summers negatively impact on reproductive functions and milk production of buffaloes in India [17]. The incidence of silent heat or poor expression will be more common at high temperatures during summer of 2015 and beyond particularly in buffaloes that have limited access to water for either drinking and/ or wallowing. These buffaloes at high temperatures may also fail to conceive due to silent heat or poor expression of heat, loss of conception, causing long dry periods and inter calving intervals [18] ultimately affecting milk production [17].

Heat stress in lactating animals result in dramatic reduction in roughage intake, gut motility and rumination which in turn contribute to decreased volatile fatty acid production and may contribute to alteration in acetate: propionate ratio. Rumen pH also declines during thermal stress [14]. Electrolyte concentrations, in particular Na^+ and K^+ are reduced in rumen fluid of heat stressed cattle. The decrease in Na^+ and K^+ are related to increase in loss of urinary Na^+ and loss of skin K^+ as well as decline in plasma aldosterone and increase in plasma prolactin [14]. Thermal stress also alters dietary protein utilization and body protein metabolism [19].

GHG EMISSION BY LIVESTOCK PRODUCTION

Livestock production is not only affected by climate change but also contributes to the cause. Greenhouse gas emissions occur throughout the livestock production cycle. Feed-crop production and management of pastures give rise to emissions associated with the production and application of chemical fertilizer and pesticides and with the loss of soil organic matter. Further emissions occur because of the use of fossil fuels in the transport of animal feed. Further emissions occur directly from the animals as they grow and produce: most notably, ruminant animals emit methane as a by-product of the microbial fermentation through which they digest fibrous feeds. Emissions of methane and nitrous oxide occur during the storage and use of animal manure. Processing and transport of animal products give rise to further emissions, mostly related to use of fossil fuel and infrastructure development.

On a commodity-basis, beef and cattle milk are responsible for the most emissions, respectively, contributing 41 percent and 20 percent of the sector's overall GHG outputs (This figure excludes emissions from cow manure and cattle used as drought). They are followed by pig meat (9 percent of emissions), buffalo milk and meat (8 percent), chicken meat and eggs (8 percent), and small ruminant milk and meat (6 percent). The remaining emissions are sourced to other poultry species and non-edible products. Emission intensities (i.e. emissions per unit of product) vary from commodity to commodity. They are highest for beef (almost 300 kg CO2-eq per kilogram of protein produced), followed by meat and milk from small ruminants (165 and 112kg CO2-eq.kg respectively). Cow milk, chicken products and pork have lover global average emission intensities (below 100 CO2-eq/kg.) (At the sub-global level, within each commodity type there is very high variability in emission intensities, as a result of the different practices and inputs to production used around the world. Enteric emissions and feed production (including manure deposition on pasture) dominate emissions from ruminant production. In pig supply chains, the bulk of emissions are related to the feed supply and manure storage in processing, while feed supply represents the bulk of emissions in poultry production, followed by energy consumption.

Greenhouse gas emissions by the livestock sector could be cut by as much as 30 percent through the wider use of existing best practices and technologies, according to a new study released by the UN Food and Agriculture Organization (FAO), 2013.

CHALLENGES ASSOCIATED WITH CHANGING CLIMATE ON LIVESTOCK PRODUCTION SYSTEM

Livestock production system is expected to be exposed to many challenges due to climate change in India. They are listed as follows:

A. Challenges Associated with the Direct Effects of a Changing Climate and its Alleviation

Direct effect of climate change through raised temperature, humidity and solar radiation may alter the physiology of livestock, reducing production and reproductive efficiency of both male and female and altered morbidity and mortality rates. Heat stress suppresses appetite and feed intake, however, animals' water requirements is increased. In general, the high-output breeds especially crossbreds, which provide the sizable amount of Indian production, are more vulnerable to heat stress as compared to indigenous one. Also, as people are lured by immediate money making methods, indiscriminate cross breeding is adding to the concern, however, this approach is not sustainable.

Options for alleviating heat stress include adjusting animals' diets to minimize diet-induced thermogenesis (low fibre and low protein) or by increasing nutrient concentration in the feed to compensate for lower intake; taking measures to protect the animals from excessive heat load (shading/improving ventilation by using fans) or enhance heat loss from their bodies (Sprinklers/misters); or genetic selection for heat tolerance or bringing in types of animals that already have good heat tolerance [20-22]. All these options require some degree of initial investment, some require access to relatively advanced technologies, and all except simple shading require ongoing input of water and/or power. The practicality of implementing cooling measures depends on the type of production system. They can most easily be applied in systems where the animals are confined and where the necessary inputs can be afforded and easily accessed. In extensive grazing systems, it is difficult to do more than provide some shade for the animals and possibly places for them to wallow. Livestock producers in areas where relative humidity is high (north-eastern part of India) face additional problems as there is less potential for the use of methods based on evaporative cooling. Small-scale producers who have adopted high-output breeds, but struggle to obtain the inputs needed to prevent the animals from becoming overheated, may find that their problems are exacerbated by climate change.

B. Challenges Associated with Livestock Feeding and Nutrition and its Alleviation

Livestock production and its economic efficiency depend on quantity and quality of feed and water that animals need to survive, produce and reproduce. About 10% of cropland is used for producing animal feed and other agriculture land provides crop residues used for feeding livestock. The future of livestock production systems depends on the continued productivity of these various feed-producing areas – all of which are potentially affected by climate change.

The influence of the climate on the distribution of plant variety and type is complex. The effects of climatic interaction with soil characteristics and its direct effect on plants influences the distribution of the various other biological components of the agro-ecosystem – pests, diseases, herbivorous animals, pollinators, soil microorganisms, etc. – all of which in turn influence plant communities. All these processes have the potential to influence directly or indirectly the growth of the plants on which livestock feed.

Pressure on feed resources and other constraints to traditional livestock-keeping livelihoods have promoted the spread of agro-pastoralism (i.e. livelihoods that involve some crop production in addition to livestock keeping) at the expense of pastoralism. In production systems where animals are fed on concentrates, rising grain prices (may be driven by climate change) increase the pressure to use animals that efficiently convert grains into meat, eggs or milk. Thus, within such systems climate change may lead to greater use of poultry and pigs at the expense of ruminants, and greater focus on the breeds that are the best converters of concentrate feed under high external input conditions. Increases in the price of grain may also contribute to the further concentration of production in the hands of large-scale producers.

C. Challenges Associated with the Effects of Diseases and Parasites

The geographical and seasonal distributions of many infectious diseases, particularly vector borne, as well as those of many parasites and pests of various kinds are affected by climate. Pathogens, vectors, and intermediate and final hosts can all be affected both directly by the climate (e.g. temperature and humidity) and by the effects of climate on other aspects of their habitats (e.g. vegetation). If the climate changes, hosts and pathogens may be brought together in new locations and contexts, bringing new threats to animal (and in some cases human) health and new challenges for livestock management and policy. However, it is difficult to segregate out epidemiological changes that can be attributed unambiguously to climate change. Climate is characterized not merely by averages, but also by short-term fluctuations, seasonal oscillations, sudden discontinuities and long term variations, all of which can influence disease distribution and impacts.

Rapid spread of pathogens, or even small spatial or seasonal changes in disease distribution, whether driven by climate change or not, may expose livestock populations to new disease challenges. Disease-related threats can be both acute or chronic and can be caused by the direct effects of disease or indirectly by the measures used to control disease. The most severe recent epidemics in India in terms of the numbers of livestock lost have involved quite a narrow range of diseases: most notably foot-and-mouth disease, avian influenza, Blue tongue, African swine fever, classical swine fever and contagious bovine pleuropneumonia.

ADAPTATION AND MITIGATION STRATEGIES TO CLIMATE CHANGE/VARIABILITY

Since climate change could result in an increase of heat stress, all methods to help animals cope with or, at least, alleviate the impacts of heat stress could be useful to mitigate the impacts of climate change on animal responses and performance. Different managemental options for reducing the effect of thermal stress are:

I. Genetic Approach

Many local breeds are having valuable adaptive traits that have developed over a long period of time which includes

- Tolerance to extreme temperature, humidity etc
- Tolerance /resistance to diseases
- Adaptation to survive, regularly produce/ reproduce in low/ poor management conditions and feeding regimes.

Hence, Genetic approach to mitigate the climate change should include measures such as

1. Identifying and strengthening the local genetic groups which are resilient to climatic stress/ extremes
2. Genetic selection for heat tolerance or bringing in types of animals that already have good heat tolerance and crossbreeding the local genetic population with heat and disease tolerant breeds.
3. Identifying the genes responsible for unique characteristics like disease tolerance, heat tolerance, ability to survive in low input conditions and using it as basis for selection of future breeding stock will help in mitigating the adverse effect of climate stress.
4. **Breeding management strategies:** Changing the breeding animal for every 2-3 years (exchange from other district herd) or artificial insemination with proven breed semen will help in enhancing the productivity. This may be supplemented with supply of superior males through formation of nucleus herd at block level. Synchronization of breeding period depending on the availability of feed and fodder resources results in healthy offsprings and better weight gain. Local climate resilient breeds of moderate productivity should be promoted over susceptible crossbreds.

In India, with small flock sizes, large fluctuations in rearing conditions and management between flocks, and over time within a flock, lack of systematic livestock identification, inadequate recording of livestock performances and pedigrees, and constraints related to the subsistence nature of livestock rearing (where monetary profit is not the most important consideration), the accuracy of selection will be much lower, resulting in even lower rates of genetic gain. However, locally adapted breeds are likely to be highly variable and the highest performing animals of such breeds can have great productive potential. Therefore, the screening of livestock populations previously not subjected to systematic selection is likely to give quicker results to provide high genetic merit foundation stock for nucleus flocks.

II. Nutritional Adjustments

The feed intake by the livestock during thermal stress is significantly lower than those in comfort zone. Hence, the care should be directed towards providing more nutrient dense diet while will help to minimize production losses due to the high temperatures as well as those feed which generates less heat during digestion. This can be achieved by following measures:

- Feeding dietary fat remains an effective strategy of providing extra energy during the time of negative energy balance. Incorporation of dietary fat at level of 2 – 6 % will increase dietary energy density in summer to compensate for lower feed intake.
- Adjusting animals' diets to minimize diet-induced thermo genesis (low fibre and low protein diets). High-fiber diets generate more heat during digestion than lower fiber diets.
- Using more synthetic amino acids to reduce dietary crude protein levels. Excessive dietary protein or amino acids generate more heat during digestion and metabolism.
- Feeding of antioxidant (Vitamin A, C & E, selenium, Zinc) reduces the heat stress and optimize feed intake.
- Addition of feed additives/vitamins and mineral supplementations that helps in increasing feed intake, modify gut microbial population and gut integrity and maintain proper cation and anion balance.
- During lean/drought periods, shepherds migrate along with their animals in search of fodder. This

migration sometimes creates social conflicts with local people for available scarce fodder resources. Further, this could invite new diseases and parasites which pose health problems in small ruminants. Protein is the first limiting nutrient in many grazing forages and protein availability declines in forages as the plant matures towards the end of winter season. When daytime temperatures and humidity are elevated, special precautions must be taken to keep livestock comfortable and avoid heat stress. Allow for grazing early in the morning or later in the evening to minimize stress.

- Concentrate mixture (18% DCP and 70% TDN) prepared with locally available feed ingredients should be supplemented to all categories of animals. When no green fodder is available, addition of vitamin supplement in concentrate mixture helps in mitigating heat stress.

- Further, in extreme conditions, energy intake becomes less compared to expenditure as the animal has to walk more distance in search of grazing resources which are poor in available nutrients. Hence, all the animals should be maintained under intensive system with cut and carry of available fodder. The concept of complete feed using crop residues (60%) and concentrate ingredients should be promoted for efficient utilization of crop residues like red gram stalk, etc. Further, productivity and profitability from ruminants can be increased by strengthening feed and fodder base both at village and household level with the following possible fodder production options.

III. Managemental Interventions

1. Water supply: Animals must have access to large quantities of water during periods of high environmental temperatures. Much of the water is needed for evaporative heat loss *via* respiration to help them cool off. Hence, provision has to be made for supply of continuous clean, fresh and cool water to the animals. Cleaning the feeding trough frequently and providing fresh feed will encourage the animals to take more feed. Splashing the cool water over the animals at regular intervals during the hot period will reduce the heat stress.

2. Feeding time: Providing feed to the animals during cool period i.e. evening or night will improve the feed intake by the animals.

3. Stocking density: Reducing the stocking density during hot weather will help the animals in dissipating the body heat more efficiently through manifestation of behavioural adaptation.

4. Shade: The use of shades is an effective method in helping to cool animals. Shades can cut the radiant heat load from the sun by as much as 40%. Shades with straw roofs are best because they have a high insulation value and a reflective surface. Uninsulated aluminum or bright galvanized steel roofs are also good. The best shades have white or reflective upper surfaces. Provision of trees at certain distance from the shed which will provide shade to the animals. Shifting the animals to cool shaded area during the hot climatic conditions.

5. Provision of vegetative cover over the surrounding area will reduce the radiative heat from the ground. The surface covered with green grass cover will reflect back 5 – 11% of solar radiation as compared to 10 – 25% by dry bare ground and 18 – 30% by surface covered by dry sand adding to thermal stress.

6. Provision of elongated eaves or overhang will provide shade as well as prevent rain water from entering the sheds during rainy season.

7. Ventilation: increasing the ventilation or air circulation in the animal sheds will aid the animals in effective dissipation the heat. The air circulation inside the shed can be increased by keeping half side wall i.e., open housing system, use of fan, increasing the height of the building etc.

8. Roof material: the roof material to be used should be bad conductor of heat. i.e., it should prevent radiative heat from entering into the shed. Thatch along with bamboo mat is excellent roofing material for tropical conditions. However, it is prone for fire hazards as well as its longevity is less. The outer surface of the roof should be painted white so that the white surface will reflect the solar radiation back. Some materials such as aluminium reflect heat well as long as they are not too oxidized.

IV. Other Interventions

A. Revival of Common Property Resources (CPRs)

Majority of the total feed requirements of ruminants are met by the CPRs. There is no control over the number of animals allowed to be grazed, causing severe damage on the re-growth of number of favourable herbaceous species in grazing lands. Thus causing severe impact not only on herbage availability from CPRs but also quality of herbage affecting the productivity of animals adversely; hence there should be some restriction on number and species of animals to be grazed in any CPR as a social regulation. CPRs need to be reseeded with high producing legume and non-legume fodder varieties at every 2-3 years intervals as a community activity. Further, grazing restriction till the fodder grows to a proper stage and rotational grazing as community decision would improve the carrying capacity of CPRs.

B. Intensive Fodder Production Systems

Growing of two or more annual fodder crops as sole crops in mixed strands of legume (Stylo or cowpea or hedge Lucerne, etc) and cereal fodder crops like sorghum, ragi in rainy season followed by berseem or Lucerne etc., in rabi season in order to increase nutritious forage production round the year. Fodder crops like Stylo hamata and Cenchrus ciliaris can be sown in the inter spaces between the tree rows in orchards or plantations as hortipastoral and silvopastoral systems for fodder production

C. Use of Unconventional Resources as Feed

The available waste products form food industries like palm press fibre, fruit pulp waste, vegetable waste, brewers' grain waste and all the cakes after expelling oil etc., and thorn-less cactus should be used as feed to meet the nutritional requirements of animals.

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Received on 28-09-2013 Accepted on 23-11-2013 Published on 30-11-2013

DOI: http://dx.doi.org/10.12970/2310-0796.2013.01.01.5