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Livestock Production Adapting to Climate Change

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1. Introduction

While climate change is a global phenomenon, its negative impacts are felt more severely by poor people in developing countries, who rely heavily on the natural resource for their livelihoods. Rural poor communities depend a lot on agriculture and livestock for their survival. Further, animal agriculture is amongst the most climate-sensitive economic sectors in India. Global demand for livestock products is expected to double during the first half of this century as a result of the growing human population and its growing affluence. Over the same period, we expect big changes in the global climate. Today climate change is one of the most serious long-term challenges facing farmers and livestock owners around the globe. Climate change is widely considered to be one of the most potentially serious environmental problems ever confronting the global community. Besides being a major contributor to climate change, livestock play important roles in farming system in developing countries by providing food and income, draught power, fertilizer and soil conditioner, household energy and a means of disposing of otherwise unwanted crop residues. About 12 % of the world's population depends solely on livestock for their livelihood.

The continuous heat waves and drought as a result of climate change has impacted livestock production resulting in severe economic loss to the poor and marginal farmers in particular in India. It is therefore imperative that animal agriculture practices and the welfare of animals be considered when developing climate change policies and programs. This chapter is an attempt to project the strategic plans and climate resilient technologies that are needed to sustain livestock production in the changing climate scenario.

2. Climate change and its consequences on livestock economy

Global climate change is expected to alter temperature, precipitation, atmospheric carbon dioxide levels, and water availability in ways that will affect the productivity of crop and livestock systems (Hatfield, *et al.* 2008). 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 the efficiency by which livestock convert feed into retained products (especially meat and milk). Climatic changes could increase thermal stress for animals and thereby reduce animal production and profitability by lowering feed efficiency, milk production, and reproduction rates (St-Pierre and Schnitkey, 2003).

Climate changes, could impact the economic viability of livestock production systems worldwide. Surrounding environmental conditions directly affect mechanisms and rates of heat gain or loss by all animals (NRC, 1981). Environmental stress reduces the productivity and health of livestock resulting in significant economic losses. Heat stress affects animal performance and productivity of dairy cows in all phases of production. The outcomes include decreased growth, reduced reproduction, increased susceptibility to diseases, and ultimately delayed initiation of lactation. Heat stress also negatively affects reproductive function (Amundson *et al.* 2006). Normal estrus activity and fertility are disrupted in livestock during summer months. Economic losses are incurred by the livestock industries because farm animals are generally raised in locations and/or seasons where temperature conditions go beyond their thermal comfort zone. The livelihood of the rural poor in developing countries depends critically on local natural resource-based activities such as crop and livestock production. As a result of negative weather impact on livestock rearing, the poor shepherds/farmers whose principal livelihood security depends on these animal performances is directly on stake. Housing and management technologies are available through which climatic impacts on livestock can be reduced, but the rational use of such technologies is crucial for the survival and profitability of the livestock enterprise (Gaughan *et al.,* 2002).

3. Impact of climate change on livestock production

The scientific evidence of anthropogenic interference with the climate system through greenhouse gas (GHG) emissions has led to worldwide research on assessing the impacts that might result from potential climate change associated with GHG accumulation. As the ecosystems are sensitive to changes in climate, it is necessary to examine the likely impact of climate change on various sectors within the ecosystems to be able to comprehensively understand the effects of climate change. The agricultural sector has generated considerable interest in this regard and most international studies that examine the impact of climate change on this sector due to global warming conclude that in many instances agriculture will be disadvantaged. The anticipated negative impact of global warming on the climate of India is large.

In India, although the emission rate per animal is much lower than the developed countries, due to huge livestock population, the total annual methane emission is about 9- 10 Tg from enteric fermentation and animal wastes. India possesses the largest livestock population in the world and accounts for the largest number of cattle (world share 16.1 %), buffaloes (57.9 %), second largest number of goats (16.7 %) and third highest number of livestock (5.7 %) in the world (FAOSTAT). The livestock production is an integral part of mixed farming systems practiced in the entire length and breadth of the country. The potential impacts of climate change to livestock sector in India are:

- The anticipated rise in temperature between 2.3 and 4.8°C over the entire country together with increased precipitation resulting from climate change is likely to aggravate the heat stress on farm animals, adversely affecting their productive and reproductive performance,
- Given the vulnerability of India to rise in sea level, the impact of increased intensity of extreme events on the livestock sector would be large and devastating for the low-income rural masses,
- The predicted negative impact of climate change on Indian agriculture would also adversely affect livestock production by aggravating the feed and fodder shortage.

4. Climate Change and concept of multiple stresses

In the present changing climate scenario, there are numerous stresses other than the heat stress which constrain the livestock and have severe consequences on their production. The projected climate change (CC) seriously hampers the pasture availability especially during the period of frequent drought in summer. Thus, livestock suffer from drastic nutrition deficiency. Both the quantity and the quality of the available pastures are affected during extreme environmental conditions. Further, with the changing climate, animals have to walk a long distances in search of pastures. This locomotory activity also put the livestock species under enormous stress. The majority of domesticated ruminants are raised solely or partially in semi-extensive or extensive production systems in which most nutrients are derived from grazed forage. Grazing is associated with daily activities considerably different than for confined animals, such as time spent eating and distances travelled. These activities result in greater energy expenditure than in confinement, which can limit energy available for maintenance and production.

The grazing animals in the tropical areas usually have access to poor quality food available at lower densities per unit area, and to counter such hardship, animals increase their grazing time and disperse widely. Hence it's not only the heat stress that need to be counteracted but the nutrition and walking stress are also of great concern. Though the animals live in a complex world, researchers most often study the influence of only one stress factor at a time. Comprehensive, balanced, and multifactorial experiments are technically difficult to manage, analyze and interpret. When exposed to one stress at a time, animals can effectively counter it based on their stored body reserves and without altering the productive functions. However, if they are exposed to more than one stress at a time, the summated effects of the different stressors might prove detrimental to these animals. Such a response is attributed to animal's inability to cope with the combined effects

of different stressors simultaneously. In such a case, the animal's body reserves are not sufficient to effectively counter multiple environmental stressors. As a result their adaptive capabilities are hampered and the animals struggle to maintain normal homeothermy. Moberg (2000) hypothesized that when animals are exposed to only one stress, they may not require the diversion of biological resources needed for other functions. If, however, two of these stressors occur simultaneously, the total cost may have a severe impact on other biological functions. Thus, normal basal functions are drastically affected which jeopardizes production.

5. Adaptation measures to be undertaken to improve livestock production under changing climatic scenario

Adaptive strategy and capacity is likely to vary, depending on availability and access to technology at various levels in all sectors. Many of the adaptive strategies for managing climate change directly or indirectly involve technology. Livestock has the potential to support the adaptation efforts of the poor. In general, livestock is more resistant to climate change than crops because of its mobility and access to feed. However, it is important to remember that the capacity of local communities to adapt to climate change and mitigate its impacts will also depend on their socio-economic and environmental conditions, and on the resources they have available. Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. However, the expanding human population, urbanization, environmental degradation and increased consumption of animal source foods have rendered some of those coping mechanisms ineffective. In addition, changes brought about by global warming are likely to happen at such a speed that they will exceed the capacity of spontaneous adaptation of both human communities and animal species.

Broadly speaking, at the regional, national or local level, the new strategies consist of a displacement of livestock into areas where natural resources are available. At the local level, new feeding approaches are used, leading to the adoption either of new feeds, or other forms of rangeland management. There are a number of initiatives of adaptation to climate change on a regional or national scale. Be they regional or national, the strategies proposed by political authorities to respond to climate change, have in common the fact that they are not specific to livestock, even in arid and sub-arid countries where livestock is an important part of the economy and very often is the sector most affected by climate change. With regard to regional initiatives, these are at the stage of design and strategy development rather than concrete proposals ready for implementation.

National actions are envisaged by the States under the United Nations Framework Convention on Climate Change. These include the National Communication Programs for climate change and the National Action Programs for Adaptation (PANA). In fact, under these two frameworks, states have limited their actions to doing a vulnerability analysis and an inventory of measures for adaptation and mitigation without advocating to appropriate actions relevant to national agro-climatic conditions and traditional livestock practices. Table 1 describes the different adaptation strategies under the changing climate scenario.

Table. 1. Livestock adaptation strategies under ensuing climate change scenario

Sl.No.	Parameters for livestock adaptation	Respective livestock adaptation strategies
1.	**Production adjustments**	Change in quantity and timing of precipitation
2.	**Breeding strategies**	i) Identifying and strengthening local breeds that have adapted to local climatic stress and feed sources ii) Improving local genetics through cross-breeding with heat and disease-tolerant breeds
3.	**Market Responses**	i) For example, promotion of interregional trade and credit schemes
4.	**Institutional and policy changes**	i) Removing or introducing subsidies, insurance systems ii) Income diversification practices iii) Livestock early warning systems
5.	**Science and technology development**	i) Understanding of the impacts of climate change on livestock ii) Developing new breeds and genetic types iii) Improving animal health iv) Enhancing soil and water manage
6.	**Capacity building for livestock keepers**	i) Understanding and awareness of climate change ii) Training in agro-ecological technologies and practices
7.	**Livestock management systems**	i) Provision of shade and water to reduce heat stress from increased temperature ii) Reduction of livestock numbers in some cases iii) Changes in livestock/herd composition iv) Improved management of water resources

5.1. Different livestock adaptation options to sustain production

- Developing and promoting drought-tolerant and early-maturing crop species
- The adoption of improved animal breeds and grass/ legume seed stock with increased resilience to projected climate conditions
- Adapt annual production cycle to better match feed production
- Adopting Integrated Disease Surveillance Response systems and emergency preparedness to prevent, mitigate, and respond to epidemic
- Strengthening meteorological services to provide timely weather and climate forecast/information early-warning systems
- Promoting and strengthening aquaculture, poultry raising, and the like as alternative livelihood options
- Developing and promoting guidelines for using herbal and alternative medicines
- Increasing agriculture extension activities for wide dissemination of knowledge about climate change impact
- Migration of livestock to better fodder production areas during drought

5.2. Technological interventions to meet the climate change challenge in smallholder livestock system

- Conserving genetic resources: This requires better characterization of breeds, production environments and associated knowledge; the compilation of more complete breed inventories; improved mechanisms to monitor and respond to threats to genetic diversity; more effective *in situ* and *ex situ* conservation measures; genetic improvement programs targeting adaptive traits in high-output and performance traits for developing countries in their management of

animal genetic resources; and wider access to genetic resources and associated knowledge

- A variety of technologies can be used to deal with the effects of short-term heat waves, including shading or sprinkling to reduce excessive heat loads. Improved farmhouse micro-climate management through the use of thermal insulating construction materials and modern ventilation systems to protect livestock from extreme conditions and increase productivity
- Improved pasture management by matching stocking rates to pasture production and integrating pasture improvement to increase feed value
- Efforts are needed to develop suitable breeding program specific for climate change adaptation and mitigation. Projections suggest that further selection for breeds with effective thermoregulatory control will be needed. This calls for the inclusion of traits associated with thermal tolerance in breeding indices, and more consideration of genotype-by-environment interactions (GxE) to identify animals most adapted to specific conditions. Selections for heat tolerance based on temperature-humidity index (THI) in genetic evaluation models are promising. Significance of including molecular markers and marker assisted selection in such breeding programs offers huge scope for developing the most appropriate breed which can survive and reproduce normally in specific agro-ecological zone

5.3. Supporting adaptive capacities

- Adaptive capacity, at individual, community or national levels, is poorly understood. However, there are risks inherent in externally-driven determination of risks and opportunities for adaptation. Top-down and externally driven approaches have often been harmful to development in the past and it is critical to develop a broader understanding of the determinants of adaptive capacity. The ability to adapt may consist of a number of fundamental attributes that are relevant across a range of threats.
- ***Improving the assessment of threats:*** This can enable farmers and planners to react appropriately and rapidly. This requires better access to information and greater capacity to interpret information and understand the implications of a given threat. At a local level this requires training and awareness, improved understanding between farmers and extension workers, and investment in information infrastructure. At the national level, greater investment may be required to improve meteorological data collection and dissemination so that information is available regularly and reliably.
- ***Capability to adopt the chosen strategy:*** This relies to a large extent on the core livelihood assets: human, social, physical, financial and natural capital. In more practical terms, to be capable of deploying a preferred adaptation option, people need particular skills, resources and infrastructure. Many of the basic capabilities of livestock keepers are weak, leading to their underdevelopment and contributing to their vulnerability to climate change and other threats. Training is important to develop these capabilities, as is access to financial services and markets.
- ***Freedom to implement the chosen strategy:*** these cuts across policy, governance and rights. At a local level, farmers need secure property rights, strong and equitable local institutions, and functioning legal systems. They also need government to put in place supportive policies, to relax policy disincentives, and to effectively implement key policies. Important policy gaps include market development, natural resource governance and tenure, women's rights, legitimizing local organizations, and the regulation and protection of transhumance routes. Freedom to adapt can also be constrained by cultural and societal norms, which must be taken into consideration by adopting appropriately participative and empowering approaches to adaptive development.
- ***Enabling informed choice:*** Livestock keepers and advisors/planners do not necessarily require the development of new choices. Many adaptation options are already known and it is important to ensure that farmers and planners can make both sense and use of the options available to them. This requires the building of human capabilities through education and improved extension services and through better

access to information sources. Collaborative research is required where adaptation options still need to be developed, to ensure that both endogenous and exogenous knowledge is considered.

6. Sustenance of livestock production and mitigation of climate change

The livestock sector is relatively small, even when looked at as a global industry, but social contribution is huge, both in terms of the production of a quality, healthy red meat and through the use of livestock as a positive environmental management tool. Promotion of sustainable livestock production will be vital to ensure that the impact of climate change is minimized on the livestock farmers. This will involve rearing of animals which are more sturdy, heat tolerant, disease resistant, and relatively adaptable to the adverse conditions. In such a situation some of the indigenous breeds will be able to cope much better than the crossbred as crosses containing higher exotic inheritance exhibiting problems of survival when compared to indigenous breeds.

Relatively, there is a lot of basic knowledge on the interaction between heat stress and livestock production, reproduction, and health traits. The implementation of the knowledge to maintain the welfare of animals maintained under extensive management systems is difficult because of objective limitations to monitor heat stress and economic compulsions in applying measures to ameliorate heat stress. From welfare point of view, ideally the animals should be raised in the zone of optimal thermal well being. However, these would be almost impracticable goal to attain in dominant grazing system of the world. The following recommendations are general rules that can be applied under extensive conditions: (i) provision of shade shelter in areas where typical ambient temperature during summer exceeds above than normal; (ii) provision of water: it is recommended that the distance between watering spot and grazing area be such that grazing livestock are able to visit the water spot at least once a day. In order to avoid negative interactions with other stressful factors, particular emphasize should be given for adequate supplementation and provision of clean water. There are substantial environmental benefits associated with sustainable livestock production. In extensive system of rearing generally, sustainable livestock production is pasture-based and requires little or no supplemental feed. The ways and means by which sustainable livestock production can minimize climate change are:

- Producing forage on-site and without the use of energy-intensive inputs including fertilizers, herbicides, and fuels to dry and store feed, generally lowers the embodied energy in livestock feed
- When feeding native hay and grains that are produced locally, the energy required for transportation is reduced further due to shorter distances between the feed source and the livestock
- Since fossil fuels are primary sources of greenhouse gas emissions such as CO_2, using fewer energy inputs usually reduces emissions as well
- Providing livestock with access to pasture forage improves the ecological balance between forage and livestock
- Pastured livestock efficiently close the loop between harvesting forage and returning nutrients to the soil, and with less energy than if forage were harvested and hauled from the pasture and manure was then hauled back out onto the pasture
- Distributing manure and urine on the pasture also reduces methane emissions from manure slurry
- Proper soil and pasture management can also mitigate the release of emissions. Under certain soil conditions, N_2O emissions are released from the soil through a process called de nitrification. An excessive buildup of manure and urine (nitrogen, ammonium) in water-saturated soils can lead to de nitrification and the release of N_2O, a greenhouse gas 310 times more powerful than CO_2. Rotating animals through pastures and moving feeding, watering, and shade areas will help spread the manure and urine out more uniformly and may help decrease N_2O emissions from pasture soils

As livestock is the ruminant animal, its contribution to global warming is by far through CH_4 production.

Hence while aiming at sustainable livestock production; it is imperative to concentrate on reduction strategies for enteric methane production. The enteric methane emission reduction strategies can be grouped under three broader headings including managemental, nutritional and other molecular strategies. Any reduction strategies must be confined to the following general framework such as development priority, product demand, infrastructure, livestock resource and local resources. The most attractive emissions mitigation projects must balance the needs in all of these areas, so that no one factor creates a constraint on continued improvement in production efficiency, and the resulting CH_4 emission reductions. Within this framework, CH_4 emissions mitigation options for enteric fermentation can encompass a wide range of activities across these areas. However, underlying these activities must be specific options for improving the production efficiency of livestock. Without these options, CH_4 emissions cannot be reduced.

6. Concluding remarks

Scientific research can help the livestock sector in the battle against climate change. All animal scientists must collaborate closely with colleagues of other disciplines, first with agronomists then, physicists, meteorologists, engineers, economists, etc. The effort in selecting animals that up to now has been primarily oriented toward productive traits, from now on, must be oriented toward robustness, and above all adaptability to heat stress. In this way molecular biology could allow to directly achieve genotypes with the necessary phenotypic characteristics. Research must continue developing new techniques of cooling systems such as thermo-isolation, concentrating more than in the past on techniques requiring low energy expenditure. New indices that are more complete than THI to evaluate the climatic effects on each animal species must be developed and weather forecast reports must also be developed with these indices, to inform the farmers in advance. Above all to beat the climate change or in any case not to let the climate beat livestock systems, researchers must be very aware of technologies of water conservation.

7. Future Perspectives

Responding to the challenges of global warming necessitates a paradigm shift in the practice of agriculture and in the role of livestock within the farming system. Science and technology are lacking in thematic issues, including those related to climatic adaptation, dissemination of new understandings in rangeland ecology, and a holistic understanding of pastoral resource management. Livestock farmers should have key roles in determining what adaptation and mitigation strategies they support if these have to sustain livestock production in changing climate. The integration of new technologies into the research and technology transfer systems potentially offers many opportunities for further development of climate change adaptation strategies.