1. INTRODUCTION

Livestock sector is socially and economically very significant in developing countries like India due to the multi-functionality of livestock performing output, input, asset and socio-cultural functions. Rapid population growth, urbanization and income growth in developing countries is fuelling a massive increase in global demand for food from animal origin. Driven by the drivers of demand, the world agriculture is slated to witness livestock revolution in the next 20 years or so (Delgado et al., 1999). However, with looming threat of climate change posing formidable development challenge to biological production systems, concerns have emerged regarding the ability of the livestock system to sustain increase in supply for keeping pace with the burgeoning demand of livestock products. As the issues of vulnerability and adaptation of livestock production to climate change have begun to occupy the center stage for the future course of development of the sector, this chapter focuses on the coping strategies that will have to be put in place for countering the sensitivity of livestock to changing climate.

The discussion in this chapter deliberates around dairy production as dairying has predominant share in livestock production and population. The dairy sector in India produces output worth Rs. 1245.2 billion (2005-2006) that is 67% of the value of output from livestock sector and highest among all the agricultural commodities. Among the various species of livestock, cattle and buffalo account for 61% of the livestock population in the country. India possesses about 105 million dairy animals (2003 livestock census) producing 100 million tonnes of milk. With 15% of the world milk production, 16 and 58% of world population of cattle and buffaloes, respectively, it is the top ranking country in the world in terms of milk production and number of dairy animals. In this backdrop, this chapter throws light on the sensitivity of livestock production to climate change, particularly in the context of dairy production in India, and focuses on the need to target the climate change adaptation responses. A detailed discussion on the various adaptation strategies that can insulate the smallholder dairy production to climate change vulnerability is also presented.

2. VULNERABILITY OF DAIRY PRODUCTION TO CLIMATE CHANGE

Climate strongly influences the growth, production, reproduction, health and well-being of the livestock through affecting animal physiology; incidence of diseases; feed, fodder and water availability etc.

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2.1 Heat Stress

Livestock must regulate their body temperature within a relatively narrow range to remain healthy and productive. The ambient temperature below or above the thermoneutral range creates stress conditions in animals. The approximate thermal-comfort zone for optimum performance of adult cattle is reported to be 5 to 15 °C (Hahn, 1999), however, significant changes in feed intake or in numerous physiological processes will not occur within the range of 5 to 25 °C (McDowell, 1972).

Increase in ambient temperature decreases the difference between the temperature of the animal’s surroundings and its body, hence, increasing reliance on evaporative cooling (sweating and panting) to dissipate body heat. In the situation of high relative humidity the effectiveness of evaporative cooling is reduced. Thus, during hot, humid weather conditions the cow cannot eliminate sufficient body heat and suffers from heat stress. The critical values for minimum, mean and maximum Temperature Humidity Index (THI), which incorporates the combined effects of temperature and relative humidity, are determined to be 64, 72 and 76 respectively (Igono et al., 1992).

Net effect of heat stress is increase in heat loss by evaporation and decrease in heat production by metabolism. Heat stress induces physiological changes in cattle, which include reduced feed intake and metabolic activity and thereby declining their productivity (NRC, 2001). The estimated milk yield reduction per unit increase in THI was reported to range from 0.20 to 0.32 kg (Ingraham et al., 1979; Ravagnolo et al., 2000). A few studies give a much higher magnitude of decline; for instance, the milk yield for Holsteins was observed to decline by 0.88 kg per THI unit increase for the two-day lag of mean THI (West et al., 2003).

Systematic studies of similar nature for the Indian dairy animals are not available; albeit the experimental studies have shown milk yield of crossbred cows in India (e.g., Karan Fries, Karan Swiss and other Holstein and Jersey crosses) to be negatively correlated with temperature-humidity index (Shinde et al., 1990; Kulkarni et al., 1998; Mandal et al., 2002a). The influence of climatic conditions on milk production is also observed for local cows which are more adapted to the tropical climate of India. The rising temperature decreased the total dry matter intake and milk yield in Haryana cows (Lal et al., 1987). The productivity of Sahiwal cows also showed a decline due to increase in temperature and relative humidity (Mandal et al., 2002b). In case of buffaloes also, heat stress has detrimental effect on the reproduction of buffaloes (Kaur and Arora, 1982; Tailor and Nagda, 2005) even though the morphological and anatomical characteristics of buffaloes make them well-suited to hot and humid climates.

Some preliminary estimates of economic losses from heat stress in dairy animals, at the national and sub-national level, work out to be whopping Rs. 2661.62 crores (at 2005-06 prices), about 2% of the value of output from milk group. The economic losses were highest in UP (> Rs. 350 crores) followed by Tamil Nadu, Rajasthan and West Bengal (Fig. 1). With likely increase in temperature due to climate change the heat stress in dairy animals would accentuate, thereby, further increasing the magnitude of economic losses attributable to heat stress. The high resolution climate change scenarios and projections for India, based on regional climate modeling system, known as PRECIS (Providing REgional Climates for Impacts Studies) developed by Hadley Center for Climate Prediction and Research, shows that by the end of the century, the annual mean surface temperature is expected to rise by 2.5 to 5 °C, with warming more pronounced in the northern parts of the country (Kumar et al., 2006).

2.2 Susceptibility to Extreme Events

Besides being susceptible to increased heat stress from climate change, the cattle in India are also exposed to the increased risk of extreme events. UNEP (1989) identifies India among the 27 countries that are