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# Sensitivity of Livestock Production to Climatic Variability under Indian Drylands and Future Perspective

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**ABSTRACT**

The livestock production system is considered equally sensitive to climate change as that of core agriculture system and at the same time livestock itself is also contributing to the phenomenon. The present paper attempts to analyze the sensitivity of livestock productivity in rainfed regions to climatic variability, significance of climate change with respect to Indian livestock and mitigation options and leverage points in such a scenario. The sensitivity of livestock productivity was examined by using district level data of milk productivity of cow as well as buffalo for the year 1992 and 1997 for 100 districts which was regressed on important weather variables. The analysis shows that weather variables like rainfall and temperature do significantly influence the milk productivity of animals in rainfed regions. Increased climatic variability due to changing climate is likely to negatively influence the livestock productivity. Based on analysis and stakeholders consultation the paper suggests appropriate adaptation strategies particularly focusing on mitigating feed scarcity situations arising due to climatic variability.

**Key words:** Livestock, Sensitivity to Climatic Variability, Drylands, Adaptation.

## INTRODUCTION

Climate change is a global phenomenon; its negative impacts are likely to be felt more severely by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. Agriculture and livestock are among the most climate sensitive economic sectors. The IPCC (2007) predicts that by 2100 the increase in global surface temperature may be between 1.8 and 4.0$^0$ C[1]. If global average temperature increases by 1.5 – 2.5$^0$ C, approximately 20-30 % of plant and animal species are expected to be at risk of extinction[2]. Worldwide, the livestock sector is growing faster than any other agricultural sub-sector, providing livelihoods for around 1.3 billion people and contributing about 40% to global agricultural output[3]. Livestock are also a source of renewable energy and plant nutrients. In India too, the livestock is a major component of agriculture especially in rainfed areas. It provides not only food, fuel, manure and draught power but is a most stable source of income for resource poor rural people in the rainfed regions. Faced with low productivity and high uncertainty in crop production, rural people in rainfed regions are increasingly dependent on livestock rearing for their livelihood. Besides contributing over one-fourth to the agricultural GDP, the livestock provides employment to 22.45 million people in principal or subsidiary status with 75 % of them being women[4]. However the livestock production system is considered equally sensitive to climate change as that of core agriculture system and at the same time livestock itself is also contributing to the phenomenon. As per FAO (2007) the livestock rearing attributes to about 18 percent of total anthropogenic GHG emissions[5]. Consequently, the livestock sector is often condemned for its contribution to climate change. On the other hand poor smallholder livestock keepers and pastoralists are more likely to be impacted by climate change than to contribute significantly to global warming.

The climate change is expected to have far-reaching consequences for dairy, meat and wool production mainly via impacts on grass and range land productivity. Heat distress on animals may reduce the rate of animal feed intake and cause poor growth performance[6]. The impacts that climate change may bring about are expected to exacerbate the vulnerability of livestock systems and reinforce existing factors that are simultaneously affecting livestock production systems such as rapid population and economic growth, increased demand for food and feed products and increased conflict over scarce resources. Loss of livestock assets for rural communities might lead to their collapse into chronic poverty with long term effect on their livelihoods. Hence, the climate change has been considered to be an increasingly formidable challenge to the development of the livestock sector in India. Responding to the challenge of climate change requires analyzing sensitivity of livestock to climatic variability and appropriate adaptation and mitigation options for the sector, number of studies have been undertaken on physiological aspects and methane emission potential of livestock under different feeding conditions[7,8,9,10]. But there is still need to understand much more about the impact of changing climate on livestock production and its adaptation potential. Livestock production is blamed globally for greenhouse gas emissions[3]. But it also needs to be understood that livestock production system as such also results in green house gas mitigation, especially small holder livestock production system in developing countries. In this backdrop the present paper attempts to analyze the sensitivity of bovine milk productivity in rainfed regions to climatic variability, significance of climate change with respect to Indian livestock and mitigation options and leverage points in such a scenario.

## MATERIALS AND METHODS

Climate change, particularly, the increase in temperature is a very slow process. The humans as well as animals may adapt to a certain extent to slow changing climatic process, but the extreme events like droughts, floods, erratic rainfall are likely to have greater impact on the productivity of animals. An attempt has been made in the present study to examine sensitivity of livestock productivity by using district level data of milk productivity of cow as well as buffalo for the year 1992 and 1997 for 100 districts. The average productivity is regressed on two important weather variables viz., annual maximum temperature and annual rainfall besides time trend representing technological change. The data on livestock population was sourced from Livestock Census, Govt. of India (1992, 1997, 2003 and 2007)[11], and climate data from Http://www.indiawaterportal.org/, district level data computed from Climate Research Unit (CRU) TS2.1 dataset, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia in Norwich, UK[12]. The care was taken that districts selected for analysis were not affected by any disease outbreak during the study period.

The regression model is expressed as given below.

$Y_\beta = f(X_T, X_R, X_Y)$

$Y_C = f(X_T, X_R, X_C, X_Y)$

Where, $Y_C$ = District wise milk productivity of cow (liter/year)

$Y_\beta$ = District wise milk productivity of buffalo (liter/year)

$X_T$ = Annual maximum temperature ($^0$C)

$X_R$ = Total annual rainfall (mm)

$X_Y$ = Time (year)

$X_C$ = % of crossbreed cows in total

The regression functions were fitted by using district level data from the four rainfed states namely Andhra Pradesh, Maharashtra, Karnataka and Tamilnadu. The functions were fitted separately for cow and buffalo and using data only from the rainfed districts of these states. A district has been defined as 'rainfed' which is either DPAP (drought prone area programme) or DDP (desert development programme) district or has less than 30 % net irrigated area under dry sub-humid ecosystems[13, 14]. This functional analysis is only a preliminary effort to understand the sensitivity of livestock productivity to changing weather parameters as the non-availability of data on critical parameters pertaining to livestock production was a major limitation. Data for the recent period is not available on district-level milk productivity of cows and buffalo. Further, the time-series data on fodder availability or area under cultivated fodder and milk prices is also not available. Moreover, breed is an important factor affecting milk productivity. However, breed-wise population of cow or buffalo at district level is not available. Even the numbers of commercial dairy farms which manage to get feed and fodder from long distances also affect the district level average milk productivity, the information on them is not available. Hence the functional analysis was carried out with available data set. Further, the present study reviews the past studies and interactions with the stakeholders to analyze the impact of changing climate on livestock sector and suggest adaptation strategies.

## RESULTS AND DISCUSSION

### Livestock in the Context of Changing Climate

In the next few decades there is need to enhance livestock production significantly to meet the continuously increasing demand for its products due to increasing human population, per capita income and changing food habits. During the same period significant climate changes are also expected globally. The livestock is considered one of the causes of greenhouse gas emissions, at the same time livestock production is also likely to get adversely impacted due to changing climate. Hence increased climatic variability and change is a major long-term challenge for the livestock keepers throughout the world. Poor land use, like deforestation and overgrazing contributes to more

**Table 1: Districts with highest population growth of major livestock species during 1992-2007 (compound annual growth rate (CAGR))**

| Cattle | | Buffalo | | Goat | | Sheep | |
|---|---|---|---|---|---|---|---|
| **District** | **CAGR** | **District** | **CAGR** | **District** | **CAGR** | **District** | **CAGR** |
| Tirunelveli | 33.2 | Tirunelveli | 53.0 | Theni | 55.2 | Sheopur | 153.3 |
| Sonipet | 27.3 | Kanpur City | 18.6 | Kanpur City | 24.4 | Gondiya | 111.5 |
| Theni | 26.9 | Patan | 13.1 | Kancheepuram | 22.4 | Theni | 108.9 |
| Kanpur City | 18.9 | Panchkula | 12.4 | Thiruvarur | 20.0 | Washim | 67.6 |
| Kancheepuram | 15.4 | Theni | 11.9 | Ananthapur | 15.9 | Tirunelveli | 56.8 |
| Gandhinagar | 14.3 | Jajpur | 11.4 | Malkangiri | 13.4 | North Cachar Hills | 50.1 |
| Washim | 14.3 | Gandhinagar | 11.2 | Kodagu | 12.7 | Harda | 48.6 |
| Katni | 14.1 | Sonipet | 10.6 | The Nilgiris | 11.3 | Kanpur City | 46.1 |
| Sheopur | 10.1 | Jaisalmer | 9.2 | Koppal | 10.3 | Kancheepuram | 23.8 |
| Virudhunagar | 8.5 | Anand | 8.8 | Pondicherry | 9.8 | Dindori | 20.8 |
| Dindori | 7.6 | Sheopur | 7.9 | Fatehgarh Sahib | 8.8 | Goalpara | 17.9 |
| Shrawasti | 7.1 | Kancheepuram | 7.5 | Gandhinagar | 8.8 | Koppal | 17.4 |
| Namakkal | 6.8 | Dahod | 7.3 | Umaria | 8.4 | Bongaigoan | 15.6 |
| Chitrakut | 6.7 | Katni | 7.1 | Davanagere | 8.0 | West Godavari | 15.4 |
| Valsad | 6.6 | Jhunjunu | 7.1 | Pudukkottai | 7.8 | Delhi | 15.2 |
| Hyderabad | 6.5 | Barmer | 7.1 | Khammam | 7.8 | Pondicherry | 14.8 |
| Umaria | 6.2 | Dindori | 7.0 | Tirunelveli | 7.8 | Ananthapur | 14.0 |
| Thoothukudi | 6.0 | Ananthapur | 6.7 | Kurnool | 7.6 | Goa | 13.9 |
| Kullu | 5.3 | Valsad | 6.3 | Virudhunagar | 7.6 | Hyderabad | 13.9 |
| Arwal | 4.7 | Surendranagar | 6.3 | Panipet | 7.6 | Nizamabad | 13.8 |
| Kishanganj | 4.7 | Datia | 6.3 | Nizamabad | 7.3 | Kasaragod | 13.7 |
| Saharsa | 4.7 | Shrawasti | 6.1 | Dahod | 7.2 | Katni | 13.4 |
| Banka | 4.7 | Muktsar | 6.0 | Adilabad | 6.9 | Davanagere | 13.0 |
| Rohtas | 4.7 | Adilabad | 6.0 | Sonbhadra | 6.8 | Nalbari | 13.0 |
| Jamui | 4.7 | Porbandar | 5.6 | Hyderabad | 6.6 | Medak | 12.6 |
| East Champaran | 4.7 | Jhabua | 5.5 | Thiruvananthapuram | 6.6 | Kodagu | 12.5 |
| Kaimur (Bhabua) | 4.7 | Tikamgarh | 5.5 | Cuddapah | 6.5 | Hailakandi | 12.3 |
| Munger | 4.7 | Junagadh | 5.5 | Guntur | 6.1 | Warangal | 12.2 |
| Purnea | 4.7 | Ujjain | 4.9 | Medak | 6.0 | Sonipet | 12.2 |
| Katihar | 4.7 | Delhi | 4.8 | Lakhimpur | 5.7 | Barpeta | 11.3 |

than one-third of the greenhouse gases attributed to livestock production [15]. In many developing countries including India, land degradation is common due to overgrazing by livestock. It has been found that appropriate soil and water conservation, controlled grazing, and using manure could double the production of grains and livestock[15]. Large scale adoption of such practices is however slow. Poor management of manure is another major source of greenhouse gases from livestock. Reduction in such emissions is possible by adopting improved methods of animal waste management and using it for soil health improvement. For example, converting the dung into biogas would provide clean fuel as well as manure and would have implications in terms of reduced deforestation and women drudgery. One fourth of the greenhouse gases produced by livestock come from livestock itself because of the fermenting microbes in their stomach. However enteric methane production would continue to be there as long as the ruminants are reared. But that can be minimized by changing livestock's diet. Feeding of more concentrate feed reduces enteric methane production per unit of production[10]. However the intensification of livestock may put limit if it competes with human food particularly in highly populated developing countries like India. The other sources of greenhouse gases produced by livestock are due to fertilizer use for fodder production and deforestation. This could be mitigated to some extent by using the land more efficiently. At the same time it should be noted that the ruminants rearing also contribute to climate change mitigation in many ways.

The annual compound growth rate of the four major livestock species during 1992-2007 as depicted in Table 1 for top 30 districts in the country shows that the population of the livestock has been increasing at a very fast rate in some of the districts. It may be mentioned that most of these fast growing top 30 districts, fall under rainfed regions. In case of goats 19; for buffalo 18; for sheep 17 and in case of cattle 16 out of 30 top districts are the rainfed districts. In spite of general feed and fodder scarcity in the rainfed regions, the livestock has performed well. It clearly indicates the higher utility and significance of livestock as means of livelihood security in the rainfed regions. However very high grow rate in buffalo production, which comparatively require more water, in drier districts may have implications in terms of its sustainability.

**Immediate Concerns for Livestock in rainfed and Dryland Regions**

Increasing water scarcity is affecting more than a billion people in the world and climate change impacts are expected to have substantial effect on water availability in future. These will not only influence drinking water sources, but also the livestock feed production systems and pasture yields. In semi-arid regions where the length of growing seasons is likely to decrease, the range land / pasture productivity may decrease[16]. Some of the indirect effects may be brought about by change in feed resources linked to the carrying capacity of range-lands, the buffering abilities of ecosystems, increased desertification processes, increased scarcity of water resources, lower production of grain, etc.

The climatic variability especially the increased number of extreme weather events such as droughts, dry spells, erratic rainfall, flood, etc. is a particular cause of concern for the agricultural and livestock production systems in the country. The rainfed regions in India which account for 56 % of the total net sown area and 40 % of total food production and support more than 60 % livestock population of the country are more vulnerable to climatic variability because of their greater dependence on natural resources and rainwater[17]. The amount and distribution of rainfall and level of temperature through their impact on rangeland/ pasture productivity may have significant bearing on livestock productivity. The relationships between milk productivity of buffalo and cow in rainfed districts and different weather variables were examined through regression analysis and the results of which are presented in Table 2 and 3.

The regression analysis between cattle and buffalo milk productivity and weather variables is an attempt to find relationship between them. The model could not include some of the important explanatory variables like price of milk, actual availability of feed/fodder and animal breed on account of non-availability of district level data on these. However, the regression analysis to some extent does explain the relationship between milk productivity and weather variables.

In case of buffalo, positive and highly significant coefficient for annual rainfall indicates that it is one of the most important determinants of milk productivity and shows that an increase in annual rainfall would significantly increase the milk productivity of buffaloes (Table 2). The increase in rainfall in semi-arid rainfed districts of Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu would influence milk productivity of buffaloes through increased feed and fodder production from commons and private lands as water is scarce and rainfall is the major source of water in these regions. Rainwater conservation and harvesting and recycling and better management of CPRs (common property resources) should be part of the adaptation strategies. Significant coefficient of annual maximum temperature indicates that the rise in monthly maximum temperature negatively influences the milk productivity. The higher temperature months are also the months of fodder scarcity due to water scarcity and would probably have comparatively higher solar radiation. The variable time indicating the impact of technology, policy and market also had positive coefficient but not significant.

Similarly, a regression model was fitted to examine the relationship between milk productivity of cows and weather variables (Table 3). The regression coefficient of annual maximum temperature was significantly negative similar to that of buffalo. But that needs to be further examined for both cattle as well as buffalo that how much decrease in milk productivity could be attributed to increase in temperature and how much due to feed scarcity in those months and stage of lactation of the animals. However, the coefficient for annual rainfall was negative but not significant. It was possibly due to availability of poor germ plasm / low yielding animals in districts with higher rainfall. The coefficient of rainfall became positive when data from only low rainfall districts (<750 mm per annum) was included in the model. Positive and highly significant coefficient of percentage of crossbred in total cattle population indicates that it was the most important factor influencing district level milk productivity of cows. The variable time indicating the impact of technology, policy and market also had positive coefficient.

## Summing up and Future Strategies

The analysis broadly shows that weather variables like rainfall and maximum temperature do significantly influence the milk productivity of animals in rainfed regions. Increased climatic variability particularly in terms of rainfall (deficit as well as excess) and temperature are likely to negatively influence the livestock productivity. However to precisely understand the impact of climatic variability on milk productivity the experiments under control conditions need to be undertaken for different species/breeds. Hence, there is need to take up such studies and put in place appropriate adaptation

**Table. 2: Relationship between buffalo milk productivity and weather variables in rainfed districts of Andhra Pradesh, Karnataka and Maharashtra (annual rainfall ≤ 1000 mm)**

| | Regression coefficients | Standardized coefficients | Significance |
|---|---|---|---|
| Constant | -21512 | | |
| Annual rainfall, mm | 0.431 | 0.203 | 0.014 |
| Annual maximum temperature | | | |
| | -53.36 | -0.396 | 0.002 |
| Time (year) | 12.16 | 0.115 | 0.404 |
| R2 | 0.26 | | |

Dependent variable: Buffalo milk productivity (kg/annum) strategies particularly focusing on mitigating feed scarcity situations arising due to climatic variability and cost effective appropriate shelter management strategies.

The international negotiations on climate change have now rightly recognized that adaptation is as important as mitigation in dealing with climate change and even the fullest possible mitigation efforts will not prevent the projected rise in temperature till 2100. Therefore, adaptation measures to climate variability and change need greater attention in terms of policy, research and institutional support as follows:

**Effective Integration of Livestock with Agricultural Systems**

Increasing livestock productivity and integrating it effectively into agricultural system would be the best strategy to adapt to climate change. Effective integration of livestock into agricultural systems has multiple benefits. It would improve the soil health and water retention by returning the valuable biomass to the soil and would help in drought proofing. Such recycling of carbon into the soil would not only enhance the soil quality but also the carbon sequestration.

**Table. 3: Relationship between cattle milk productivity and weather variables in rainfed districts of Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra**

| Independent variables | Regression coefficients | Standardized coefficients | Significance |
|---|---|---|---|
| Constant | -39736.6 | | |
| Annual maximum temperature | -31.45 | -0.29 | 0.003 |
| Annual rainfall | -0.05 | -0.07 | 0.434 |
| Percentage of crossbred | 13.96 | 0.44 | 0.000 |
| Time (year) | 20.88 | 0.093 | 0.229 |
| R2 | 0.44 | | |

Dependent variable: cow milk productivity (kg/annum)

The importance of smallholders' livestock production systems in terms of social and environmental value is much higher than its any negative consequences. The livestock is a major source of energy particularly in developing countries like India. The use of livestock for traction and draft power reduces the need for fossil fuels. The methane , generated from animal waste could provide cooking fuel for rural households. This would result in lesser demand on fossil fuel energy by the rural households. The demand for fuel wood could be significantly reduced by promoting properly designed biogas energy solutions resulting into increased carbon sequestration in reforested areas. But bio-gas installations are expensive and their success rate for individual farmers has been very low. The cost reduction and increased adoption could be achieved by promoting customized solutions including community based biogas plants. Even an entrepreneurial model for bio-gas production may also be feasible. Effective integration of livestock into a farm system would also reduce the use of chemical fertilizers and improve soil health[18]. Eco-friendly crop-livestock farming by harnessing the synergies among the systems components has the potential to mitigate some of the adverse effects of changing climate. These integrated farming systems will help not only in better adaptation to changing climate but also contribute to mitigation of climate change impacts.

**Germplasm Diversity**

A rich diversity of number of breeds of cattle, buffalo, goat and sheep is an advantage for the sustainability of Indian livestock production system under the changing climate situation. There are number of breeds of different livestock species that perform well under adverse climatic conditions like high temperature, drought and feed scarcity.

Such breeds with high potential in *Cattle* are: Kankrej, Tharparkar, Deoni, Ongole, Nagauri, Hallikar, etc; that of *Buffalo*: Surti, Jaffrabadi; *Goat*: Sirohi, Osmanabadi, Jamunapari, Jhalawadi, Marwari; and Sheep: Patanwadi, Magra, Malpura, Mandya, etc. that perform well in adverse conditions. Hence even under the changed climate scenario the rich animal germplam available in the country may help to sustain the livestock productivity. However there is need to take up adaptation studies of some potential breeds in the areas that are likely to be affected through climate change and also take up breeding programmes to develop climate change ready breeds which performs better under stress caused due to climatic variability by using available rich germ plasm.

To ensure sustainable livestock production in rainfed regions, which are more sensitive to climatic variability, the mechanisms and arrangements like community fodder banks in dryland areas and decentralized complete feed block making units linked to fodder scarce areas would be required. Improved management of CPRs by involving community is must for sustainable livestock production. The village panchayats managing CPRs better should be incentivized. It may be ensured that the budget allocated for development of livestock component in each watershed project as per common guidelines must be spent for the purpose. Finally it emerges that livestock is not only a problem but also a part of the solution to the challenge of climate change. However there is need to generate species/breed specific information on climate change impacts and immediately put in place appropriate adaptation strategies addressing mitigation of feed scarcity situations arising due to climatic variability and cost effective appropriate shelter management strategies.

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