



## Effect of drought on livestock enterprise: Evidence from Rajasthan

VINITA KANWAL<sup>1</sup>, SMITA SIROHI<sup>2</sup> and PREM CHAND<sup>3</sup>

National Dairy Research Institute, Karnal, Haryana 132 001 India

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### ABSTRACT

Livestock act as a cushion against vagaries of nature and augment income of the farmers, particularly in drought prone Rajasthan. However, to what extent it withheld the adverse climatic situation has been a less probed area at least at macro-level. This paper studies the impact of drought on milk and meat enterprises in the drought prone state of Rajasthan using district level secondary data for the period of 1983/84 to 2015/16. Standardized Precipitation Index (SPI) was used to determine drought years. Results indicated that although the sector has been able to absorb the minor shocks of droughts, the major droughts affect the livestock adversely. The drought prone districts of western Rajasthan were found to be much prepared for drought than the southern and south eastern districts. Study recommends that the strategies followed by western districts such as stock of fodder, fodder bank, perennial grasses, etc. should be promoted in rest of the areas of the state for sustainable livestock production.

**Key words:** Climate Risks, Livestock, Sustainability, Standardized Precipitation Index

Livestock enterprise which is often considered to cushion the rural livelihoods against vagaries of nature is itself getting more and more susceptible to weather conditions, especially in the context of climate change due to global warming (Hulme *et al.* 2002; Olival and Daszak 2005; Sirohi and Michaleowa 2007; Thornton *et al.* 2009; Gill *et al.* 2010; Choudhary 2017). Most of the studies conclude that elevation of heat stress due to rise in ambient temperature will have adverse effect on the productivity of dairy animals (West 2003; De Rensis and Scaramuzzi 2003; Nardone 2010). Even in case of small ruminants that are more adapted to harsh climatic conditions, the exposure to thermal stress affects voluntary feed intake and maintenance requirement resulting in a decrease of body weight, average daily gain, etc. (Shelton 2000; Abdel-Hafez 2002).

Besides being susceptible to a general temperature increase from climate change, livestock are also exposed to an increased risk of extreme events like drought. In regions where livestock are expensively reared on rangelands, the effect of drought on rangeland productivity has important bearing on the dynamics of livestock population (Begzsuren *et al.* 2004; Desta and Coppock 2004). As dry periods progress, livestock are obliged to mobilize body fat reserves to balance for the nutrients deficiency in the diet. Eventually, droughts cause livestock

population fluctuations through increased mortality and reduced birth rates (Ellis and Swift 1988; Oba 2001).

In India, which is one of the most prone to risk to extreme events due to climate change among the 27 countries (UNEP 1989), studies on the impact of extreme events such as drought on livestock production and population dynamics are very limited (Umamaheswari *et al.* 2001; Biradar and Sridhar 2003; Narain and Kar 2005; Chand and Biradar 2017) and mostly focused at micro-level. This paper aims to bring out the influence of drought on the population and production based on long-term data sets at the state and district level, in the state of Rajasthan, as it is one of the highly drought prone states in the country.

### MATERIALS AND METHODS

**Data source:** The study is entirely based on secondary data. Data on livestock heads domesticated in Rajasthan were obtained from Quinquennial Livestock Census pertaining to period from 1982 to 2012. On the production side, since milk and meat are the major livestock products in the state constituting 87% of the total value of output of livestock products (CSO, 2016), the effect of drought was studied on only these two products. State level data on production and productivity of milk and meat was taken for 1985–2015 from Integrated Sample Survey Reports and Statistical Abstract of Rajasthan. The corresponding data at district level were taken for consecutive major drought years (from 1998 to 2002).

In India, the state governments are the ultimate authority to declare a drought year and local politics and administration often plays lead role in drought declarations

Present address: <sup>1</sup>Research Associate (vinitakanwal888@gmail.com), <sup>3</sup>Scientist (Sr. Scale) (prem3281@gmail.com), ICAR-NIAP, New Delhi. <sup>2</sup>Adviser-Agriculture and Marine Products (smitasirohi@yahoo.com), Embassy of India to the EU, Belgium and Luxembourg, 217 Chaussee de Vleurgat, 1050 Brussels.

(Rathore, 2004). Thus, the final declaration of drought year may not coincide with the actual water deficit years and it may not always capture the actual incidence and intensity of the drought. Hence to avoid such discrepancies this study has taken the metrological data to delineate the extreme and severe drought years from normal years.

Time series daily precipitation data for the period of 1985 to 2013 on the grid scale of  $0.25^{\circ} \times 0.25^{\circ}$  was obtained from Indian Meteorological Department, Pune. District-wise data for Rajasthan was extracted from all India database and severity of climate extremes was determined based on the data. All the district level data used for analysis have been adjusted to district boundaries of 1985 in order to account for changes in the administrative boundaries of districts due to formulation of new districts.

*Analytical tools:* Standardized Rainfall Anomaly/ Standardized Precipitation Index (SPI) as used by Kanwal (2018) was applied to delineate the drought years. The years for entire study period were categorized into four categories, viz. no drought year ( $Z > -0.84$ ), moderate drought ( $0.84 > Z > -1.28$ ), severe drought ( $-1.28 > Z > -1.65$ ) and extreme drought year ( $Z < -1.65$ ) taking the drought severity classes from Chappel and Agnew (1999).

*Indicators for influence of drought on livestock:* The influence of drought was studied in terms of changes in numbers and composition of livestock population, production and productivity trends in the drought and non-drought years.

## RESULTS AND DISCUSSION

*Major drought years:* Based on the Standardized Precipitation Index (SPI), only seven years (1988, 1992, 1994, 1995, 2011, 2012 and 2013) received normal rainfall with no drought incidence in the state of Rajasthan. All the remaining years encountered droughts of various intensities in various districts across the state although the officially declared drought years included 1987, 1999, 2000 and 2002. In total, six years (1987, 1998, 1999, 2000, 2001 and 2002) had extreme or severe droughts in more than 1/10<sup>th</sup> districts and these have been taken to study the influence on livestock enterprise.

*Trends and compositional changes in livestock population:* Although, the livestock census is conducted once in 5 years and hence, the trends and compositional changes at the end of five years cannot be completely attributed to droughts in the inter-census years, yet this data can give some meaningful information, especially for large ruminants as they recover at a slower rate than small ruminants. Based on the Census data and the drought years delineated in the study, the trends in compositional changes in the livestock were studied for the obtained drought years (1987, 1998, 1999, 2000, 2001 and 2002). Change in livestock population and its composition in Rajasthan is given in Table 1. Total cattle population declined at the end of both the drought years however the decline in later period was less (10.6%) over previous drought year (19.1%) perhaps due to development of some resilient mechanisms

in later period. In 1987 census, decline in population of female cattle was particularly due to sharp decline in indigenous female. These animals are more dependent on common property resources than better yielding animals such as buffalo and cross-breed and hence effects are very striking. In the next 10 years (by 1997), their population reached 1982 levels.

Effect of drought is discernible on lactating animals, also these animals are important source of daily earning. Drop in indigenous milch cattle was observed at the end of both drought durations, i.e. 1987 and continuous droughts of 1998 to 2002. Although in these years crossbred population did not drop in absolute terms but in-milk to adult female cattle ratio worsened sharply in 1988 as compared to 1983, suggesting that farmers were forced to maintain dry animals. Again in 2003 it was seen that improvement in wet dry ratio that took place in 1997 over 1992 was arrested in 2003 vis-à-vis 1997 due to series of drought year during this period. Similarly, in buffaloes although absolute numbers of in-milk population and total adult female did not decrease in drought year, yet stagnating ratio of in-milk to adult female cattle during 1997–2003 shows adverse effect of drought on the dairy farmers.

Among the bovines, the losses of cattle were much higher as compared to buffalo. More number of cattle became dry and unproductive during the drought years. Persual of table clearly brings out the impact of the drought in 1987–88, which caused the adult female cattle population to decline to a maximum extent (14.8%). In fact the decline could not recover to its pre-drought levels upto 1997 and the continuous droughts thereafter further reduce the cattle in 2003 census just conducted after these drought years. Among indigenous cattle, which comprises major bovine population, number of adult female declined by 0.76 million and in-milk cattle declined by 0.35 million over previous censuses. The number of dry cattle (crossbred) as well as buffalo increased after drought of 2002 that is also reflected in declined in-milk and adult female cattle ratio of buffalo. Rathore (2004) also noted that during drought years local cattle become unproductive and weak. He observed that there was nobody to buy cows even for slaughter due to imposed ban on cow slaughter in Rajasthan.

A major composition of total livestock included sheep and goat whose population also shows sharp decline during drought years. The small ruminants can be sold for easy cash hence population may drop substantially during drought years. However, the drop in population can be masked by faster multiplication of small ruminants. Results indicated that the population of sheep and goat declined by 26.19% and 18.6%, respectively at the end of 1988 which bounced back in 2003. After the consecutive droughts of five years of 1990s the sheep population declined by 31%. However, the number of goats did not reduce much significantly this time (declined by just 0.96%) over the drought of 1987. This significant reduction in the population of small ruminants is observed probably because of animal sacrifices during scarce years or animal selling as major coping mechanism

Table 1. Changes in bovine composition in Rajasthan

| Particulars              | Category | 1983  | 1988    | 1992  | 1997    | 2003    | 2007    | 2012    |
|--------------------------|----------|-------|---------|-------|---------|---------|---------|---------|
| Cross-bred               | AFC*     | 15    | 28      | 56    | 85      | 249     | 420     | 929     |
|                          |          |       | -86.7   | -100  | -51.8   | -192.9  | -68.7   | -121.2  |
|                          | IM**     | 10    | 15      | 28    | 54      | 173     | 316     | 654     |
|                          |          |       | -50     | -86.7 | -92.9   | -220.4  | -82.7   | -107    |
| Indigenous-cattle        | IM:AFC   | 0.64  | 0.54    | 0.5   | 0.64    | 0.69    | 0.75    | 0.7     |
|                          | AFC      | 5099  | 4342    | 4566  | 4993    | 4652    | 5093    | 5540    |
|                          |          |       | (-14.8) | -5.2  | -9.4    | (-6.8)  | -9.5    | -8.8    |
|                          | IM       | 2110  | 1762    | 2100  | 2411    | 2208    | 2726    | 3091    |
|                          |          |       | (-16.5) | -19.2 | -14.8   | (-8.4)  | -23.5   | -13.4   |
|                          | IM:AFC   | 0.41  | 0.41    | 0.46  | 0.48    | 0.47    | 0.54    | 0.56    |
| Total cattle Population  |          | 13504 | 10920   | 11666 | 12141   | 10854   | 12119   | 13324   |
| Buffalo                  |          |       | (-19.1) | -6.8  | -4.1    | (-10.6) | -11.7   | -9.9    |
|                          | AFC      | 3115  | 3467    | 4133  | 5221    | 5658    | 5824    | 6733    |
|                          |          |       | -11.3   | -19.2 | -26.3   | -8.4    | -2.9    | -15.6   |
|                          | IM       | 1590  | 1863    | 2429  | 3136    | 3392    | 3929    | 4448    |
|                          |          |       | -17.2   | -30.4 | -29.1   | -8.2    | -15.8   | -13.2   |
|                          | IM:AFC   | 0.51  | 0.54    | 0.59  | 0.6     | 0.6     | 0.67    | 0.66    |
| Total buffalo population |          | 6054  | 6340    | 7775  | 9756    | 10414   | 11092   | 12976   |
|                          |          |       | -4.7    | -22.6 | -25.5   | -6.7    | -6.5    | -17     |
| Total livestock          |          | 49650 | 40916   | 48445 | 54348   | 49136   | 56663   | 57732   |
|                          |          |       | (-17.6) | -18.4 | -12.2   | (-9.6)  | -15.3   | -1.9    |
| Small ruminants          |          | 28911 | 22506   | 27849 | 31556   | 26863   | 32693   | 30746   |
|                          |          |       | (-22.2) | -23.7 | -13.3   | (-14.9) | -21.7   | (-6.0)  |
| Sheep                    |          | 13431 | 9913    | 12497 | 14585   | 10054   | 11190   | 9080    |
|                          |          |       | (-26.2) | -26.1 | -16.7   | (-31.1) | -11.3   | (-18.9) |
| Goats                    |          | 15480 | 12593   | 15352 | 16971   | 16809   | 21503   | 21666   |
|                          |          |       | (-18.6) | -21.9 | -10.5   | (-1.0)  | -27.9   | -0.8    |
| Camels                   |          | 756   | 721     | 744   | 669     | 498     | 422     | 326     |
|                          |          |       | (-4.6)  | -3.2  | (-10.1) | (-25.6) | (-15.3) | (-22.7) |

\*AFC, Adult Female Cattle comprised of population of in-milk, dry, not yet calved and other breedable female animals; \*\*IM, population of in milk animals; Figures in parenthesis denote percentage change over previous census.

to mitigate the drought effects. Other probable reason of this declining livestock population during droughts could be animal death during scarce season, forced selling and illness of livestock due to unavailability of quality fodder, unbearable cost of livestock, need to meet the daily consumption expenses, thefts, etc. (Khera 2005). Population of camel registered a negative growth throughout the study years. Thus, in case of camel, drought cannot be considered as a major factor responsible for declining population and there are other factors playing major role.

*Effect of drought on milk production: evidences from*

*state level data:* Operation flood has an important role in making India self-sufficient in milk sector and thus there is sustainable rise in milk production since 1985. There is a continuous rise in milk production in Rajasthan since 1985, particularly after 2007 this increase has been much rapid (Fig. 1). The trend in milk production in Rajasthan during 1985 to 2015 indicates that the milk production being function of number of in-milk population and productivity was affected during the drought years. It was either declined or the rate of increase was sluggish during drought years, 1987 being the worst year.

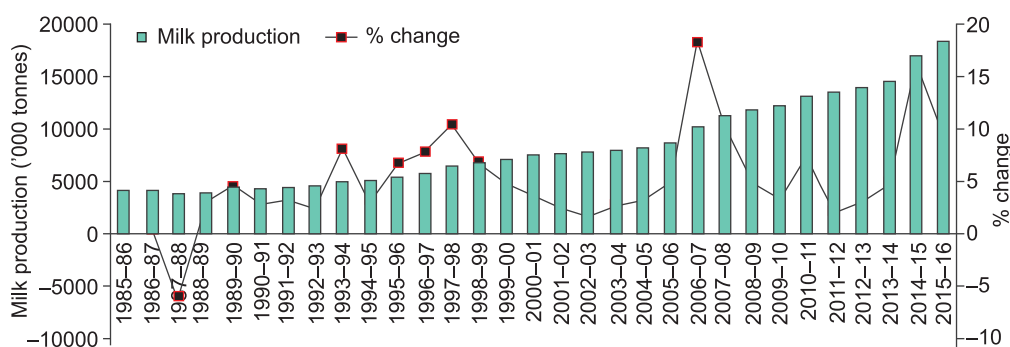


Fig. 1. Trends of milk production and year-on-year change (%) in Rajasthan.

Though milk production rose steadily during study period (except 1987) but the rate of increase witnessed a decline corresponding to drought years estimated in the study. For example, in the drought year of 1987 there was negative growth in milk production over previous year. However, during the long stretch of continuous drought (between 1997 and 2002), the milk production though increased but at the declining rate. Results bring out that over the years the preparedness for drought mitigation has increased.

**Changes in milk productivity:** Average milk productivity trends of indigenous cattle, buffalo and crossbred (Fig. 2) reveals that in initial years, productivity was constant. There was decline in productivity of both cattle and buffalo in the severe drought year of 1987–88. In case of cattle, this declined was the most (7.35%). Average productivity for indigenous cattle and buffalo was stagnant during subsequent drought years. There was a negligible dip in average milk productivity for all three categories of cattle in the drought year of 2002 indicating an insignificant effect of it. Though, separate data on milk yield for crossbred cattle were available from 1994–95 onwards only, it also replicated the trend during the stretch of continuous droughts. These findings indicate that the technology and infrastructure development over the period has played important role in mitigating the droughts.

In a study of this type conducted at all-India level, taking secondary data, BIRTHAL *et al.* (2004) also indicated a rise in overall production as well as productivity of milk. Dividing entire study period of 1982 to 2003 into 1981–1990 and 1991–2003, the researcher concluded that growth in livestock production declined in later period over previous one. Thus, the study attributed this increase in total milk production both to increase in cattle population and productivity without taking the recognition of climate extremes.

**Effect of drought on milk: evidence from meso-level data:**

The analysis above based on state-level aggregate data may not be sufficient to capture the effect of drought as inter-district variability of such effects might have reduced in

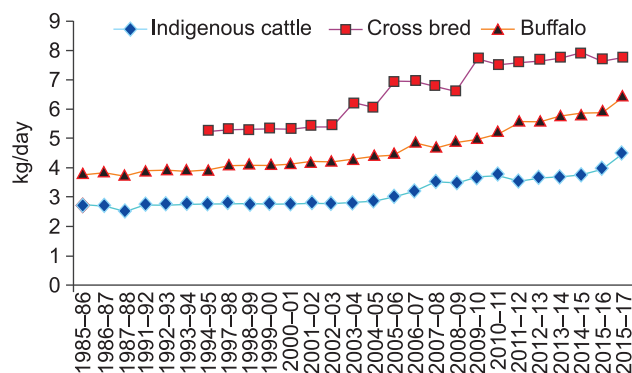


Fig.2. Trends of average productivity of milk in Rajasthan

aggregation. Therefore, it was further substantiated by taking district-level data of milk production and rainfall anomalies, particularly for the years of consecutive droughts (1998–2002) and their extent of association was further analyzed for districts.

Change in production and rainfall anomalies are expected to have positive co-variance, as higher rainfall anomaly put downward pressure on livestock production. Thus, districts with least value of SPI (Fig. 3) indicate high drought incidences and are expected to have greater decline in milk production during drought years. In majority of districts having high value of SPI ( $>-0.7$ ), the change in milk production is also positive except for Jhalawar, Chittorgarh and Dholpur. Among the districts in which average value of SPI was low ( $<-0.7$  indicating high intensity of droughts), milk production also declined at the end of consecutive drought years except for Jaipur, Banswara, Udaipur, Alwar and Sirohi. These results indicate that a slight incidence of water scarcity has large effect in Jhalawar, Chittorgarh and Dholpur, probably due to technical impediments and lack of mitigation mechanisms. On the other hand the districts of Jaipur, Banswara, Udaipur, Alwar and Sirohi were found having less effect of rainfall anomaly on milk production probably due to well-developed common pastures and grazing land in these districts and hence ample availability of green and dry fodder.

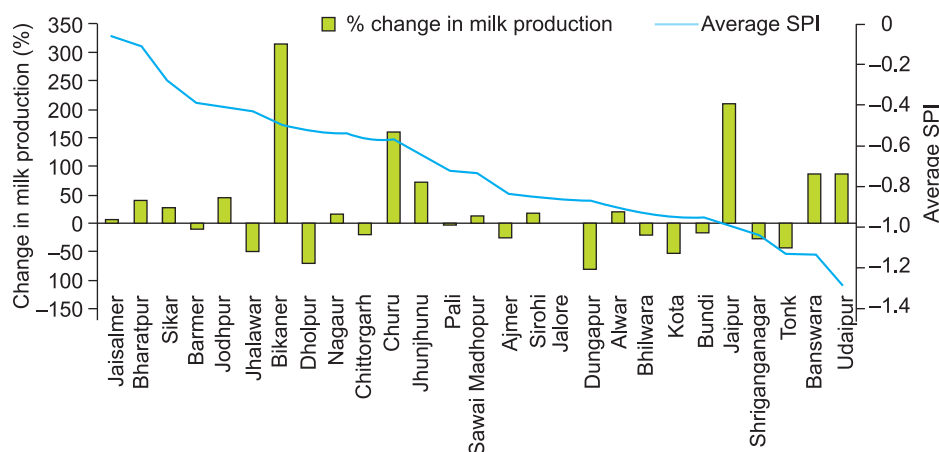


Fig.3. Relation between SPI and change in milk production across districts of Rajasthan (1998–2002)

Given that livestock contributes significantly to livelihood of farmers in the state of Rajasthan, livestock production is susceptible to extreme drought events. Over the years the intensity of effects of drought on livestock in the state has come down as the development of infrastructure, technology and market network has played key role in drought mitigation and relief. Technology led growth in the sector is crucial for sustaining livestock production in the state (Chand and Sirohi 2015). Technological advancement and application, particularly in the area of fodder resources is still area of concern. The Common Property Resources (CPRs) have an important role in developing drought resilience among livestock development in the state. However, their quality is being deteriorating over the years making these animals vulnerable to disasters. Joint community property resource management in line of joint forest management is recommended.

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