AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Agricultural Economics Research Review
Vol. 28 (Conference Number) 2015 pp 81-92
DOI: 10.5958/0974-0279.2015.00024.5

Sectoral Priorities for Sustainable Livestock Development in Rajasthan: Lessons from Total Factor Productivity Growth§

Prem Chand[a]* and Smita Sirohi[b]

[a]ICAR-Agricultural Technology Application Research Institute, Jabalpur-482 004, Madhya Pradesh
[b]Dairy Economics, Statistics & Management Division, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana

Abstract

The paper has examined long-term trends in total factor productivity of the livestock sector in Rajasthan and has assessed the development priorities in seven agro-climatic zones of the state. In the span of past five decades, from 1960-61 to 2009-10, there has been a negligible growth in the TFP and its contribution to nominal and real output growth in livestock sector is about 12 per cent and 0.4 per cent, respectively. In the situation of large feed and fodder deficit in the state in relation to the nutritional requirement of animal stock, the sustainability of input driven growth is a serious concern. The slow growth in real output of meat group (1.4%) and declining trend in wool and hair (growth rate, -0.5%) during the previous decade, needs to be addressed as the state has large stock of small ruminants that are reared mostly by marginalized socio-economic groups. The study has used multi-criterion scoring method (congruence method) for normative allocation of the investment resources across agro-climatic zones in Rajasthan. For balancing the efficiency, equity and sustainability criteria for livestock development in the state, the top two zones that require ardent policy attention are Arid Western Plains and Southern Plain and Aravali Hills, where nearly 43 per cent of the resources for livestock development should be invested. Highlighting the regional priorities for livestock development in the state, the study has emphasized on reducing the yield gap through technological advancement, interventions for decreasing the stocking rate of livestock, dissemination of region-specific scientific livestock farming practices and introduction of value-added livestock products for enhancing calorie intake.

Key words: Total factor productivity, resource allocation, livestock sustainability, carrying capacity

JEL Classification: O30, D24, Q01, Q16, Q18, Q56

Introduction

Under the arid and semi-arid climatic conditions in the state of Rajasthan, the livestock-rearing is considered as a 'survival enterprise' for millions of households as it acts as an adaptation and coping instrument against frequent droughts and weather-induced vulnerability. The share of livestock sector in the total value of output from agricultural and allied activities is about one-third in the state, higher than the corresponding national average of 28 per cent (CSO, 2013). In the arid region of Rajasthan, livestock contributes more than 50 per cent to the total household income which goes even up to two-thirds of the total income in the years of drought and famine (GoR, 2007). An assessment of sustainability status of the livestock sector in the state, encompassing the ecological, economic and social dimensions of sustainability, has

* Author for correspondence
Email: prem3281@gmail.com , prem_mahala@yahoo.com

§ This paper is drawn from PhD Thesis of first author entitled "Sustainability assessment of livestock sector in Rajasthan" submitted to ICAR-National Dairy Research Institute, Karnal in 2008

revealed the mean value of Sustainable Livestock Production Index (SLPI) to be 0.343 (on the scale of 0 to 1), and found that inter-zonal variations in SLPI were not very sharp (C.V. = 20.3%) across the state (Chand *et al.*, 2011).

In the backdrop of the importance of livestock and empirical evidence of weak sustainability status of livestock production in various agro-climatic zones, the main objective of this paper was to provide policy guidelines for the development of this sector in the state of Rajasthan. The study has examined the long-term trends in total factor productivity of livestock sector, has carried out analysis at the zonal level, generating indices of investment priorities, and has delineated the key areas of intervention warranted for livestock development in each zone of Rajasthan.

The estimates of total factor productivity (TFP) in the primary and secondary sectors of economy have been widely used in the economic literature for diverse purposes, such as understanding the sources of growth (Rosegrant and Evenson, 1992; Kalirajan and Shand, 1997), impact of public policies (Fan *et al.*, 1999; Chand *et al.,* 2012), globalization (Balakrishnan *et al.*, 2000; Goldar and Kumari, 2003), other drivers of development (Gordon, 2000; Mitra *et al.*, 2011), etc. Lynam and Herdt (1989) proposed total factor productivity as the appropriate measure of output to determine sustainability. Following their work, a number of studies (Ehui and Spencer, 1990; Sidhu and Byerlee, 1992; Whitaker and Lalitha, 1993; Kumar *et al.*, 1998; 2004; Ali and Byerlee, 2001; Chandel, 2007) have used inter-temporal factor productivity to measure the sustainability of crop or farming system. Unlike the crop sector, the studies of TFP in livestock production, in general, are very limited (Rae *et al.*, 2006). In the Indian context, only a few studies for livestock sector have been conducted at the national level (Kumar and Pandey, 1999; Aliva and Evenson, 2004) and for some states like Haryana (Elumalai and Pandey, 2004)) and Tamil Nadu (Prabhu, 2008).

Database and Methodology

The study is based on the secondary data from various published and unpublished sources. The two major tools used in the analysis were the time series estimates (1960-61 to 2009-10) of total factor productivity, and a multi-criterion scoring method (congruence method) for normative allocation of the investment resources for livestock development across agro-climatic zones in Rajasthan, based on the triennium ending (TE) 2008-09 data on various relevant aspects, outlined later.

Estimation of TFP — Tornqvist-Theil index has been extensively used in literature for computation of the TFP. The estimation procedure requires construction of an output and input index, each weighted by factor shares. The general formula used for construction of index is:

Total output index : $TOI_t / TOI_{t-1} = P_j (Q_{jt} / Q_{jt-1}) (R_{jt} + R_{jt-1})^{1/2}$

Total input index : $TII_t / TII_{t-1} = P_i (X_{it} / X_{it-1}) (S_{it} + S_{it-1})^{1/2}$

where, R_{jt} and S_{it} are the shares of jth output and i^{th} input in the total value of livestock products and inputs, respectively; Q_{jt} and X_{it} are the quantities of jth livestock product and i^{th} livestock input, respectively in the tth time period.

For productivity measurement over a long period of time, the indices are chain linked, whereby, the indices for successive periods are multiplied together. Hence,

$TOI_t = TOI_1 . TOI_2 \ldots\ldots TOI_{t-1}$ and

$TII_t = TII_1 . TII_2 \ldots\ldots TII_{t-1}$ (t=0,…T)

and finally, $TFP_t = TOI_t/TII_t$

Livestock Output — As per the National Accounts Statistics, the total output of livestock sector has 7 product groups, viz. milk, meat, eggs, wool and hair, silk worm cocoon and honey, dung and increment in animal stock. The data series for each of these product groups is available at the national level from 1950-51 onwards, but state-wise estimates are provided only from 1990-91. The disaggregated product group-wise data on the value of output from livestock sector in the state of Rajasthan were therefore taken from the official sources (CSO, 2006; 2008; 2013) for the period since 1990-91, while for the earlier period, viz. 1960-61 to 1989-90, were estimated as per methodology suggested by the Central Statistical Organization (CSO, 2004). The estimation of value of livestock production for the years when CSO series was not available, has been done by multiplying the quantities of production by the corresponding wholesale prices.

In addition to the above 7 product categories, the animal draught power was also considered as an output item from the livestock sector. However, the CSO estimates do not provide the value of output from draught power. Hence, the data series on animal draught power was generated on the basis of some realistic assumptions as used earlier in the literature (Pandey *et al.,* 1983, Kumar and Pandey, 1999; Elumalai and Pandey, 2004), wherein, the horsepower availability from per animal of bullocks, he-buffalo, horse and ponies, mules and donkeys of more than three years age was assumed as 0.5 HP, while that of camels above four years as 1 HP and the working per animal was assumed at 100 days in a year. The quantum of draught power was converted into fuel equivalent required by a tractor to do same amount of work. The average price of diesel was multiplied to get the value of output of draught power.

Livestock Inputs — For construction of total input index, a three-input framework was used. The animal feed and labour are the two major inputs in livestock production and the third is animal capital, captured through interest on population stock. Unlike the value of output, the CSO does not provide any data on the value of livestock inputs at the state level, hence, the estimation of the input value was done for each component. Livestock feed comprises roughages and concentrates. For roughage, 95 per cent of production of stalks and straws, the entire production of fodder, cane trash and grass in the agriculture sector were considered to be consumed by the livestock. The value of dry fodder was taken as 95 per cent of the value of straw and stalk produced in Rajasthan. The production of green fodder was worked out from the data on area under fodder crops, forest, pasture and grazing lands (Land Utilisation Statistics), and average yield estimates of cultivated fodder, grasses and tree leaves (DAHD, undated). The estimates of concentrate production were based on the methodology used by Jain *et al.* (1996) and Ranjhan *et al.* (1999).

For working out the labour input in the livestock sector, one-fourth male and three-fourth female cultivators and agricultural labourers were considered to be employed for livestock rearing and maintenance. Further, it was assumed that three women labourers were equivalent to two men labourers (Elumalai and Pandey, 2004). To compute the third component of input value, interest of 9 per cent was charged on the value of livestock population, a product of livestock number in Adult Cattle Unit (Kumbhare *et al.*, 1983; Bhati, 1981) and prices of adult cattle. The prices of animals, oilcakes, fodder, grasses and wheat and rice bran were collected from *Agricultural Prices in India* and *State Directorate of Economics and Statistics*, while, the wage rates were collected from various issues of *Agricultural Wages in India*.

Zonal Investment Allocation for Sectoral Development — Based on the agro-climatic zoning done by National Agricultural Research Project (Ghosh, 1991) and Planning Commission (Khanna, 1989), this study delineated seven agro-climatic sub-zones which cover all the districts within the state of Rajasthan (Table 1).

The approach followed for suggesting investment proportion at the zonal level, has been used by many researchers for setting research priorities (Jha *et al.,* 1995; Kelly and Ryan, 1995; Birthal *et al.,* 2002; Sirohi and Saxena, 2012). Three goals of livestock development were considered: efficiency, viz. enhancing productivity; equity, viz. augmenting income of poor; and sustainability, viz. improving

Table 1. Agro-climatic zones of Rajasthan state

Agro-climatic zone	Districts included
Zone I: Irrigated North-Western Plain	Ganganagar & Hanumangarh
Zone II: Semi-Arid Eastern Plain	Ajmer, Dausa, Jaipur & Tonk
Zone III: Flood Prone Eastern Plain	Alwar, Bharatpur, Dholpur, Karauli & Swai Madhopur
Zone IV: Southern Plain and Aravali Hills	Bhilwara, Chittorgarh, Rajsamand & Udaipur
Zone V: Arid Western Plain	Barmer, Jaisalmer, Jodhpur, Bikaner & Churu
Zone VI: Transitional Plain	Jalore, Jhunjhunu, Nagaur, Pali, Sikar & Sirohi
Zone VII: Southern and South-Eastern Plain	Banswara, Baran, Bundi, Dungarpur, Jhalawar & Kota

Table 2. Criteria for resource allocation to livestock sector in Rajasthan

Objective	Extensity parameters and their weights	Intensity parameters and their weights
Efficiency	Value of livestock output (0.30)	Scope for growth in milk production (yield gap) (0.34)
Equity	Poor people (0.50)	Per capita gross district domestic product (0.11) Per cent share of small and marginal farmers in total number of holdings (0.11) Per capita calorie availability from livestock products (0.11)
Sustainability	Common property resources (0.20)	Density of livestock (0.33)

livestock carrying capacity of land. The resource allocation was based on two types of parameters, the extensity and intensity parameters, encompassing the indicators that reflect the magnitude and severity aspects, respectively, related to the objectives of investment in livestock sector (Table 2). The method used for arriving at the zone-wise sectoral allocations involved computation of a weighted index based on the extensity parameters and adjusting the same using the intensity parameters (Sirohi and Saxena, 2012). Three-year average (TE 2008-09) data were used for the analysis.

Trends in Total Factor Productivity Growth

The long-term trends of output and input indices have shown sharp real growth (2004-05 prices) in livestock production from the 1990s, which was largely driven by the corresponding growth in production inputs (Figure 1). The trends in TFP growth have been dismal (Table 3). During 1960s, the output and input indices (at constant prices) both declined, but the rate of decline was more in input indices (-1.57 %) than output indices (-0.96 %) and thereby the TFP growth was positive but low at the rate of 0.61 per cent.

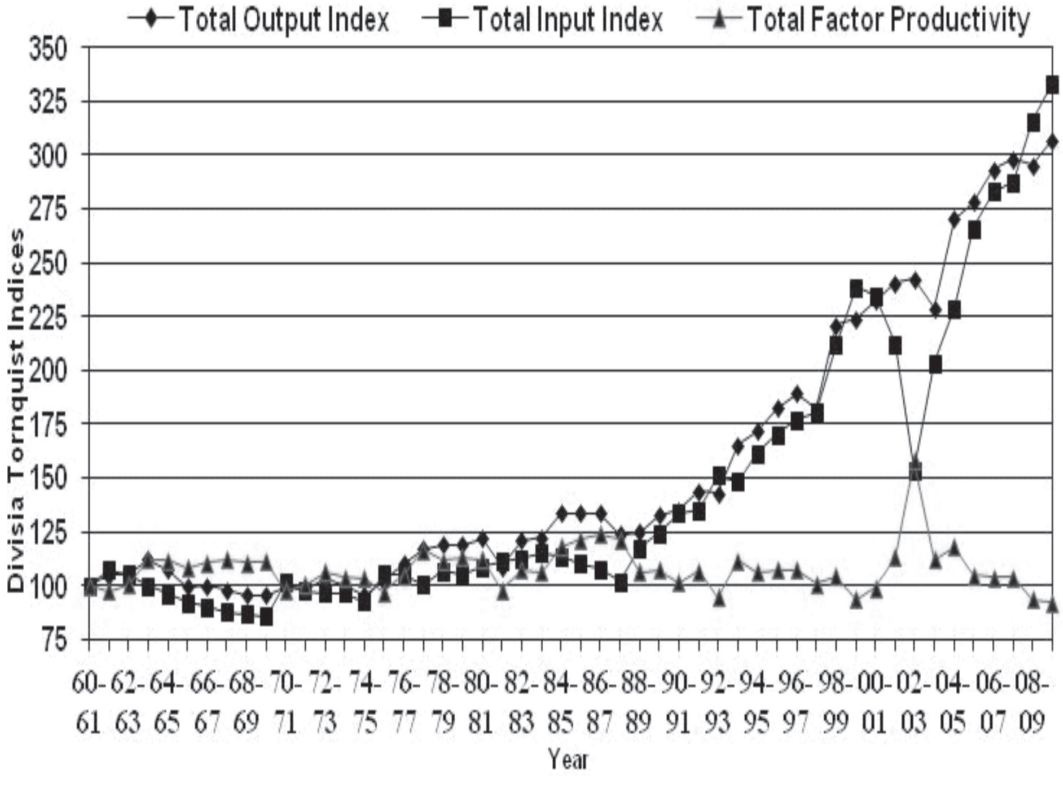

Figure 1. Trends in input, output and TFP indices of livestock production in Rajasthan: 1960-61 to 2009-2010 (at 2004-05 prices)

Table 3. Compound annual growth rate of output, input and TFP indices of livestock production in Rajasthan, 1960-61 to 2009-10

Period	Compound annual growth rate (%)					
	Output Index		Input Index		TFP Index	
	At current prices	At 2004-05 prices	At current prices	At 2004-05 prices	At current prices	At 2004-05 prices
1960-61 to 1970-71	5.80	-0.96	7.61	-1.57	-1.81	0.61
1970-71 to 1980-81	11.71	2.49	7.99	1.07	3.72	1.42
1980-81 to 1990-91	9.75	1.31	9.43	1.18	0.32	0.13
1990-91 to 2000-01	14.94	5.67	10.79	6.19	4.15	-0.52
2000-01 to 2009-10	10.97	3.56	10.05	6.38	0.92	-2.82
1960-61 to 2009-10	10.06	2.45	8.86	2.44	1.20	0.01

Although for a slightly different period, similar results were reported by Kumar and Pandey (1999) at all-India level during the period 1950-51 to 1970-71. In the decade of 1970s, the growth in TFP picked up (1.42 %) and it contributed around 57 per cent to the output growth. Thereafter, the decadal growth rate of TFP has declined continuously, reducing significantly to 0.13 per cent during the 1980s and registering a negative growth rate in the next two decades. Overall, in the period of five decades from 1960-61 to 2009-10, the TFP growth has almost been stagnant (0.01%) in the livestock sector.

The results based on the current prices are, however, quite different from those based on the constant price series. The variations are particularly notable in the decades of 1960s, 1990s, and 2000s. In the 1960s, the current price input index rose at a much sharper rate (7.61%) than the output index (5.80%), hence TFP declined at rate of 1.81 per cent per annum during this period. In the two subsequent decades, the trend of positive growth in TFP was similar based on both, current and constant prices basis, though magnitude of growth was higher based on current prices series. In the decade of 1990s, the TFP growth was very high (4.15%), while the same was -0.52 per cent at 2004-05 prices. This high growth was not sustained in the following decade and TFP growth rate plummeted to 0.92 per cent during 2000-01 to 2009-10. The roller-coaster decadal trends in the TFP growth at current prices, averaged to 1.2 per cent in the overall period, just contributing 12 per cent to the output growth in the livestock sector.

The current price series, however, has the limitation that the value of output or input can increase due to inflationary pressure without a rise in physical quantity. But, it also has an advantage that it reflects the changing prices due to potential change in the quality of the product. Therefore, meaningful lessons can be drawn from interpreting the both current and constant price estimates of Output, Input and TFP indices.

The output growth in the livestock sector has largely been driven by the growth in inputs and hence its sustainability is under pressure. However, the role of infrastructure and other development initiatives in the livestock sector cannot be dejected, as during the period of droughts, the output index has not fallen despite a steep decline in the input index, due to feed and fodder shortages. For instance, in 2002-03, the input index dropped to 153 from 212 in 2001-02, but the output index nearly stagnated during this period. This also substantiates that livestock is a coping mechanism for drought management in Rajasthan.

After the 1990s, there has been an impressive growth in output and input indices, but the pace of real increase is faster in inputs than output. The value of output from the livestock sector has increased more because of increase in prices of the livestock products, than increase in its quantity, despite improvement in availability of inputs. High prices of products may boost the profitability of livestock farmers in the short-run, but the trend would not be sustainable as inflationary pressure would dampen the demand. The decline in nominal growth in output by about 4 percentage points, from 14.94 per cent in 1990s to

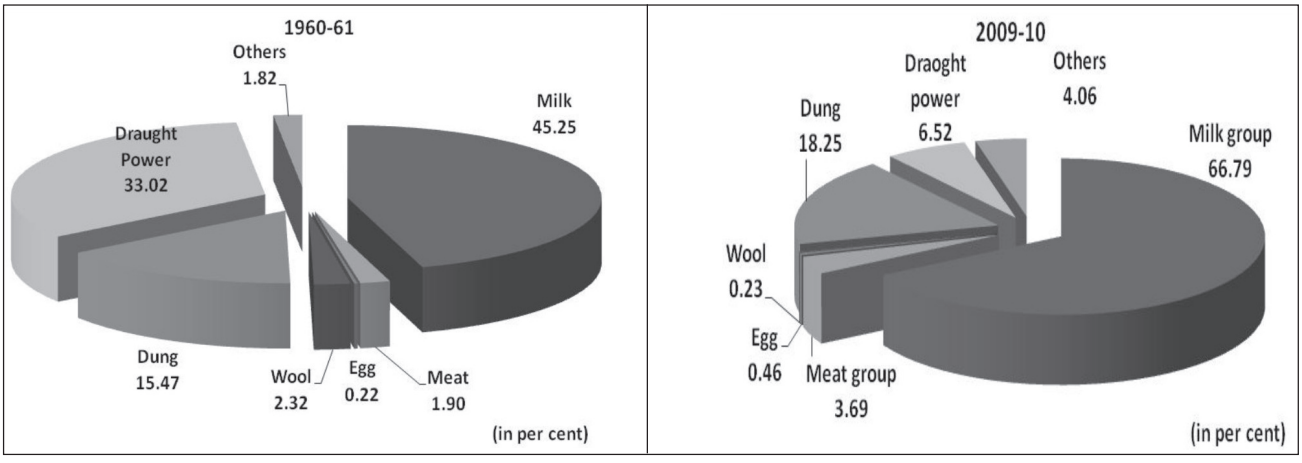

Figure 2. Composition of value of output from livestock sector in Rajasthan, 1960-61 and 2009-10

10.97 per cent in 2000-01 to 2009-10, also substantiates this premise.

The predominant share of livestock output in the state is being contributed by the milk group, followed by animal dung and draught power (Figure 2). Rajasthan is one of the leading states in the country in terms of sheep and goat population, yet the meat and wool production is marginal; ₹11.3 billion and ₹0.8 billion, respectively out of total output value of ₹274.4 billion from the livestock sector (including draught power) during TE 2009-10.

The composition of livestock output has undergone some changes. There have been some noteworthy changes in the factor shares, with progressively increasing importance of milk group in the output basket and steep decline in the share of draught power, primarily due to mechanisation of agricultural operations. The value share of dung has also gone up, partially due to increase in animal numbers, but more because of rise in dung prices. During 1960-2010, except for draught power and wool and hair, the output growth in real terms was over 2 per cent for all the products (Table 4). The dominant milk group has shown a spectacular performance after 1990s, registering a compound annual growth rate of over 4.5 per cent. The efforts of the government, particularly of the departments concerned with dairying, animal husbandry and veterinary services, have played a big role in raising the productivity of dairy animals (Kurien, 1997). The contribution of the cooperative sector has also been significant, both in creating a market and in supporting farmers with technical inputs, viz. feed, breeding and veterinary services. These technical inputs provided an impetus for the higher growth of this sector.

Among the other components of livestock output, although the absolute value of meat group continued to be low, the growth rate showed an uptrend till 2000-01, and decelerated thereafter. The declining real output of wool and hair, but increasing nominal value is indicative that there may be shift from coarse to finer quality of wool, and despite declining output, the price realization was better. During 1990-91 to 2000-01, the production of wool increased by 21 per cent reaching 194 lakh kg in 2000-01. Thereafter, there was a sharp decline in wool production to 154 lakh kg in 2005-06 and further to 125 lakh kg in 2009-10.

The production of livestock output worth ₹274.4 billion (TE 2009-10) was achieved with input use of ₹170.6 billion, more than half of which was on account of feed and fodder inputs. The real growth in value of feed which was negligible up to the end of 1980s, picked up sharply in the two subsequent decades. Together with improvement in availability of feed and fodder, another welcome trend is the decline in roughage: concentrate ratio (Figure 3). The share of concentrates has increased from mere 4 per cent in early-1960s to over 33 per cent by 2009-10.

The broad points which emerge from the above discussion are: (i) there are serious concerns about sustaining the growth of livestock sector in the state, especially in the case of non-dairy products, (ii) the growth has been driven by increase in availability of feed and fodder and its changing composition towards inputs of higher nutritional quality, which in itself is

Table 4. Growth trends in component-wise value of output from livestock sector

Item	1960-61 to 1970-71	1970-71 to 1980-81	1980-81 to 1990-91	1990-91 to 2000-01	2000-01 to 2009-10	1960-61 to 2009-10
			At current prices			
Milk group	7.98	12.43	11.48	14.21	12.60	11.58
Meat group	7.98	13.76	11.02	20.59	9.46	13.31
Eggs	12.85	13.66	14.24	14.58	7.46	12.99
Wool & hair	1.98	11.28	9.40	5.59	2.18	6.55
Dung	4.80	10.76	12.75	16.92	7.45	12.23
Draught power	2.67	10.41	1.36	8.49	6.34	7.50
Others	7.20	12.40	13.05[@]	11.30[$]	22.64	14.05[$]
			At 2004-05 prices			
Milk group	-1.66	3.81	2.44	5.83	4.79	2.99
Meat group	0.04	1.78	2.17	4.33	1.40	3.09
Eggs	6.09	8.53	7.68	7.34	2.88	7.11
Wool &hair	-0.41	-3.39	-0.21	2.31	-0.51	-1.00
Dung	-0.63	1.34	1.31	8.10	2.87	2.36
Draught power	0.15	0.90	-2.11	0.50	-2.99	0.22
Others	1.92	3.77	2.87[@]	4.37[$]	9.42	8.16[$]

Note: [@]Growth rates calculated from 1980-81 to 1989-90; [$]Growth rates calculated excluding the negative value from 1990-91 to 1992-93

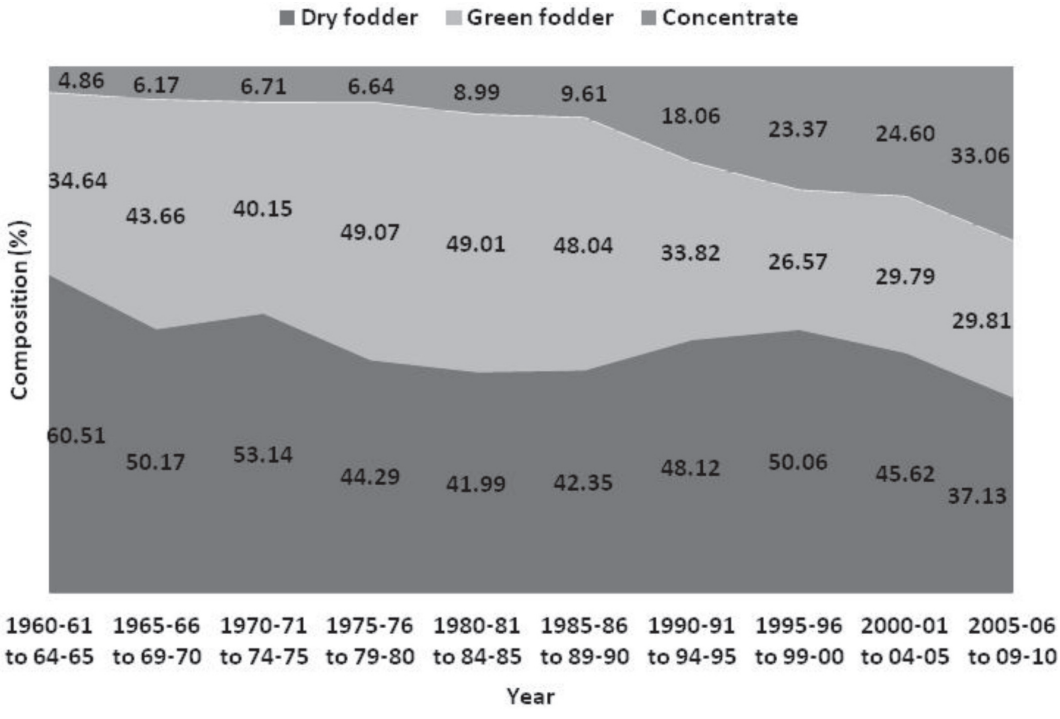

Figure 3. Composition of livestock feed in Rajasthan

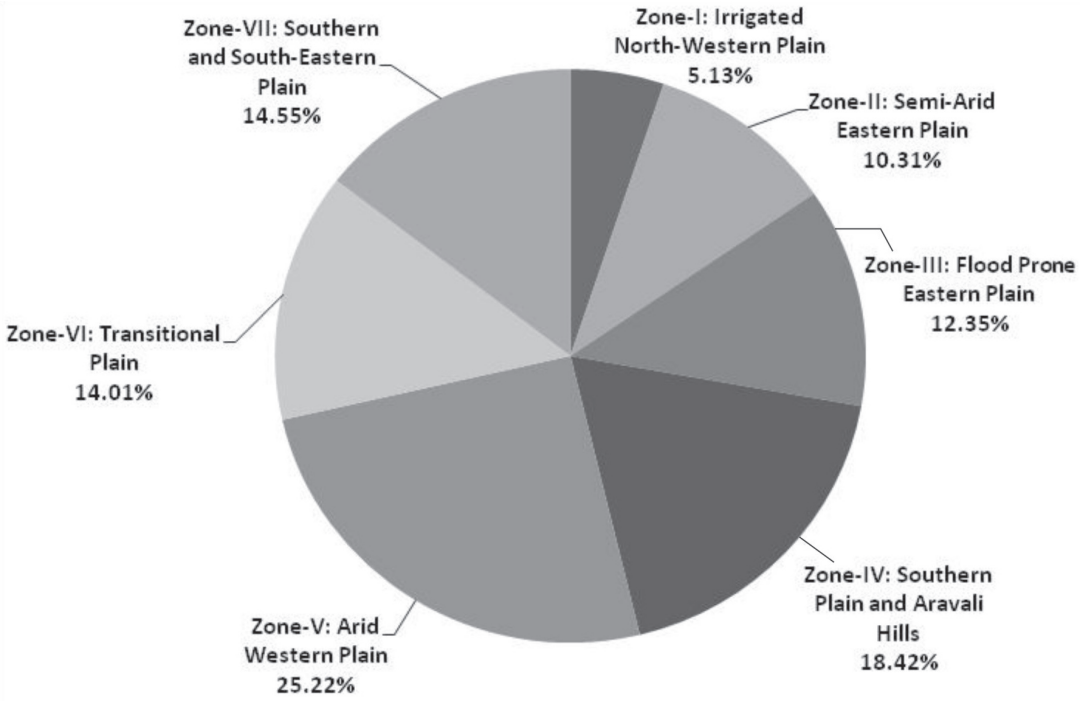

Figure 4. Indices of investment priorities in livestock sector across agro-climatic zones of Rajasthan

suggestive of technological improvement from the aspect of animal nutrition, (iii) the contribution of TFP to nominal and the real output growth is estimated to be 12 per cent and 0.4 per cent, respectively during the 5-decade period; however, this does not account for the enhancement in livestock production from technological improvements in animal nutrition.

Regional Priorities for Livestock Development

The budgetary allocation for balancing the efficiency, equity and sustainability criteria for livestock development suggests that about one-fourth of resources should be allocated to the Arid Western Plain Zone (Figure 4). The Zone V has vast expanse of common property resources (Table 5), but there is scarcity of water in the desert region. The livestock density is low (39 ACU/sq km) and hence the availability of feed and fodder is not a containing factor (Chand *et al.*, 2013). But, due to frequent incidence of droughts, the livestock farmers often migrate temporarily with their livestock in search of feed and fodder. Setting up of fodder banks, emphasis on R&D initiatives for identification and development of suitable animal feed sources, especially from grasses, trees and non-conventional feed resources are important policy options for improving the sustainability of livestock production, particularly as the concentrate production in the region is low and feed requirement is mostly met from the CPRs. The topography of the Arid Western Plain that covers the Thar desert also necessitates establishing mobile veterinary and health care facilities to cover the vast stretch of area.

The zone IV (Southern Plains and Aravali Hills) ranks second in terms of warranted investment for livestock development. The region covers 11.28 per cent of the geographical area of Rajasthan, but it inhabits 24 per cent of the poor households. The region is 44 per cent deficit of feed and fodder resources, which is also reflected in the high yield gap in milk and wool production. The yield gap has been estimated as the ratio of average yield in zone to that of best performing district in the state; the lower the ratio, the higher is the gap in the yield and hence more potential to increase the productivity of animals. The emphasis on yield enhancement in the phase of high feed and fodder shortages, requires two pronged strategy. One, increasing the cultivation of green fodder crops and two, orienting the livestock breeding policy towards selective breeding for producing animals with higher genetic potential. Therefore, instead of keeping a large stock of low productive animals the farmers can rear a

Table 5. Indicators of extensity and intensity parameters for investment prioritization in Rajasthan, TE 2009-10

Agro-climatic zone	Extensity Parameters			Intensity Parameters							
	Value of livestock output (in billion ₹)	No. of households below poverty line (in lakh)	Area under CPRs ('000 ha)	Yield gap in milk production			Yield gap in wool production	Annual per capita domestic product ('000 ₹)	Share of small and marginal holdings (%)	Per capita availability of livestock products (kcal/day)	Livestock density (ACU/ sq km)
				Local cows	Cross-bred cows	Buffalo					
Zone-I: Irrigated North-Western Plain	21.44	1.13	56.01	0.82	0.79	0.81	0.71	30.10	19.30	328.0	79.25
Zone-II: Semi-Arid Eastern Plain	58.17	1.90	571.86	0.74	0.84	0.74	0.73	33.38	68.39	540.0	121.35
Zone-III: Flood Prone Eastern Plain	43.21	2.54	401.53	0.62	0.84	0.79	0.80	22.56	65.05	396.0	122.97
Zone-IV: Southern Plain and Aravali Hills	26.33	5.36	1568.33	0.44	0.66	0.60	0.54	28.17	69.22	426.0	108.12
Zone-V: Arid Western Plain	45.43	3.83	4500.62	0.78	0.79	0.87	0.72	21.63	23.95	498.0	38.72
Zone-VI: Transitional Plain	56.48	2.85	828.27	0.66	0.92	0.75	0.60	21.52	51.61	297.0	84.94
Zone-VII: Southern and South-Eastern Plain	23.37	4.68	616.25	0.41	0.63	0.60	0.51	22.77	76.39	246.0	117.66

few high producing animals, thus reliving the pressure on available feed and fodder resources.

Similarly, in another zone (Zone VII) in the southern part of Rajasthan, the yield gap and feed and fodder deficit is high. This zone has large concentration of tribal population, especially in the Dungarpur and Banswara districts that have been declared as the 'Scheduled Area' as per the Constitutional provisions. The per capita calorie intake from livestock products is least in this zone. The southern part of the state requires instantaneous policy attention to improve livestock productivity through technological advancement, labour productivity by training them in scientific livestock farming practices, and introduction of value-added products for enhancing calorie intake.

The next in investment priority is Zone VI (Transitional Plain), comprising the districts of Jalore, Jhujhunu, Nagaur, Pali, Sikar and Sirohi. About one-fifth (21%) of the livestock output of Rajasthan comes from this Zone. The concentration of households below poverty line is not the maximum among the various zones, but the per capita domestic product is least in this Zone. The policy imperatives for sustainable livestock development in the zone include providing input support services in general, and improving the network of organized livestock products marketing in particular.

The Flood Prone Eastern Plain Zone (Zone III) and Semi-arid Eastern Plain Zone (Zone II) follow in terms of investment priotization. The eastern part of the state has high livestock population pressure and shrinking area under pastures and grazing lands. In terms of infrastructure endowments, the region is well-suited for commercial livestock farming. The policy emphasis in this direction would go a long way in fulfilling the goal of livelihood and nutritional security from lower stock of livestock, thus, making production sustainable in the region.

The smallest zone in Rajasthan is the Irrigated North-Western Plain, comprising the agriculturally advanced districts of Ganganagar and Hanumangarh. These districts have fertile alluvial soil deposits of the Ghaggar river. Due to availability of three canal systems, proportions of land available for cultivation is high which facilitates livestock production in the Zone. The availability of feed and fodder resources in the Zone is adequate (surplus of 6% in relation to requirement), but there is yield gap for all three types of dairy animals which can be plugged by dissemination of improved dairy farming practices among the farmers.

Conclusions and Policy Implications

Livestock are the important means of livelihood security in the drought-prone state of Rajasthan. However, the sustainability of livestock production is a serious concern as sectoral growth has come predominantly from the increase in inputs, with marginal contribution of TFP growth. The availability of feed and fodder inputs has increased over time, yet 5 out of 7 agro-climatic zones face acute feed shortages with deficit ranging from 20 per cent to 45 per cent in relation to demand.

The CPRs have an important role in livestock development in the state. Traditionally, Rajasthan has a unique system of reserving about 10-15 per cent of the total land in every village for community pastures. However, over the years, these pastures have been heavily degraded and forage yields have come down to 15-20 per cent of their potential. Technologies need to be developed for improving the productivity of fodder crops such as improved dual purpose fodder availability, fodder seed production, improving quality of CPRs, etc. There is also a need to develop region-specific feed technologies for improvement of energy availability from crop residues.

Another area of concern is the slow growth in livestock output from small ruminants. Rajasthan is among the top two states in the country in terms of small ruminant population. Both, sheep and goat are generally reared under low-input extensive system by the economically weaker sections, largely belonging to scheduled tribes, scheduled castes and other backward castes. The productivity of small ruminants is quite low as they subsist on poor quality herbages on CPR lands. The provision of input and output support services and reaching out to the resource-poor small ruminant farmers with improved package of practices are some of the important policy initiatives required for the sustained TFP growth in the state of Rajasthan.

Acknowledgements

The authors thank the learned referee for helpful suggestion on the earlier draft of the paper.

References

Ali, M. and Byerlee, D. (2001) Productivity growth and sustainability in post-green revolution agriculture in the Indian and Pakistan Punjabs. *World Bank Research Observer,* **16**(2): 199-218.

Avila, A.F.D. and Evenson, R.E. (2004) *Total Factor Productivity Growth in Agriculture: The Role of Technology Capital*. Mimeo, Yale Economic Growth Center, New Haven, CT, United States.

Balakrishnan, P., Pushpangadan, K. and Babu M.S. (2000) Trade liberalization and productivity growth in manufacturing: Evidence from firm-level panel data. *Economic and Political Weekly*, **35**(41): 3679-82.

Bhati, J.P. (1981) *Population, Resource-use and Ecological Stress in Western Himalyas: An Integrated Strategies for Hill Area Development*. PhD Dissertation. University of Hawaii, Manoa, Honolulu, US.

Birthal, P.S., Joshi, P.K. and Kumar, A. (2002) *Assessment of Research Priorities for Livestock Sector in India*. Policy Paper 11. ICAR-National Centre for Agricultural Economics and Policy Research, New Delhi.

Chand, P. and Sirohi, S. (2012) District level sustainable livestock production index: Tool

for livestock development planning in Rajasthan. *Indian Journal of Agricultural Economics*, **63** (2):199–212.

Chand, P., Sirohi, S. and Sirohi, S.K. (2011) Using sustainable livestock production index for development of livestock sector: A case study of an arid region in India. *Journal of Applied Animal Research*, **39** (3):234-238.

Chand, P., Sirohi, S. and Sirohi, S.K. (2013) Production and demand estimates of livestock feed and fodder in Rajasthan. *Indian Journal of Animal Nutrition*, **30** (2): 149-156.

Chand, R., Kumar, P. and Kumar, S. (2012) Total factor productivity and returns to public investment on agricultural research in India. *Agricultural Economics Research Review*, **25**(2):181-194.

Chandel, B.S. (2007) How sustainable is the total factor productivity of oilseeds in India? *Indian Journal of Agricultural Economics*, **62** (2): 244-258.

CSO (Central Statistical Organisation) (2004) *Source and Methods*. National Account Statistics, Ministry of Statistics and Programme Implementation, New Delhi.

CSO (Central Statistical Organisation) (2006) *State-wise Estimates of Value of Output from Agriculture and Livestock: 1990-91 to 2002-03*. National Account Statistics, Ministry of Statistics and Programme Implementation, New Delhi.

CSO (Central Statistical Organisation) (2008) *State-wise Estimates of Value of Output from Agriculture and Allied Activities with New Base-Year 1999-2000 (1999-2000 to 2005-06)*. National Account Statistics, Ministry of Statistics and Programme Implementation, New Delhi.

CSO (Central Statistical Organisation) (2013) *State-wise Estimates of Value of Output from Agriculture and Allied Activities 2013.* National Account Statistics, Ministry of Statistics and Programme Implementation, New Delhi.

DAHD (Department of Animal Husbandry and Dairying) (undated) *Dry and Green Fodder Production – State-wise*. Ministry of Agriculture, New Delhi. Available at:http://dahd.nic.in.

Ehui, S.K. and Spencer, D.S.C. (1990) Measuring the sustainability and economic viability of tropical farming systems: A model from Sub-Saharan Africa. *Agricultural Economics,* **9**: 279-296.

Elumalai, K. and Pandey, U.K. (2004) Technological change in livestock sector of Haryana. *Indian Journal of Agricultural Economics*, **59** (2): 249-258.

Fan, S., Hazell, P.B.R. and Thorat, S. (1999) *Linkages between Government Spending, Growth, and Poverty in Rural India*. Research Report No.110. International Food Policy Research Institute, Washington, DC.

Ghosh, S.P. (1991) *Agro-climatic Zone Specific Research: Indian Perspective under NARP*. Indian Council of Agricultural Research, New Delhi.

Goldar, B. and Anita, K. (2003) Import liberalization and productivity growth in Indian manufacturing industries in the 1990s. *Developing Economies*, **41** (4): 436-60.

GoR (Government of Rajasthan) (2007) *Rajasthan State Livestock Development Policy.* Department of Animal Husbandry, Dairying and Fishery, Jaipur.

Gordon, R. J. (2000) Does the 'New Economy' measure up to the great inventions of the past? *Journal of Economic Perspectives*, **14** (4): 49-74.

Jain, D.K., Sharma, K.N.S., Walli, T.K. and Rai, S.N. (1996) *Estimates of Nutrient Requirement and Availability for Bovine Population across Major States in India*. Technical Bulletin, ICAR-National Dairy Research Institute, Karnal.

Jha, D., Kumar, P., Mruthyunjaya, Pal, S., Selvarajan, S. and Singh, A. (1995) *Research Priorities in Indian Agriculture*. Policy Paper 3. ICAR-National Centre for

Agricultural Economics and Policy Research, New Delhi.

Kalirajan, K.P. and Shand, R.T. (1997) Sources of output growth in Indian agriculture. *Indian Journal of Agricultural Economics*, **52**(4):693-706.

Kelly, T.G. and J.G. Ryan. 1995. Applied participatory priority setting in international agricultural research: Making trade-offs transparent and explicit. *Agricultural Systems,* **49**: 177-216.

Khanna, S.S. (1989) The agro-climatic approach. In: *The Hindu Survey of Indian Agriculture*. Eds: G. Kasturi National Press, Madras. pp. 28-37.

Kumar, A. and Pandey, U.K. (1999) Total factor productivity, In: *Sources of Growth in the Livestock Sector*, Eds: P.S. Birthal, Anjani Kumar, A. Ravishankar and U.K. Pandey. Policy Paper 9, ICAR-National Centre for Agricultural Economics and Policy Research, New Delhi.

Kumar, P., Joshi, P.K., Johansen, C. and Asokan, M. (1998) Sustainability of rice-wheat based cropping systems in India: Socio-economic and policy issues. *Economic and Political Weekly*, **33**(39): A-152 - A-158.

Kumar, P., Kumar, A. and Mittal, S. (2004) Total factor productivity of crop sector in the Indo-Gangetic Plain of India: Sustainability issues revisited. *Indian Economic Review*, **39**(1): 169-201.

Kumbhare, S.L., Sharma, K.N.S. and Patel, R.K. (1983) Standardisation of bovine units. *Indian Journal of Animal Science*, **53**:543-547.

Kurien, V. (1997) Coming of second miracle. *Dairy India*, **29**(52): A183-A188.

Lynam, J.K. and Herdt, R.W. (1989) Sense and sustainability: Sustainability as an objective in international agricultural research. *Agricultural Economics,* **3**: 381-398.

Mitra, A., Sharma, C. and Véganzonès-Varoudakis, M.A. (2011) *Total Factor Productivity and Technical Efficiency of Indian Manufacturing: The Role of Infrastructure and Information & Communication Technology*. CERDI, Etudes et Documents, 2011.15, Clermont-Ferrand, France. Available at: http://publi.cerdi.org/ed/2011/2011.15.pdf

Pandey, U.K., Patel, R.K. and Suhag, K.S. (1983) The comparative economics of various sources of farm energy in Haryana agriculture. *Urja- Indian Journal of Energy,* **13**(1): 27-32.

Prabu, M. (2008) *Growth of Livestock Sector in Tamil Nadu – A Total Factor Productivity Approach*. Unpublished PhD thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai.

Rae, A.N., Ma, H.Y., Huang, J.K. and Rozelle, S. (2006) Livestock in China: Commodity-specific total factor productivity decomposition using new panel data. *American Journal of Agricultural Economics,* **88**:680–695.

Ranjhan, S.K., Sen, K.C. and Ray, S.N. (1999) *Nutritive Value of Indian Cattle Feeds & Feeding of Animals*. Indian Council of Agricultural Research, New Delhi.

Rosegrant, M.W. and Evenson, R.E. (1992) Agricultural productivity and sources of growth in South Asia. *American Journal of Agricultural Economics*, **74**(3): 757-761.

Sidhu, D.S. and Byerlee, D. (1992) *Technical Change and Wheat Productivity in the Indian Punjab in the Post-Green Revolution Period*. CIMMYT Economics Working Paper *92-02.* Mexico, D.F.

Sirohi, S. and Saxena, R. (2012) Research and development priorities for sustainable milk production in Karnataka. *Indian Journal of Animal Sciences,* **82** (2): 209–215.

Whitaker, M. and Lalitha, S. (1993) *Quantifying the Relative Productivity and Sustainability of Alternative Cropping Systems*. Progress Report No. 115, Resource Management Programme, Economics Group, ICRISAT, Patancheru, Hyderabad.