Ind. Jn. of Agri. Eco.
Vol.67, No.2, April.-June, 2012

ARTICLES

District Level Sustainable Livestock Production Index: Tool for Livestock Development Planning in Rajasthan

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I

INTRODUCTION

Since the past two decades, the concept of sustainability has increasingly occupied the centre stage for the development of the agriculture and allied sectors. With the manifestation of stagnating or declining productivity levels, widening regional disparities and the emergence of environmental externalities, the concerns emerged that development process should be sustainable, i.e., it should be environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO, 1991).

Before targeting the policy interventions to maintain/enhance the sustainability of a crop or livestock production system, it is imperative to examine whether or not certain necessary conditions essential for sustainable development are present in a given region or ecosystem. The major approaches used in the literature to assess the sustainability of a biological production system in a particular region include, estimation of total factor productivity (Ehui and Spencer, 1990; Rosegrant and Evenson, 1995; Kumar and Mittal, 2006), computation of composite indices covering varied dimensions of sustainability (Saleth and Swaminathan, 1992; Yadav and Rai, 2001; Calker *et al*., 2004; Sen and Hatai, 2007; Singh and Hiremath, 2010) and Response-Inducing Sustainability Evaluation (RISE) (Hani *et al.,* 2003). While each of these techniques has its own utility, the indexing approach provides a simple practical tool for indicating a set of projects and policies that can be implemented to address the problem areas that impede sustainability. In India, the empirical application of indexing approach has been made in the context of livelihood security, focusing on the ecological and economic dimensions related to crop production. Although in a recent study by Singh and Hiremath (2010), recognising the importance of dairying in economic and nutritional security of rural livelihoods in Gujarat; milk yield and per capita milk availability were taken as indicators in the construction of district level Sustainable Livelihood Security Index (SLSI), but

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This paper is based on the Ph.D. Thesis of the first author under the guidance of the second author submitted to Division of Dairy Economics, Statistics and Management, National Dairy Research Institute, Karnal (Haryana).

largely, the livestock related indicators have not been covered by most of the studies, in general, and sustainability assessment of livestock production system itself has hardly been attempted, in particular.

Given the vital role of livestock (48 per cent share in total value of output from agricultural and allied activities) in agrarian economy of Rajasthan, this paper follows the indexing approach by constructing the Sustainable Livestock Production Index (SLPI) to characterise the districts according to their relative sustainability status of livestock production and to identify the specific dimensions that require policy attention for orientation of development programmes towards sustainable development of the livestock sector in each district.

METHODOLOGY

Taking the cue from SLSI originally proposed by Swaminathan (1991) and later empirically illustrated by several scholars (Saleth, 1993; Sen and Hatai, 2007; Singh and Hiremath, 2010), the SLPI was constructed using eight indicators, three each capturing the economic and social dimension of sustainability and two for the ecological aspect (Table 1). Table 1 also indicates the year and source of district level data used in the study.

Rationale for Indicator Selection: For evaluating the economic efficiency of the livestock production systems of districts the variable livestock productivity was selected. Since the analysis took into account all the four major livestock products, viz., milk, meat, eggs and wool, aggregate productivity was expressed in monetary terms. This helped to capture not only physical productivity as influenced by feed and fodder quality, climate and technology, but also the performance of marketing and other rural institutions affecting the farm prices. To counter the potential bias arising out of a region's specialisation in high value products, the per capita calorie availability from livestock products was also included as an indicator of economic sustainability. This has bearing on the food and nutritional security aspect of the district. Labour productivity reflecting the efficiency of labour in this sector was taken as another indicator as livestock farming is largely labour intensive.

Female labour has predominant role to play in livestock production systems and account for 69 per cent of the total work force in the livestock sector. Therefore, female literacy was taken to capture social equity. The literacy level of females indicates not only the potential for women's social and economic participation but also for population stabilisation. Another indicator of social equity considered in the study was the access to public infrastructure facilities for livestock sector. The livestock support services have a vital role to play in enhancing the productive performance. In the scenario where such facilities are largely provided by the state, their access and quality is important for the sustainability of livestock production system. In the absence of quantifiable data for capturing quality aspect, the study took into account the inter-district variations in availability of public infrastructure as an

TABLE 1. INDICATORS AND SOURCE OF DATA FOR CONSTRUCTING SLPI IN RAJASTHAN

Indicators (1)	Operational definition (2)	Year (3)	Data source (4)	Source of Conversion Factors (5)
		Economic Efficiency		
Livestock productivity	Value of livestock products (milk, meat, wool and eggs) per Standard Animal Unit (Rs.)	Triennium average 2003/04-2005/06	*Integrated Sample Survey Report* *District Statistical Outline* *Livestock Census 2003*	SAU: Kumbhare *et al.*, (1983), Bhati (1981):
Labour productivity	Value of livestock products per labour employed in livestock sector (Rs.)	Triennium average 2003/04-2005/06	*Integrated Sample Survey Report* *District Statistical Outline* *Population Census 2001*	Labour employment: Elumalai and Pandey (2004)
Energy availability from livestock products	Per capita calorie availability from edible livestock products (cal.)	Triennium average 2003/04-2005/06	*Integrated Sample Survey Report* *Population Census 2001*	Calorie content in livestock products: Narasingh *et al.* (1991)
		Social Equity		
Female literacy	Literate females in total rural female population (per cent)	2001	*Population Census 2001*	
Access to public infrastructure facilities for livestock	Veterinary health, breeding and extension institutions (no./ km^2 of geographical area)	Triennium average 2003/04-2005/06	*Integrated Sample Survey Report* *Statistical Abstract of Rajasthan*	
Growth rate of CPRs	Compound annual growth rate of CPRs (per cent)	1985/86-2005/06	Agricultural Statistics in India	
		Ecological Security		
Relative area under natural vegetation cover to cultivated land	Area under forests, permanent pastures & grazing land to net sown area (per cent)	Triennium average 2003/04-2005/06	*Agricultural Statistics in India*	
Surplus animals in relation to carrying capacity of land	Difference between actual livestock population and optimum stock maintainable on available feed and fodder (per cent)	Triennium average 2003/04-2005/06	*Statistical Abstract of Rajasthan* *Agricultural Statistics in India,* *Livestock Census 2003*	Feed & fodder availability dry matter basis: DAHD (Undated), Jain *et al.*, (1996), Ranjhan *et al.*, (1999). Recommended nutritional intake: Government of India (2001)

indicator, with the presumption that higher density of such facilities imply their better access, thus, contributing positively to social dimension of sustainability. Public infrastructure facilities include veterinary health institutions (hospitals, dispensaries, sub-centres and diagnostic units), breeding institutions (Artificial Insemination centres and sheep breeding farms) and extension institutes (breeding extension centres and training institutions). The common property resources (CPRs) that

include area under forest, permanent pasture and grazing land, land under miscellaneous tree crops and groves, supplement the income of resource poor households and cater to their food, fodder and fuel requirements. Rural inequalities generated by private property based farming system can be partly reduced by CPRs and hence, higher growth of CPR was postulated to promote social equity.

Besides reflecting the social equity aspect, the area under forests, pasture and grazing lands also have a bearing on the ecological dimension of sustainability. The area under such natural vegetation cover is the most valuable natural habitat for maintaining the wide flora and fauna in the agricultural landscape and to preserve the quality of land keeping sufficient land area under natural vegetation cover is normally the most appropriate way. Hence, in a district, relative area under forests, pasture and grazing land vis a vis the net sown area was taken as one indicator of ecological security. The carrying capacity of land assessed through percentage of surplus animals in relation to feed and fodder was another important variable used in the study. The feed and fodder availability (on dry matter basis) was worked out for each district. Considering annual dry matter requirement as 2.555 tonnes per adult cattle unit (Government of India, 2001), the normal carrying capacity, that is, the optimum livestock population (in standard animal unit, SAU) which should be sustained with the given feed resource base in a district was calculated. The percentage difference between the actual SAU and the optimum SAU denoted the excess livestock population in relation to carrying capacity of land and had negative relation with sustainability of the livestock production system.

Construction of SLPI: After the identification of the indicators for the evaluation of economic, social and ecological dimensions of sustainability, the next step was to calculate three indices, i.e., Economic Efficiency Index (EEI), Social Equity Index (SEI) and Ecological Security Index (ESI) for each district and thereafter, derivation of the overall district-wise SLPI by combining the three indices.

Following the generalization of relative approach underlying the Human Development Index developed by UNDP (1990), each indicator (variable) I_{ijk} was indexed:

$$I_{ijk} = \frac{X_{ijk} - MinX_{ijk}}{M_j axX_{ijk} M_j inX_{ijk}}$$ when indicator has +ve association with SLPI

$$I_{ijk} = \frac{Max\ X_{ijk} - X_{ijk}}{M_j axX_{ijk} M_j inX_{ijk}}$$ when indicator has -ve association with SLPI

where,

X_{ijk} = value of i-th variable representing j-th component of SLPI of k-th district.

Three indices were computed as the simple mean of their respective indexed variables, that is:

$$EEI_k = \frac{\sum_{i=1}^{3} I_{ik}}{3}, SEI_k = \frac{\sum_{i=1}^{3} I_{ik}}{3}, \text{ and } ESI_k = \frac{\sum_{i=1}^{2} I_{ik}}{2}$$

The composite index for each district was calculated as a weighted mean of the three indices obtained from above equation, i.e.,

$$SLPI_k = \frac{W_1 * EEI_k + W_2 * SEI_k + W_3 * ESI_k}{3}$$

where 'W' denotes the weight assigned to the respective component of the SLPI. The assignment of appropriate weights for different components is an important issue in construction of an index. A number of earlier studies based on the indexing approach have given equal weightage to all the components of the index; a rather restrictive approach considering that the relative importance of economic, ecological and social aspects varies across regions. Hence, in the present study, differential weights are assigned to the three components for each region and to each component across the regions by calculating the weights as the ratio of inverse of the proportional contribution of EEI, SEI and ESI to the sum of all the three inverse proportions. This approach gives more weight to the weaker component in the region rather than equal weight to all the components.

Correlates of SLPI: In order to understand the socio-economic, technological and infrastructural factors that affect the sustainability of livestock production, the correlates of SLPI were studied with the help of simple correlation matrix taking into account following variables at the district level:
(i) proportion of Scheduled Tribe population (STS), (ii) literacy rate (LITERACY), (iii) urbanisation (URBAN), (iv) per capita income (PCI), (v) cropping intensity (CI), (vi) irrigation intensity (IRR), (vii) crossbred adoption (CB), (viii) concentrate production per SAU (CONCENTRATE), (ix) cultivated fodder production per SAU (FODDER), (x) grass production per SAU (GRASS), (xi) village road connectivity (ROAD), (xii) percentage of household with access to electricity (ELEC), (xiii) number of dairy cooperative societies (DCS), (xiv) number of veterinary and animal husbandry institutions per SAU signifying livestock support services (LSS).

III

RESULTS AND DISCUSSION

In general, the sustainability status of livestock production is weak in Rajasthan as on scale of 0 to 1 the mean value (geometric mean) of SLPI in 0.312 (Table 2) in

the state. Given the close interaction between the crop-livestock sector, the poor status of agricultural sustainability in Rajasthan was also reported by Saleth (1993) based on the average Sustainable Livelihood Security Index (SLSI) score of 0.389 across agro-climatic zones in the state.

TABLE 2. DISTRICT-WISE SUSTAINABILITY STATUS OF LIVESTOCK PRODUCTION IN RAJASTHAN

Districts	EEI	Rank	SEI	Rank	ESI	Rank	SLPI	Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Hanumangarh	0.705	5	0.597	5	0.337	9	0.495	1
Karauli	0.617	7	0.487	13	0.411	4	0.491	2
Bikaner	0.562	11	0.392	23	0.524	1	0.481	3
Ganganagar	0.864	1	0.514	12	0.293	12	0.460	4
Rajsamand	0.535	12	0.534	10	0.343	8	0.451	5
Sirohi	0.393	18	0.415	20	0.489	3	0.429	6
Jhunjhunu	0.595	10	0.708	2	0.220	20	0.393	7
Dausa	0.803	3	0.518	11	0.206	22	0.374	8
Dholpur	0.533	13	0.547	7	0.225	19	0.368	9
Sikar	0.498	14	0.746	1	0.197	24	0.357	10
Ajmer	0.732	4	0.537	9	0.191	26	0.354	11
Bundi	0.341	20	0.396	22	0.321	10	0.350	12
Churu	0.262	24	0.467	16	0.353	7	0.341	13
Jaipur	0.858	2	0.633	4	0.154	30	0.324	14
Jaisalmer	0.379	19	0.239	31	0.390	5	0.320	15
Jodhpur	0.476	17	0.347	28	0.206	23	0.305	16
Alwar	0.657	6	0.669	3	0.145	31	0.302	17
Pali	0.490	16	0.352	27	0.187	27	0.293	18
Barmer	0.292	22	0.368	26	0.237	17	0.290	19
Bhilwara	0.281	23	0.416	19	0.228	18	0.289	20
Bharatpur	0.611	8	0.589	6	0.142	32	0.288	21
Kota	0.215	27	0.442	17	0.285	13	0.288	22
Jhalawar	0.244	26	0.416	18	0.255	15	0.287	23
Nagaur	0.319	21	0.374	25	0.195	25	0.274	24
Tonk	0.493	15	0.289	29	0.181	28	0.272	25
Jalore	0.610	9	0.253	30	0.171	29	0.262	26
Udaipur	0.131	30	0.478	15	0.500	2	0.255	27
Sawai Madhopur	0.255	25	0.215	32	0.249	16	0.238	28
Baran	0.133	29	0.412	21	0.364	6	0.237	29
Chittorgarh	0.124	31	0.480	14	0.261	14	0.214	30
Banswara	0.139	28	0.386	24	0.218	21	0.209	31
Dungarpur	0.047	32	0.546	8	0.299	11	0.114	32
Geometric Mean	0.371		0.442		0.257		0.312	
Coefficient of Variation (per cent)	51.40		28.35		37.91		27.39	

The SLPI ranged from a lowest level of 0.114 in Dungarpur district to 0.495 in Hanumangarh district. Although it is a relative index showing the comparative status of each district, yet it is notable that in all the 32 districts, the value of SLPI was below the half way mark of 0.5. Based on the distribution of the values of the indices the districts were classified into three categories of sustainability status, viz., Low (Index < 0.3), Moderate (0.3 to 0.5) and High (>0.5), and mapped with the help of geographical information system. The mapping of SLPI indicates that the

sustainability of livestock production is weaker in the southern part of the state (Figure 1).

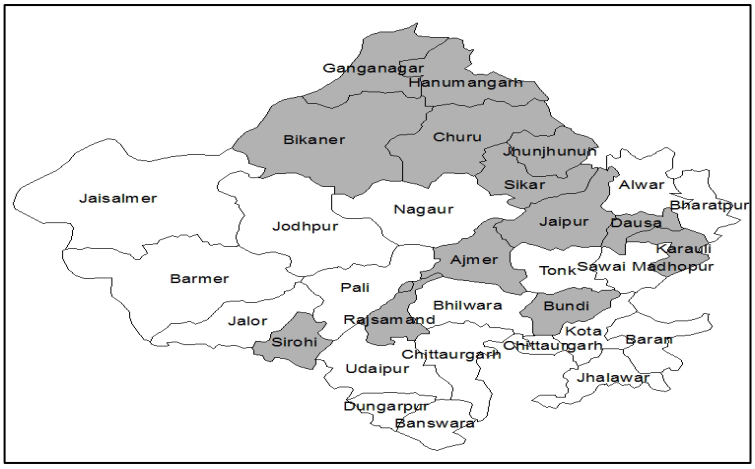

Figure 1. Overall Sustainability Status

Among the various components of sustainability, the ecological dimension was the weakest as the mean value of component indices worked out to be 0.371, 0.442 and 0.237 for economic (EEI), social (SEI) and ecological (ESI) component, respectively. The inter-district variations were maximum in case of EEI (C.V. 51.40 per cent) and lowest in SEI (C.V. 28.35 per cent) implying that the regional disparities in social aspects related to the livestock production are low in the state.

For a comprehensive analysis of various dimensions, the discussion is carried out according to categorisation of districts as per their overall livestock sustainability status.

Low Sustainability Status (SLPI <0.3)

Among the 15 districts with SLPI <0.3, located mostly in south and south-eastern parts of the state, the two worst performing districts of Dungarpur and Banswara also ranked as bottom two districts in the state Human Development Index (HDI) (IDS, 2008). Both the districts have predominance of tribal population and have been declared as the 'Scheduled Area' as per the Constitutional provisions. Among the three component indices of sustainability, the EEI is the least in the districts. The EEI is particularly low in Dungarpur (0.047). The productivity of the livestock sector is very low in the districts, primarily due to shortage of feed and fodder. During the study period, the average annual productivity of dairy animals was only 540 liters and 780 liters in Dungarpur and Banswara, respectively much below the state average of 1333 liters per annum. The shortage of feed and fodder is reflected in the low index

value of surplus livestock population (Table 3). The actual livestock population in the districts exceeded the carrying capacity of feed and fodder resources by 73 to 78 per cent. Therefore, besides the deplorable status of economic dimensions in the districts, their ecological security status is also poor.

TABLE 3. INDICES VALUES OF SUBSTANTIALITY INDICATORS

	Economic Indices			Social Indices			Ecological Indices	
Districts (1)	Livestock productivity (2)	Labour productivity (3)	Calories availability (4)	Female literacy (5)	Infrastructure for livestock (6)	CGR of CPRs (7)	Surplus livestock population (8)	Natural vegetation cover : cultivated area (9)
Bottom 15 districts (SLPI<0.3)								
Dungarpur	0.000	0.022	0.120	0.109	1.000	0.530	0.221	0.378
Banswara	0.101	0.055	0.261	0.010	0.624	0.525	0.187	0.249
Chittorgarh	0.049	0.041	0.281	0.265	0.351	0.825	0.207	0.315
Baran	0.124	0.083	0.193	0.434	0.216	0.585	0.301	0.427
S. Madhopur	0.314	0.185	0.267	0.235	0.329	0.080	0.302	0.196
Udaipur	0.039	0.163	0.189	0.480	0.419	0.534	0.000	1.000
Jalore	0.489	0.340	1.000	0.000	0.209	0.551	0.302	0.039
Tonk	0.534	0.379	0.566	0.141	0.257	0.468	0.294	0.067
Nagaur	0.371	0.278	0.308	0.383	0.185	0.554	0.364	0.026
Jhalawar	0.253	0.166	0.311	0.381	0.278	0.588	0.249	0.260
Bharatpur	0.574	0.371	0.888	0.492	0.764	0.511	0.249	0.035
Kota	0.311	0.334	0.000	1.000	0.327	0.000	0.315	0.255
Bhilwara	0.222	0.219	0.401	0.176	0.457	0.614	0.212	0.243
Barmer	0.232	0.259	0.384	0.486	0.051	0.569	0.407	0.067
Pali	0.379	0.532	0.557	0.272	0.208	0.574	0.224	0.151
Top 17 districts (SLPI ≥ 0.3)								
Hanumangarh	0.658	0.464	0.991	0.747	0.175	0.870	0.675	0.000
Karauli	0.590	0.440	0.819	0.531	0.310	0.619	0.295	0.527
Bikaner	0.358	0.604	0.723	0.445	0.056	0.675	1.000	0.049
Ganganagar	0.936	0.815	0.840	0.746	0.267	0.529	0.554	0.032
Rajsamand	0.358	0.554	0.692	0.307	0.729	0.567	0.265	0.421
Sirohi	0.250	0.485	0.445	0.292	0.371	0.581	0.325	0.653
Jhunjhunu	0.723	0.405	0.657	0.966	0.600	0.559	0.356	0.085
Dausa	0.857	0.563	0.990	0.463	0.598	0.493	0.311	0.102
Dholpur	0.433	0.441	0.725	0.440	0.436	0.766	0.316	0.134
Sikar	0.488	0.416	0.591	0.865	0.636	0.736	0.308	0.087
Ajmer	0.793	0.774	0.628	0.640	0.331	0.640	0.225	0.156
Bundi	0.277	0.242	0.505	0.303	0.290	0.595	0.311	0.330
Churu	0.520	0.000	0.265	0.781	0.114	0.507	0.698	0.009
Jaipur	1.000	1.000	0.573	0.850	0.548	0.502	0.200	0.107
Jaisalmer	0.011	0.640	0.484	0.140	0.000	0.578	0.613	0.167
Jodhpur	0.593	0.513	0.323	0.345	0.112	0.582	0.358	0.054
Alwar	0.664	0.328	0.981	0.487	0.520	1.000	0.202	0.087
Overall Mean	0.422	0.379	0.530	0.444	0.368	0.572	0.339	0.210
C. V. (per cent)	63.9	63.1	52.9	60.10	62.8	31.8	55.3	103.4

Other than these tribal districts where more than 60 per cent of the population is that of the Scheduled Tribes (STs), among the bottom 15 districts as the SLPI,

Udaipur, Sawai Madhopur, Chittorgarh and Baran also have sizeable ST population. The EEI is low in all these districts. The Spearman's rank correlation coefficient (R) across district ranking of SLPI, EEI, SEI and ESI, shows that there is a significantly high positive rank correlation (0.714) between sustainability index and the economic efficiency of livestock production (Table 4). However, the rank correlation between EEI and ESI indices is negative and significant (-0.363). These results suggest that by strengthening economic efficiency the livestock sustainability can be improved but at the same time there would be a trade-off in terms of ecological security. Hence, it is important that the livestock development policy focuses on the utilisation of natural resources taking into account the ecological considerations. The districts wherein the economic development and ecological restoration works require special attention are Chittorgarh, Jhalawar, Kota, Bhilwara and Barmer.

TABLE 4. RANK CORRELATION BETWEEN SUSTAINABILITY COMPONENTS

Variables (1)	Spearman's rank correlation coefficient (2)
SLPI and EEI	0.714**
SLPI and SEI	0.395*
SLPI and ESI	0.241
EEI and SEI	0.413*
EEI and ESI	-0.363*
SEI and ESI	0.125

** and * Significant at P≤ 0.01 and P≤ 0.05 level.

Out of all the districts having low sustainability status of livestock production, the performance of Swai Madhopur district is of particular concern, as this is the only district in the state with low indices (<0.3) of all the three dimensions, viz., economic, social and ecological. The district is characterised by very low cropping intensity of 124.42 per cent despite of 58 per cent of gross irrigated area (58 per cent) in the district (IDS, 2008). Low cropping intensity, coupled with sharp fall in the area under CPRs (compound annual growth rate -5.47 per cent during 1985/86-2005/06) is one of the reasons for low level of livestock output in the district. This in turn leads to poor per capita calorie availability from animal products and low productivity of labour engaged in the livestock sector, hence, adversely affecting the economic sustainability of livestock production. The decline in area under CPRs and relatively less area under the natural vegetation cover to cultivated area (0.43:1) adversely impinge on the social and ecological dimensions of sustainability, particularly as more than 40 per cent of the human population in the district belongs to Scheduled Castes and Scheduled Tribes; that are traditionally considered to be socio-economically weaker sections of the society with heavy reliance on the natural common property resources for their livelihoods.

Moderate Sustainability Status (SLPI 0.3-0.5)

The northern and north-eastern parts of Rajasthan have relatively better sustainability status of livestock production, perhaps because of agricultural development as a result of agro-climatic advantages (Ganganagar and Hanumangarh) or better access to markets due to proximity to urbanised areas (Jaipur, Ajmer, Alwar and Dausa). However, the districts of Hanumangarh and Ganganagar that rank first and fourth, respectively in terms of SLPI, need to improve the livestock support services as the indices for livestock infrastructure availability are low in the districts. Also, as large proportion of geographical area is under cultivation leaving little natural vegetation cover, therefore, the development policy in the districts should be focused on advancing the technologies for conservation of soil and water resources for their ecological sustainability.

The districts of Alwar, Jaipur, Ajmer, Dausa, Dholpur, Jhujhunu and Sikar have moderate to high economic efficiency and social equity scores, but the ecological security indices are low in all these districts. The livestock population in these districts far exceeds the carrying capacity of land and also, the natural vegetation cover is in general, less. Among the other moderate SLPI districts, Karauli, Rajasmand, Sirohi and Bundi, although the score of all three components is greater than 0.3, yet, the indices of sustainability indicators bring out two aspects requiring policy attention; one, the development of infrastructural facilities and other, enhancing feed and fodder availability for livestock. Additionally in the latter three districts, the female literacy is also relatively lower and needs to be increased.

Interestingly, in the four districts, Bikaner, Churu, Jaisalmer and Jodhpur, located in the arid western plains of Rajasthan, the livestock sustainability is relatively better than several districts of southern Rajasthan. The strength of the livestock production system in these districts is that the livestock population in the region does not exceed the carrying capacity of land. Further, the region is home tract of good native breeds of cows like, Tharparkar and Rathi and except in Jaisalmer the milk productivity is above state average in the districts. The key area of development priority in these districts is ensuring good network of livestock support services. The topography of the region necessitates establishing mobile veterinary and health care facilities to cover the vast stretch of area. In the desert region, since the natural vegetation cover is poor, 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 feed and fodder crops, grasses and top feed species and rational exploitation of the non-conventional feed resources are important policy options for improving the sustainability of livestock production in these districts as well as other districts where the relative area under natural vegetation cover to the cultivated land is low.

Correlates of Sustainable Livestock Production

While the district-wise indices of the indicators of sustainability discussed above bring out the weak aspects of economic, social and ecological dimensions of sustainability that need to be addressed by researchers, extension agencies and policy makers; the correlation between SLPI, socio-economic, technology and infrastructural variables outlined in the methodology throws more light on the R&D imperatives in the study area.

The SLPI was significantly correlated with 5 out of 14 variables considered in the study (Table 5). The earlier observation that the sustainability status of livestock production is relatively very poor in the tribal districts has been reiterated by the strong negative correlation (r = -0.522) between the SLPI and proportion of ST population in the district. Technology (captured through adoption of crossbreeding in cows), input availability (viz. availability of cultivated green fodder per SAU), infrastructure (rural road connectivity) and social progress (reflected in literacy level) have significant positive effect on the sustainability of livestock production.

TABLE 5. CORRELATES OF SUSTAINABILITY

		Correlation coefficient		
(1)	(2)	(3)	(4)	(5)
STS	SLPI -0.522**	LITERACY -0.553**	CI 0.372*	FODDER -0.425**
LITERACY	SLPI 0.415**	URBAN 0.584**	ROAD 0.333*	ELEC 0.548**
CB	SLPI 0.323*	LITERACY 0.569**	LSS 0.55**	STS -0.298*
FODDER	SLPI 0.417**	CI -0.518**		
ROAD	SLPI 0.453**	LSS 0.315*	STS -0.344*	
CI	SLPI -0.051**			
IRRI	SLPI 0.215	CI 0.373*		
CONCENTRATE	SLPI 0.159	IRRI 0.8**		
GRASS	SLPI -0.035			
URBAN	SLPI 0.209	ELEC 0.644**	STS -0.465**	
PCI	SLPI 0.256	URBAN 0.616**		
ELEC	SLPI 0.233	STS -0.389*		
LSS	SLPI 0.026			
DCS	SLPI -0.066	URBAN 0.554**		

** and * Significant at P≤ 0.01 and P≤ 0.05 level.

Besides these determinants that directly show high and positive correlation with the SLPI, there are a number of correlates that have indirect effect on sustainability and hence, should receive priority attention of the research and development agencies. For instance, the adoption of crossbreeding is facilitated by the better network of public veterinary healthcare and breeding institutions (r= 0.550). For improving the outreach of health and breeding infrastructure, better village road connectivity is vital. Better access of villages to all-weather roads also promotes literacy. Besides roads, literacy level is highly correlated with the households access to electricity (r=0.548). The districts wherein access to electricity is better, the irrigation intensity is higher (r= 0.302), largely due to energisation of pumpsets. The

irrigation intensity and cropping intensity show a positive relation. Given the supplementary and complementary relationship between the crop and livestock production, rise in cropping intensity would lead to increased availability of feed and fodder for the livestock. The observed negative and significant correlation between cropping intensity and fodder availability per SAU (r= -0.518) in Rajasthan, manifests that cultivation of green fodder crops has not been adequately propagated in the state even in districts where a higher percentage of land is cultivated more than once. There are several promising varieties of forage crops suitable for the agro-climatic conditions in Rajasthan (IGFRI, 2011) that can be cultivated in the state to increase the green fodder supply for the livestock.

The state is also hugely deficit in the production of oilcakes, the gap between availability and requirement of concentrates for livestock feeding being to the tune of 95 per cent (Planning Commission, 2009). In this study, the correlation between the SLPI and concentrate production per SAU works out to be weakly positive, primarily because of two reasons, one, unlike green fodder, concentrate feed is more transportable from one region to other, hence local production is not the only criterion for its usage and two, in the regions with better availability of concentrate feed, the stocking rate of livestock is far higher than the optimum, thus adversely affecting the ecological dimension of sustainability. However, as there emerges a strong positive correlation between the irrigation intensity and concentrate production (r=0.800), improvement in irrigation coverage can also enhance the oilcake availability for animal feeding in the state. Better availability of concentrates would facilitate sustainable livestock production through its positive effect on livestock production and productivity.

The availability of marketing facilities is another important correlate of sustainable production. However, in Rajasthan, as the network of dairy co-operative societies (DCS) is largely concentrated in the districts where urbanisation has taken place (r=0.554), therefore, as of now, the contribution of DCS towards sustainable livestock production in the state seems to be negligible. Therefore, provision of better access to marketing channels is another area where focus of both, public and private institutions is required.

IV

CONCLUSIONS

SLPI is a composite index that can work as a powerful tool for assessing the necessary conditions of sustainable livestock development in a functional unit of development planning. As a policy tool, it identifies the districts which require greater policy attention and specifically focuses on the critical areas for formulating district livestock plans. The selected variables do have a good capacity to reflect the overall economic, social and ecological aspects of a region's livestock production system, although there is always a scope for further refinement with more volume of

quality data. The indicator selected to represent a given dimension also reflected the concerns in the other dimensions of livestock sustainability, and hence, most of the indicators display both, positive and negative correlations among them. Rather than being a problem, this actually enhances the capacity of the constructed index to capture the inherent conflicts and also the intrinsic synergy among various aspects of livestock sustainability.

Based on relative values of SLPI and component indices (EEI, SEI and ESI), the study brings out that although in Rajasthan, all the three dimensions of sustainability need to be improved, yet the relative emphasis to be given across districts on the economic, social and ecological aspects is not quite the same. The districts in the southern and south-eastern part (Dungarpur, Udaipur, Bhilwara, Chittorgarh, Jhalawar Banswara, Baran and Kota) and a few districts located in the western Rajasthan (Barmer, Churu and Jaisalmer) require ardent policy attention to strengthen the economic dimensions, by improving livestock productivity through technological advancement, labour productivity by training them in scientific livestock farming practices, and introduction of value added high value products for high calorie intake. The tribal districts require special attention in terms of infrastructure development. Traditionally, Rajasthan had 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 heavily degraded and forage yields have come down to 15-20 per cent of their potential. The maintenance of CPRs and balancing the livestock population in tune with the available resources in the region is another policy area that should be incorporated in the district livestock planning, particularly in the districts that have weak status of ecological security.

Received July 2010. *Revision accepted April 2012.*

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