Indian Journal of Animal Sciences **82** (2): 209–215, February 2012

Research and development priorities for sustainable milk production in Karnataka

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Received: 8 April 2011; Accepted: 7 September 2011

ABSTRACT

The paper develops a typology of dairy production systems in Karnataka state and assesses the priorities for dairy development using the twin approach, yield gap analysis and generating indices of investment priorities. The yield gaps for the three types of dairy animals, worked out at the district level with respect to the best performing district, indicate existence of very high productivity differentials across districts. Among the determinants of milk yield, animal health and breeding infrastructure, existence of milk cooperatives, availability of concentrate and green fodder have significant effect in increasing milk productivity. The climate variability across districts also has notable effect on the productivity of the animals. The study used multi-criterion scoring method (congruence method) for normative allocation of the investment resources across zones and districts in Karnataka. The investment priorities suggest that across zones 40.2% resources should be allocated to arid/semi-arid rainfed zone, 44.7% to arid/semi-arid irrigated zone and 15.1% to humid coastal zone. The state needs to focus on resource endowment based animal breeding policy, productivity improvement through selective breeding, management of CPRs, ensuring nutritional requirement of animals and also management of heat stress.

Key words: Dairy production systems, Priortization, Productivity determinants, Yield gap

Dairying is an important means of rural livelihood throughout the country. In the state of Karnataka, where rainfed agriculture is more predominant (70% unirrigated NSA), 40% of the farmer households are engaged in dairy farming (NSSO 2005). The average value of milk output was ₹ 39.67 billion (at 1999–00 prices) during TE 2005–06; nearly 11% of the total value of output from agriculture and allied activities. In contrast to the growth performance registered during the mid 80s to mid 90s (1987/88 to 1995/96), wherein milk production increased at compound annual rate of 4.76%, during the past decade (1997/98–2007/08), it has nearly stagnated at about 4.2 million tonnes per annum (compound annual growth rate, 0.61%). Research studies indicated that from 1987/88–1995/96 production in Karnataka had been mainly productivity driven (Birthal *et al.* 1999). Further, the annual productivity of lactating crossbred cows and buffaloes is 2100 lt. and 900 lt., respectively, lower than the corresponding national average of 2380 and 1620 lt. (DAHD 2009).

Division of Dairy Economics, Statistics and Management.

In this context, the major objective of the paper is to provide policy guidelines for the development of dairy in the state. The study develops a typology of dairy production system in Karnataka, carries out a disaggregated district level analysis to assess the priorities for dairy development using the twin approach, one, yield gap analysis and second, generating indices of investment priorities. Based on these, the study identifies the specific dimensions that require policy attention for orientation of development programmes towards enhancing productivity of dairy animals and delineates the regional priorities for sustainable livelihood security through dairy farming.

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MATERIAL AND METHODS

Typology of dairy production systems

A three stage classification was made to arrive at the typology of dairy production systems. As the availability of water resources conditions the feed and fodder availability from crop by-residues, cultivated fodder crops, oilcakes and meals, pastures and forest land, etc., *In stage 1*, the districts were classified into 3 categories based on the normal rainfall and irrigation criterion. The annual rainfall threshold of 1150 mm and average irrigation threshold of 25% of net sown area was considered to categorise the districts into three zones as per Kerr *et al.* (1996). (There may be alternate views about the appropriateness of 25% as threshold level. Additionally, the limitation of such a threshold is that slight differences in irrigation levels will move some districts from one category

to the other): *Zone I*- Arid and Semi-arid Rainfed (ASRZ), *Zone II* -Arid and Semi-arid Irrigated (ASIZ) and *Zone III*-Humid and Coastal (both, rainfed and irrigated) (HCZ)

In stage 2, three broad dairy production systems were identified on the basis of proportion of cows and buffaloes in the total milch animal stock as per the Livestock Census, 2007. Cow based: >60% cows in milch animal stock; Buffalo based: >60% buffaloes in milch animal stock and

Mixed production system: Ratio of cow: buffalo ranging between 40:60 to 60:40.

In stage 3, the adoption rate of crossbreeding (% of crossbred milch stock in total milch cattle stock) was considered as the stratification criterion:

Low adoption rate, <1/3; moderate adoption, 1/3–2/3 and high adoption >2/3

Yield gap analysis and determinants of production performance

The yield gap was computed for indigenous cows, crossbred cattle and buffaloes by taking the ratio of average milk yield of milch animals in the district to the corresponding milk yield in the best performing district. To understand the factors affecting the production performance of dairy animals in the state, district level regression analysis was attempted with average annual milk productivity of dairy animals in TE 2007–08 (*equation 1*) and annual yield of crossbred cows (*equation 2*) as dependent variables. The explanatory variables considered in the equations were:

(i) *Availability of dry fodder (DF), green fodder (GF) and concentrates (CONC) per milch animal (tonnes/ annum):* Crop by-residues are the main source of dry fodder for the animals. The production of dry fodder was worked out from the crop production estimates in each district (TE 2006–07) using the ratios of grain to straw/top for different crops. To estimate the green fodder production, the data on area under fodder crops, under pasture and grazing lands, and forest were taken from land utilization statistics and average grass/fodder yield from each was used to compute total production of fodder (Jain *et al.* 1996). Concentrates are made up of oilcakes, crushed pulses, grains, rice and wheat bran, its production was estimated based on the ratio of meal to oilseed (Ranjhan *et al.* 1999), ratio of bran and grain and assumption about proportion of grain used for animal feed (Jain *et al.* 1996).

(ii) *Animal health and breeding infrastructure (INFRA) and dairy cooperatives (COOP):* The density of public funded animal health institutions and artificial insemination centers and density of dairy cooperatives in relation to geographical area was included in the regression.

(iii) *Heat stress:* Since production is negatively affected by increase in Temperature Humidity Index (THI) beyond a threshold level hence, the annual THI load (i.e. total THI units in excess of threshold level) were computed using the data on weekly normals of maximum and minimum temperature and relative humidity from 11 stations in Karnataka and calibrated to all the other districts. (The weekly average THI was computed for each of the stations from the data and weekly THI load was worked out at threshold THI of 72. Assuming the average weekly THI load to be uniform for all the seven days in the week, level of total THI load in a week was worked out. The annual THI load is sum of the total weekly load over 52 weeks.)

Research prioritization

The study used multi-criterion scoring method (congruence method) for normative allocation of the investment resources across districts in Karnataka. It is simple, transparent and flexible approach that has been used by many researchers for setting research priorities (Jha 1995, Kelly and Ryan 1995, Birthal *et al.* 2002). Three goals of dairy development were considered: *efficiency:* enhancing productivity; *equity:* augmenting income of poor; and *sustainability:* improving livestock carrying capacity of land. The identified extensity parameters/indicators reflecting the objectives of investment in dairy and the weights assigned to these parameters are enlisted in Table 1.

Based on the district values of extensity parameter and their assumed weights, initial baseline (B_i) allocating investment across regions was constructed.

$$B_i = (\sum_j w_j P_{ij});$$

where, B_i is the baseline for i^{th} district, w_j is the weight for j^{th} extensity parameter, P_{ij} is share of the i^{th} district in j^{th} extensity parameter, that is,

$$P_{ij} = (A_{ij} / \sum_j A_{ij}) \times 100; \quad A_{ij} \text{ is value of } j^{th} \text{ parameter in } i^{th} \text{ district}$$

There were 27 districts and 3 extensity parameters in this study.

The resource allocation based on the initial baseline may not fully capture the major concerns of growth, equity and sustainability, as this reflects the size of the problem (extensity) but ignores its intensity. Therefore, appropriate modifiers/intensity parameters were used for modification of the initial baseline and arriving at the final baseline that eventually reflects the priorities based on both size and intensity of the problem. The selected modifiers, their respective weights and impact on the initial baseline are given in Table 1.

The impact of selected modifiers on the initial baseline was quantified as:

$$C_i = [1 + \{(M_{ik}/\text{Max}\ (M_{ik}))\} \times w_k]\ B_i$$

Where, $M_{ik,}$ data for k^{th} modifier for i^{th} region, w_k, weight

Table 1. Criteria for prioritization

Objective	Extensity parameters and their weights	Intensity parameters and their weights	Direction of influence on IBL
Efficiency	Value of milk output (0.30)	Scope for growth in milk production (yield gap)(0.34)	Positive
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 availability of milk (0.11)	Negative, Positive, Negative
Sustainability	Common property resources (Include barren lands, permanent pastures, cultivable waste lands, area under tree and grooves and fallow lands) (0.20)	Density of milch animals (0.33)	Positive

for k^{th} modifier, $B_{i,}$ initial baseline.

The above procedure applies when modifiers have positive signs. Impact of modifiers with negative signs is obtained by subtracting (Mij/Max (Mij)) from unity. The impact of individual modifiers was summed up ΣC_{ik} over modifiers (k) to get net aggregate impact of all modifiers. The initial baseline was modified by using the aggregate impact ΣC_{ik} to get the final baseline indexed to sum up to 100 across districts;

New priority distribution or final baseline (Fi)

$F_i = (B_i^*/\Sigma B_i^*) * 100$; where B_i^* (Adjusted baseline) = $B_i + \Sigma C_{ik}$

RESULTS AND DISCUSSION

Dairy production systems

Superimposing the three classification criterions (Fig.1) indicated that in the rainfed region (ASRZ), various dairy production systems co-exist. The rainfed districts in southern Karnataka have cow based production system, some with high adoption of crossbred cows (Bangalore and Kolar) and some with moderate adoption of the technology (Tumkur and Hassan). The central part of the rainfed zone has mixed production system, wherein cows and buffaloes are nearly in equal proportion. However, there are variations in terms of composition of cow population reared in the region. Dharwad and Haveri have more than 1/3 crossbred cows but in the other districts indigenous cows of low productivity potential predominate.

In the northern part of the humid and coastal areas (HCZ) also, the dairy animals are largely indigenous cows, while the southern districts of Kodagu and Dakshin Kannada have about 35 to 45% adoption of crossbreeding technology. The irrigated semi-arid zone (ASIZ), by and large, has prevalence of mixed production system, with few exceptions. In the district Belgaum located in the North-west part of zone, buffaloes (72%) far outnumber the cattle stock (28%). In the

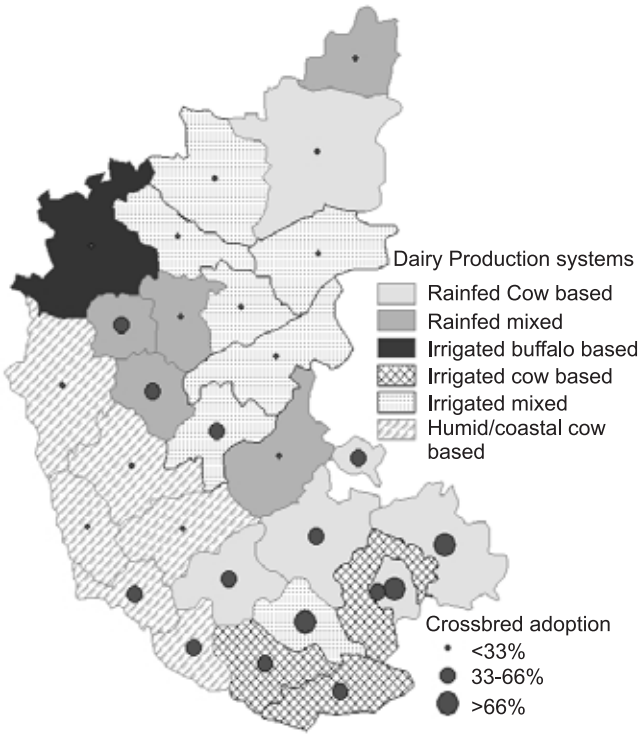

Fig. 1. Characterisation of Dairy production systems in Karnataka

southern districts of Mysore, Banglore rural and Chamrarajnagar, as in other districts in this geographical region, the cows are the major dairy animals and intensity of crossbreeding adoption is also moderately higher.

During the past decade (1997–2007), the composition of dairy animal population in Karnataka has shifted in favour of crossbred cows (Table 2). However, the growth in the milch animal stock has been very marginal (annual compound growth rate 0.5%), due to decline in the indigenous cows stock and near stagnation in milch buffaloes. The zonal trends

Table 2. Decadal growth of dairy animals in Karnataka: 1997–2007

Zone	Compound annual growth rate (%)				
	Crossbred cows	Indigenous cows	Cattle	Buffaloes	Total
Karnataka	6.9	–1.3	0.7	0.2	0.5
Arid/Semi-Arid Rainfed Zone (ASRZ)	7.2	–1.0	1.1	–0.2	0.6
Arid/Semi-Arid Irrigated Zone (ASIZ)	6.7	–1.4	0.7	1.0	0.8
Humid and Coastal Zone (HCZ)	6.7	–1.5	0.1	–2.8	–0.5

ASRZ: Bangalore (U), Bidar, Chitradurga, Kolar, Tumkur, Hassan, Dharwad, Gadag, Haveri, Gulbarga; ASIZ: Bagalkot, Bangalore (R),Belagaum, Bellary, Bijapur, Chamarajanagar, Davangere, Koppal, Mandya, Mysore, Raichur; HCZ (Rainfed): Chikamagalur, Kodagu, Uttar Kannada; HCZ(Irrigated): Dakshin Kannada, Shimoga, Udupi

are broadly similar, increasing crossbred cows and decreasing indigenous cattle. The population trend in buffaloes has shown some variation across zones; near stagnancy in rainfed region, increase in irrigated zone and decline in the humid and coastal areas.

Yield- gap analysis and determinants of production performance

The production performance of the crossbred cows is best in the rainfed zone, while the indigenous cows and buffaloes in the HC region have higher average yields than in the other zones (Table 3). At the district level, the yield gaps for the 3 types of dairy animals worked out with respect to the best performing district (In case of crossbred cows, the yield of second highest district, Bidar has been taken to work out the yield gap, as the number of crossbred animals in the highest productivity district Bijapur were only 633 as per the livestock census 2007) in the state show existence of very high productivity differentials across districts. In the rainfed districts of Hassan, Tumkur, Chitradurga and Haveri, the productivity of crossbred milch animals is less than half of the highest productivity levels of 6.32 l/day in Bidar. Similarly, in several districts in the other two zones also the yield gaps are substantially wide.

As compared to crossbreds, the yield-gap for indigenous cows is less profound across districts. But in districts like, Gulbarga, Hassan, Tumkur, Chitradurga (Zone ASRZ), Banglore rural, Mysore, Bagalkote and Mandya (Zone ASIZ), the attained level of productivity is less than half of the maximum district yield. Belgam is the only buffalo dominant district in Karnataka but the productivity of buffaloes is quite low here, less than half of the productivity level in Udupi (3.70 lt./day). In fact, in majority of the districts, the yield of the milch buffaloes is very low.

The results of the regression analysis show that all the explanatory variables in equation 1 have the expected sign (Table 4). Among the various feed inputs, the availability of concentrate has largest effect in increasing milk productivity, followed by green fodder. The availability of dry fodder though has a positive influence on productivity, yet due to poor nutritional quality of the dry fodder, the effect is not significant. In explaining the inter-district variations in crossbred productivity, concentrate is the only feed input that turned out to be significant. The area under cultivated green-fodder crops is extremely limited in the state. The requirement of green fodder is largely met from grasses and tree leaves from the common property resources. However, as the crossbred animals are stall-fed, unlike the indigenous cattle and even buffaloes which are loose for grazing, the inter-district variations in fodder availability for the crossbred cows was low, thus leading to insignificance of the green fodder variable in the equation 2. The inclusion of dry fodder in this equation was attempted but due to inconsistent results same was omitted.

Animal health and breeding infrastructure and dairy cooperatives have important role to play in providing the input and output support services to the dairy farmers. The role of infrastructure and institutions in dairy development is underscored in the equation 1, but in the later with crossbred productivity as the dependent variable only animal health care and breeding infrastructure emerged as the significant explanatory variable. While the significant effect of INFRA is self-explanatory, an earlier study based on district cross-section data of milk productivity in Karnataka for the year 1995–96 (Birthal *et al.* 1999) explained the insignificance of regression coefficient of dairy cooperatives in terms of their poor performance and limited role in supplying quality inputs to the dairy farmers. A decade later, as far as direct intervention by the cooperatives for productivity enhancement is concerned, the situation does not seem to have changed much, as is suggestive of the insignificance of this variable in affecting the yield of crossbred cows. But, due to the indirect effect of cooperative network in influencing milk productivity through providing market for the milk produced by the small holder dairy farmers rearing low productivity indigenous cows and buffaloes, the effect of this variable on weighted average of productivity level of buffaloes, local and crossbred cows (i.e. in equation 1) is positive and significant. Unlike the indigenous cows and buffaloes, the stock of crossbred cows is more predominant in districts that have better market access than provided through the cooperative network.

Table 3. Level of yield gap in dairy animals

	Indigenous cattle	Crossbred	Buffalo	Overall
Ratio (actual/potential yield)				
High (<0.50)	ASRZ: Gulbarga, Hassan, Tumkur, Chitradurga ASIZ: Bangalore(R), Mysore, Bagakot, Mandya	ASRZ: Hassan, Tumkur, Chitradurga, Haveri ASIZ: Belgaum, Mysore, Bagalkot, Davangere HCZ: Chikamaglur, D.kannada, Shimoga	ASRZ: Gulbarga, Hassan, Tumkur, Bidar, Chitradurga, Dharwad, Gadag, Haveri ASIZ: Bagalkot, Bangalore (R), Belagaum, Bellary, Bijapur, Chamarajanagar, Davangere, Koppal, Mandya, Mysore, Raichur HCZ: Chikamaglur, Kodagu, Shimoga, U. Kannada	ASRZ: Bidar, Chitradurga, Tumkur, Hassan, Dharwad, Gadag, Haveri, Gulbarga ASIZ: Bagalkot, Belagaum, Bellary, Bijapur, Chamarajanagar, Davangere, Koppal, Mandya, Mysore, RaichurHCZ : Chikamaglur, D.Kannada, Kodagu, Shimoga, U. Kannada
Moderate (0.50–0.75)	ASRZ: Bidar, Dharwad, Gadag, Haveri ASIZ: Belgaum, Chamrajanagar, Bellary, Bijapur, Davangere, Koppal, Raichur HCZ: Chikmagalur, D. Kannada, Kodagu, Shimoga, U. Kannada	ASRZ: Dharwad, Gadag ASIZ: Bangalore (R), CR Nagar, Bellary, Kopal, Mandya HCZ: Kodagu, U. Kannada	ASRZ: Kolar, Bangalore (U)	ASIZ Bangalore (R), HCZ: Udupi
Low (>0.75)	ASRZ: Kolar HCZ: Udupi	ASRZ Bangalore (U), Gulbarga, Kolar ASIZ: Bijapur, Raichur HCZ: Udupi	HCZ: D. Kannada	ASRZ: Kolar
Yield (kg per annum)				
Best performing district	Bengaluru (U) 2.28 kg/day	Bidar 6.38 kg/day	Udupi 3.79 kg/day	Bengaluru (U) 4.85 kg/day
ASRZ	453	1411	563	704
ASIZ	443	1244	592	655
HCZ	513	1224	617	684

The climate variability across districts also has notable effect on the productivity of the animals. As mentioned earlier, weather conditions have impact on the production performance of the dairy animals. The rise in ambient temperature above 25°C and increase in average temperature humidity index (THI) above 72, creates heat stress conditions in dairy animals and significant changes in feed intake and other physiological processes begin to take place. The crossbred cows are more susceptible to heat stress, the regression coefficient of THI load is negative and greater in magnitude in equation 2 as compared to equation 1.

Setting regional priorities

The investment priorities for dairy development based on the final baseline (Table 5) suggest that across zones 40.2% resources should be allocated to rainfed zone (ASR), 44.7% to irrigated (ASI) zone and 15.1% to humid and coastal (HC) zone, for balancing the efficiency, equity and sustainability criterion. Across districts, Gulbarga should receive highest priority to make dairy an instrument of economic up-liftment. The district has highest share of poor population, CPRs and is dominated by the less productive indigenous cattle. Based exclusively on the efficiency parameter (value of milk output)

Table 4. Determinants of milk yield in Karnataka

Explanatory variables	Average annual milk productivity		Annual productivity of crossbred cows	
Constant	Co-efficient	t-value	Co-efficient	t-value
	169.03		1060.384	
DF	15.01	0.868	–	–
GF	20.28	1.694***	16.688	1.29
CONC	114.13	2.184**	415.824	1.93**
INFRA	10.80	3.417*	17.32	1.750**
COOP	33.18	2.138**	13.16	0.86
Heat Stress	–0.099	2.013**	–0.412	–2.929*
R^2	0.7632*		0.5130**	
Number of observations	27		26	

Note: In second equation, one outlier district (Bijapur) has been excluded from the analysis.

*Coefficient significant at 1% level of significance; **Coefficient significant at 5% level of significance;***Coefficient significant at 10% level of significance.

the allocation for the district would have been only 4.64%, implying that neglect of equity and sustainability considerations can lead to sub-optimal resource allocations. The normative share of each district in the resource allocation is indicated which may be used for district dairy development planning. However, as the estimates of the district-wise allocations are not available, the wedge between existing and suggested regional priorities cannot be examined.

District-wise R&D imperatives for dairy development

The results of the all the three approaches have been synthesized to indicate the target species and desired research and policy intervention for dairy development in the top ten priority districts in the state (Table 6). The target dairy animal species vary across districts, hence the animal breeding policy should be based on the resource endowment of the district. The districts where mixed production systems prevail (such as, Raichur, Bellary, Kolar, Davangere and Haveri), the priority should be breed improvement of buffaloes. The productivity of non-descript local cows can be enhanced not necessarily through crossing them with exotic breeds but also through selective breeding. The native cattle breeds of Karnataka are Amritmahal, Hallikar and Deoni whose production potential is much higher than the large number of non-descript breeds. Their genetic material can be used for up-grading the non-descript stock.

The cultivated area under fodder crops is very limited in the state. In the rainfed regions there is little scope to increase the same but in the districts that are better endowed with irrigation facilities e.g. Belgaum, Mysore, Bellary and Davangere, the cultivation of green fodder can be promoted. The districts where cultivated fodder is low but green fodder availability is relatively better (such as, Belgaum, Tumkur, Bellary, Kolar, Davangere, Uttar Kannada, Haveri, Mysore),

Table 5. Indices of investment priority scores

Districts	Zone	Initial baseline (%)	Final baseline (%)
Gulbarga	Arid/Semi arid	8.8	9.0
Tumkur	Rainfed (ASRZ)	5.6	5.8
Kolar		6.1	5.4
Haveri		4.6	4.5
Bidar		3.8	3.7
Chitradurga		3.5	3.6
Bangalore(urban)		3.3	3.1
Hassan		2.6	2.8
Dharwad		1.5	1.5
Gadag		0.8	0.8
ASRZ total	40.6	40.2	
Belgaum	Arid/Semi-arid	6.9	6.9
Raichur	Irrigated (ASIZ)	6.7	6.6
Bellary		5.7	5.7
Davanagere		5.2	5.1
Mysore		4.0	4.1
Bangalore(rural)		4.3	4.1
Mandya		3.6	3.6
Bijapur		3.0	3.0
Bagalkot		2.7	2.7
Chamrajnagar		1.8	1.7
Koppal		1.3	1.2
ASIZ total	45.2	44.7	
Uttar Kannada	Humid and	4.1	4.7
Shimoga	Coastal (HCZ)	3.1	3.4
D.Kannada		2.8	2.9
Chickmagalur		1.8	1.8
Udupi		1.6	1.6
Kodagu		0.8	0.7
HCZ total	14.2	15.1	
Karnataka		100.00	100.00

common property resources are important source of providing fodder. The maintenance of CPRs in these regions should be an integral part of dairy development agenda, particularly for productivity enhancement of indigenous cows and buffaloes.

The responsiveness of milk productivity to concentrate feed input being highest among all feed inputs, enhancing the availability of concentrates is of vital importance. Unlike, the green fodder for which transportation from one region to another is difficult, concentrate input can be purchased across regions. Hence, it may be argued that its production within the region has less relevance of actual availability of the same. Nevertheless, as purchased input entails more out-of-pocket expenses for the dairy farmers, higher production within the region would be more appropriate option from the perspective of small-holder dairy farmers. For meeting the nutritional requirements of animals, the research emphasis on tapping non-conventional feed resources, enrichment of crop residues, tree leaves, grasses and increasing the bioavailability of the feeds inputs using chemical, biological

Table 6. Characterization of top priority districts for investment priorities

Top ten districts	Zone	Irrigation	Targeted species	Cultivated fodder	Green fodder availability	Concentrate availability	Infrastructure	Dairy cooperatives	Heat stress
Gulbarga	ASRZ	16.65	IC	L	L	L	L	L	H
Belgaum	ASIZ	52.80	BU	L	M	L	L	L	L
Raichur	ASIZ	32.22	IC,BU	L	L	M	L	L	H
Tumkur	ASRZ	24.36	IC,CB	H	H	M	L	L	M
Bellary	ASIZ	40.11	IC,BU	L	M	M	L	L	M
Kolar	ASRZ	17.99	CB,BU	L	H	L	L	H	L
Davanagere	ASIZ	39.61	CB,BU	L	M	L	M	L	M
Uttar Kannada	HCZ	23.46	IC	L	H	L	L	L	H
Haveri	ASRZ	19.37	BU,CB	L	M	M	L	L	L
Mysore	ASIZ	46.63	IC,CB	L	M	L	L	L	L

Note: The low (L), moderate (M) and high(H) levels are in relative terms and not in relation to any threshold

Irrigation: net irrigated area and % of net sown area; Species; IC,indigenous cows; BU, buffalo; CB, crossbred cows; *Cultivated fodder:* % NSA under fodder crops, < 1% low, 1–2% moderate, >4% high; *Green fodder availability:* Tonnes per milch animal, <2 low, 2–4 moderate, >4 high; *Concentrate availability:* quintals per milch animal, <1 low, 1–2 moderate, >2 high; *Infrastructure:* density of animal health care and breeding institutions per 100 sq. km., <10 low, 10–30 moderate, >30 high; *Dairy cooperatives:* density of dairy cooperatives per 100 sq. km., <10 low, 10–20 moderate, >20 high; *Heat stress:* Annual THI Load, <500 low, 500–1000 moderate, >1000 high.

and biotechnological approaches is required.

The availability of livestock support services and cooperative network is quite poor in the districts and needs strengthening. The productivity of animals is also constrained by the natural factors such as heat stress. The districts where intensity of heat stress is moderate to high level (such as Gulbarga, Raichur, Tumkur, Bellary, Davangere and Uttar Kannada), require research extension focus for formulating and disseminating cost-effective, region-specific, animal shelter and nutritional management technologies.

Broadly, the state of Karnataka is deficit in feed and fodder inputs and in network of institutions for supporting dairy development. The regional priorities outlined in the study may be instrumental for R&D planning in Karnataka for creating an enabling environment to make dairy farming as one of the instruments of livelihood security in the state.

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