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Regional disparities in Gujarat dairy development—Principal component approach

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ABSTRACT

Growing regional inequalities is a major concern for policy makers on developmental front. The present study reveals the regional disparities in dairy development of Gujarat which is considered as a role model for dairy industry in India. The relative development of 26 districts in Gujarat was measured by a composite dairy development Index (DDI) using 18 different indicators. Variables related to milk production, availability of resources, infrastructure facilities and dairy cooperatives were considered for the study. Holding linearity relationship assumption, principal component analysis was employed to develop the DDI. As per the index score, Anand, Banaskantha, Mehsana, Sabarkantha, Gandhinagar, Patan and Jamnagar were grouped as highly developed. Kheda, Rajkot, Porbandar, Junagadh, Amreli, Bhavnagar, Kachh, Ahmedabad, Surat and Bharuch were categorized as moderately developed while Dang, Dahod, Narmada, Panchmahal, Surendranagar, Navsari, Vadodara, Tapi and Valsad were placed in low dairy developed districts. The study reveals that the strength of dairy cooperative structure in terms of its functions and bovine breed spread can be accounted as prime factors for regional dairy development disparity. Low developed districts lacked in high quality bovine breeds and poor cooperative structure, which needs policy focus. Elimination of the regional disparities could pave way towards the balanced and sustained growth and development of the dairy sector.

Key words: Eigen value, Gujarat dairy development, PCA, Regional disparity

Crop and livestock farming are essential attributes of Indian agriculture, pursued to be complementing each other if carried out simultaneously. Livestock farming began in the country as a saviour in paucity, only as a source of income in the situation of crop failure. It is the secondary and continuous source of income for farmers, especially for small and marginal land holders. Globally, India ranks first in milk production producing165.4 million tonnes during 2016–17. In India, Gujarat is one of the developed states and historically a frontrunner in milk production activities. With an annual milk production of 12,784 thousand tonnes during 2016–17, it ranked fourth in the country accounting for about 8% share (NDDB 2017). The dairy industry in Gujarat is well established showing a significant progress over years and consequently it has been considered as a role model and recognized as a "heartland'' of dairy cooperative movement in India (Staal *et al*. 2006). Animal husbandry has not remained a subsidiary income source for livelihood in rural Gujarat, rather it has become a major economic activity in Gujarat, especially in the arid and semi-arid regions of the state. This sector has prominent role in employment generation for sub-marginal, marginal and small farmers (Swain *et al*. 2012). Surplus milk production in Gujarat contributes to ensure food and nutrition security not only in the state but elsewhere in the country too. The state is a home to about 18 breeds, and the native breeds like Girand Kankrej, Mehsani, Jaffrabadi and Surti are well known for their high quality and milk-yield capacity (NDDB 2014).

Despite the high overall dairy development in Gujarat, regional disparities do exist owing to the difference in natural resource endowment, dairying practices, adoption of technology, availability of veterinary facilities, irrigation facilities, feed availability and attitude of farmers across the districts. Several economic, cultural and social problems can arise from an unplanned process of growth which can hinder the process of dairy development in the state. Further, regional differences can lead to under/over utilization of resources, both human and natural, if the factors influencing the development are not assessed. The present study was an attempt to rank the districts in Gujarat for dairy development based on selected indicators. The role of indicators for each district was ascertained, facilitating for

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micro level planning which results in bridging the inequalities across states in the long-run.

MATERIALS AND METHODS

To measure the dairy progressiveness in terms of resource, infrastructure and milk productivity in Gujarat, the districts (26) before bifurcation were taken as the unit of study as there is a growing consensus about the need for micro level planning. Data on selected dairy development indicators for the triennium ending 2013–14 were collected for the 26 districts in Gujarat.

Data on milk production, dairy animals and their yields, veterinary institutes and artificial insemination were compiled from the Bulletin on Animal Husbandry and Dairying Statistics of various years. Surface road length data were collected from the Statistical Abstract, published by the Directorate of Animal Husbandry, Gujarat. Data on animal population were collected from the 19th Livestock Census. Data on area under pasture were sourced from the Gujarat Forest Statistics, Government of Gujarat (GoG). Area under oilseeds was collected from the published records of the Directorate of Agriculture, GoG. Data on dairy cooperatives and related indicators were collected from the Gujarat State Cooperative Milk Marketing Federation, Gujarat.

The compiled data were normalized by subtracting the minimum value from observed value and dividing by the range of the corresponding indicator (Feroze and Chauhan 2010, Ayyoob *et al.* 2013 and Ponnusamy *et al*. 2016). The next step was to test the indicators for their significance. Principal component analysis (PCA) was used to separate out the significant indicators from the nonsignificant indicators. PCA was employed on the normalized data with varimax method for the rotation of the factors using the Statistical Package for Social Sciences 19 (SPSS 19). The communalities obtained through the PCA explained the amount of variance contributed by all indicators. The thumb rule of communality used by Kale *et al*. (2016), indicating that the communality value above 0.6 as a sufficient condition for an indicator to be considered for PCA. As all the indicators were satisfying the thumb rule of communality, none was dropped from the factor analysis model and all the indicators were considered for the next step i.e. assignment of weights to the individual indicator.

The present study adopts the PCA based (Feroze and Chauhan 2010, Ayyoob *et al.* 2013, Veenti *et al*. 2015, Kale *et al.* 2016) approach to assign weights to the indicators for constructing the dairy development index (DDI) using the following formula:

$$I_{District} = \frac{\sum_{i=1} X_i W_i}{\sum_i W_i}$$

where $W_i = \Sigma \mid L_{ij} \mid E_j$; I is the index of each district; X_i is the normalized value of ith indicator; W_i is the weight of ith indicator; E_j is the eigen value of the jth factor; L_{ij} is the loading value of the ith district on jth factor; i = 1,2,3,…18 indicators; j = 1,2,…n principal components (PCs).

After calculating the index for each district, all the districts were divided into 3 categories of dairy development based on their composite index score.

High = $I_{District}$ > Mean + 0.5 SD

Moderate = Mean – 0.5 SD < $I_{District}$< Mean + 0.5 SD

Low = $I_{District}$ < Mean – 0.5 SD

The PCA result extracted 4 principal components with eigen value greater than 1 accounting for about 80% of the variability (Fig. 1). Eigen values and factor loading values represent the weights assigned to compute the index. The rotated factor loading values are given in Table 1.

Table 1. Factor loadings of corresponding principal components

Indicator	Principal components (PC)			
	PC 1	PC 2	PC 3	PC 4
YCB	0.874	0.089	0.344	–0.157
YI	0.884	0.056	0.012	0.218
YB	0.846	0.079	0.412	–0.075
PCM	0.537	0.542	0.189	–0.333
SPCB	–0.525	0.601	0.125	–0.311
SPB	0.704	–0.191	–0.215	0.476
FOD	0.24	–0.058	0.624	0.098
PAST	0.543	–0.696	0.162	0.174
IIR	0.378	0.581	–0.432	0.157
AI	–0.044	0.927	0.127	0.034
AIC	–0.664	0.483	0.372	0.014
VET	–0.739	–0.2	0.549	0.072
DC	–0.825	–0.083	–0.063	–0.113
MDC	0.242	0.859	–0.048	0.282
MPDC	0.373	0.855	0.227	0.079
ROAD	0.415	–0.295	–0.192	–0.662
AHCO	–0.659	–0.284	0.323	0.395
AUOS	0.577	–0.535	0.358	–0.141

YCB is the average/day milk yield of crossbred cattle (kg/day); YI is the average/day milk yield of indigenous cattle (kg/day); YB is the average/day milk yield of buffalo (kg/day); PCM is the/capita milk availability (g/day); SBC is the share of productive crossbred in productive bovine stock (%); SBB is the share of productive buffalo in productive bovine stock (%); FOD is the area under fodder/1,000 adult female bovine (ha); PAST is the area under pasture/1,000 adult female bovine; IRR is the percentage of gross irrigated area to total cropped area; AI is the number of AI performed/1,000 adult female bovine; AIC is the number of AI centers/1,000 adult female bovine; VET is the number of veterinary hospitals/1,000 bovine female; DC is the number of dairy co-operative societies/1,000 tonnes milk production; MDC is the number of members/primary dairy cooperative society; MPDC is the milk procurement/day/dairy cooperative society; ROAD is the surface road length; AHCO is the number of animal health camps organized/1,000 dairy animals, AUOS is the area under oilseeds/1,000 adult female bovine

RESULTS AND DISCUSSION

The composite dairy development index obtained for 26 districts of Gujarat are ranked and mapped for 3 categories of development (Table 2). Mehsana was the most dairy developed district followed by Patan and Banaskantha. The least developed districts were Dahod, Panchmahal and Vadodara that ranked 26th, 25th and 24th respectively.

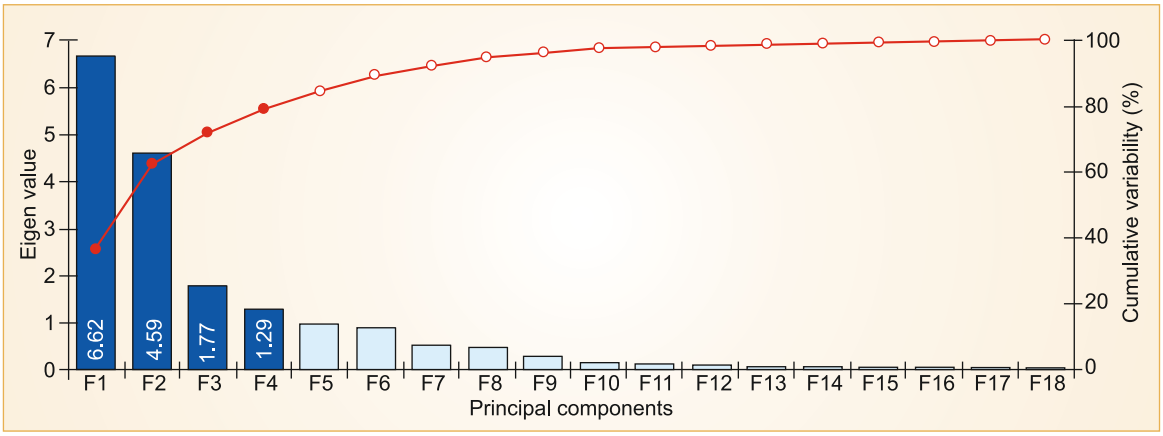

Fig. 1. Scree plot of Eigen values and cumulative variability

Based on the PC factor loading values, it has been noted that average/day milk yield of crossbred cattle (kg/day), average/day milk yield of indigenous cattle (kg/day), average/day milk yield of buffalo (kg/day), number of AI performed/1,000 adult female bovine, number of dairy co-operative societies/1,000 tonnes milk production, number of members/primary dairy cooperative society, milk procurement/day/dairy cooperative society contributed maximum in the weightage to development index. Hence focusing on these parameters will help to bring development in the dairy sector. In some less developed districts namely Valsad, Navsari, Tapi and Vadodara, the infrastructural facilities like AI, AIC, DC, and irrigation facilities were better compared to other less developed districts like Dang, Dahod, Panchmahal, and Narmada, but lower yield of all dairy animals was a common characteristic for all less developed districts. Focusing on the improvement in the milk yield through increasing the availability or transfer of various technology and knowledge on dairying in the less developed districts will enhance the milk production which were eventually lead to higher dairy development. Quality of bovine breed is the prime factor determining the dairy development which was lacking in the low developed districts which constitute the south and south-east part of the Gujarat. The highly developed districts namely Banaskantha, Sabarkantha, Mehsana, Patan and a few moderately developed districts namely Ahmedabad, Kheda, Kachchh had a high population of productive cattle and buffalo breeds, viz. Kankrej and Mehsana respectively. The moderately developed districts like Bhavnagar, Junagadh, Amreli, Rajkot, Porbandar, Kachchh had high population of quality indigenous cattle and buffalo breed, viz. Gir and Jaffrabadi respectively. Surti buffalo breed is found in Anand, Bharuch, Kheda and Surat (NDDB 2014). The differences in the yield of animals can be indirectly accounted to the breeds spread over the regions. The improvement of livestock breeds of south and south eastern part of Gujarat should be the prime focus for the development. The milk cooperative structure in highly developed district was strong in terms of membership and milk procurement compared to other districts of the state, especially Panchmahal, Dahod, Narmada, Bharuch and Dang which are home to the tribal society.

Table 2. Ranking of districts based on composite dairy development

District	Dairy development index	Category of dairy development	Rank
Ahmedabad	0.3722	Medium	14
Amreli	0.3964	Medium	12
Anand	0.4727	High	5
Banaskantha	0.5234	High	3
Bharuch	0.3662	Medium	15
Bhavnagar	0.3734	Medium	13
Dahod	0.1949	Low	26
Gandhinagar	0.5020	High	4
Jamnagar	0.4430	High	6
Junagadh	0.4320	Medium	9
Kachchh	0.3550	Medium	16
Kheda	0.4362	Medium	8
Mehsana	0.5857	High	1
Narmada	0.3393	Low	20
Navsari	0.3449	Low	19
Panchmahals	0.2942	Low	25
Patan	0.5536	High	2
Porbandar	0.4076	Medium	11
Rajkot	0.4257	Medium	10
Sabarkantha	0.4393	High	7
Surat	0.3506	Medium	17
Surendranagar	0.3271	Low	22
Tapi	0.3474	Low	18
The Dangs	0.3379	Low	21
Vadodara	0.3021	Low	24
Valsad	0.3165	Low	23

Inequality among various regions from dairying is an obvious phenomenon hampering the sector progress. It is difficult to eliminate the complete disparity but considering the reasons it can be reduced to a greater extent by an effort in unison by famers, government policies and all the stakeholders related to the sector. The disparities can be attributed majorly to the uneven availability of high yielding breeds of cattle and buffaloes. The regions having poor dairy infrastructure like veterinary facilities, irrigation facilities for fodder cultivation and road connectivity are not able to reap the optimum amount of income from the dairy farming.

Small and marginal farmers who adopt dairy farming as a subsidiary source of income often left with poor bargaining capacity during selling of milk. This problem is absent almost nil in the regions where dairy cooperatives are functional. A strong dairy cooperative not only motivates the farmer to adopt the dairying as their mainstream farming practice but also stabilize and improve their income. Cooperatives provide them with better marketing assistance, on time veterinary services and more or less fluctuation proof pricing round the year. Clearly, a substantial difference in dairy development has been noticed in Gujarat, despite a well-developed state in the sector. The study warrants that if the regional disparities are eliminated, dairy farming would become one of the most lucrative enterprises for all level of producers.

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