Tracking the disparities in Gujarat dairy development – an application of biplot analysis

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Gujarat, despite being a highly progressive state of India in terms of dairying, has great potential to enhance its milk production and make dairying a more lucrative enterprise. It is home to many high quality dairy animal breeds and has a very active milk cooperative structure which can accelerate the possibilities of uplifting the level of milk production further, if proper and balanced micro level development policies are promoted. The present study depicts the causes for disparities besides analysing the strengths and weaknesses in dairying across 26 districts in Gujarat. To identify and capture the variation in resource use which causes disparities in dairy development, the principal component analysis-based biplot technique was employed. Data on different variables like resource availability, infrastructure and veterinary facilities, and, milking animals and their yields have been sourced from 26 districts of Gujarat for tracing the disparity. The conclusions drawn from the biplot imply that promoting the quality of animal breeds and increasing the population of high yielding cattle breeds in low-developed districts can lead to high milk production. In the setting of increased milk production, the cooperative milk marketing structure will become more dynamic and result in enhanced income for dairy producers.

Keywords: Biplot, Eigen value, Gujarat dairy development, PCA, regional disparity.

INDIA is home to the largest dairy animal population and consequently has the highest milk production in the world which hovers around 155 million tonnes per annum[1]. Animal rearing is an important supplementary enterprise that provides a continuous source of income for millions of rural households engaged in agriculture[2]. The success of the dairy industry is an outcome of an integrated cooperative system of milk collection, transportation, processing and distribution to minimize seasonal demand and supply mismatch and improve retail distribution of milk and milk products, with benevolent sharing of profits with the farmer, which becomes the cause for and effect of enhanced productivity and efficiency[3].

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Gujarat is a highly developed Indian state and has consistently remained a leader in milk production. It is ranked as the fourth largest contributor to India's GDP with around 7% share[4]. It is the birthplace of the white revolution of India and has a vibrant milk cooperative sector. Recognizing the importance of well-being of cattle in order to increase milk production, the state has promoted several development programmes including the recent 'Animal Hostel' which is a private–public partnership model aimed at providing shelter to the animals in villages for enhancing milk production apart from reducing the burden on women to take care of their animals for the whole day[5]. Despite government efforts across the districts of Gujarat, there exists regional disparity in dairy development across the state due to differences in natural resources endowment, adoption of technology, dairying practices, feed and fodder availability, irrigation facilities, veterinary facilities and attitude of farmers. Therefore, the present study attempts to diagnose the most important factors that cause disparity in dairy development of different districts of Gujarat.

For the period 2011–12 to 2013–14, secondary data on 18 variables, positively contributing to dairy development were collected from official documents and records after a thorough literature review. Data on resource availability like feed, fodder and water; dairy animals and their milk yields; infrastructure like surfaced roads; and availability of veterinary facilities were compiled for 26 districts of Gujarat and normalized[6] in order to render them unit free for comparison. The inequalities can be critically studied by going through raw data on each relevant variable, however, it is a time-consuming and tedious task owing to multiple indicators. Hence, to extract maximum information from available indicators, a visual graphical tool called 'biplot analysis' was employed.

Biplot analysis, first proposed by Gabriel[7], has been tested in many variants and types in various fields including agriculture. A biplot is a graphical representation of multivariate data, where the elements of a data matrix are represented by dots and vectors associated with rows and columns of the matrix[8]. Biplot analysis is a method of scientific mapping (a two-dimensional representation of the set of elements and the relationship among them). Unlike a scatter diagram, in a biplot, the axes are not perpendicular and they assume a projection of n-dimension presentation over a surface without much loss of information. Biplot is used for summarizing correlation among variables, identifying the unusual observation and isolation of clusters of variables[9]. Typically, biplots show those two dimensions that account for the maximum amount of variation in data because display of more than two dimensions is cumbersome and indeed more difficult to interpret. Best representation of the graphical tool in low-dimensional space is possible by using the singular value decomposition (SVD). The technique furnishes the coordinates or dimensions, mathematically known as

singular vectors. To display the variability in the data set in a two-dimensional graph, the first two dimensions expressing maximum variability are used such that they are orthogonal or form a right angle. A key point to be kept in mind while constructing the actual graph for the biplot is that the horizontal and vertical coordinate axes should have the same physical scale to ensure that the subjects are projected at the correct place with respect to the variable vector. The ratio of the units on the vertical axis to the horizontal axis is also called the 'aspect ratio' and should be equal to 1. The most fundamental feature of a biplot is that the inner product of a row (subject) vector and a column (variable) vector in the plot is the best approximation to the corresponding observed value in the data set[10].

A biplot is based on the same principle as other factorial techniques used for dimensionality reduction, the only difference is that it represents variables along with the data and gives dual dimensional representation between principal components and the main coordinates. In this study, the principal component analysis (PCA) was employed for the dataset under dairy development indicators to capture the possibly correlated variables into a set of values, technically known as 'principal components'[11]. Typically, a biplot uses two principal components that capture maximum variation for explaining the multi-dimension data[7,8].

It is important to understand the meaning and importance of each variable in dairy development before discussing the results. The 'yield' variable for all three kinds of animals, i.e. crossbred, local cow and buffalo (YCB, YI and YB respectively) shows the average productivity of animals in each district. The yield of animals highly depends on the kind of breed reared and other dairy management practices like, method of giving feed and fodder (chopped or as a whole), and way of milking. The per capita milk availability (PCM) indicates the milk production capacity of each district compared to its requirement of the population to have balanced and nutritional diet. The share of productive crossbred and buffalo in total productive bovine stock (SPCB, SPB) indicates the distribution pattern of crossbred cows and buffalos across Gujarat. Area under fodder (FOD), pasture (PAST) and oilseeds (AUOS) per 1000 adult female bovine shows the ability to fulfil the feed and fodder requirement of the respective adult female bovine which is the main source of milk. Number of artificial insemination (AI) centres and number of AI actually performed per 1000 adult female bovine (AIC and AIP respectively) imply the level of availability and adoption of modern breeding practices across the districts. The number of primary dairy cooperative societies per 1000 tonnes of milk production (DS), number of members per dairy cooperative society (MDC) and milk procurement per day per dairy cooperative society (MPDC) indicate the strength of the organized milk marketing structure in terms of the organized market availability, dairy farmer participation and scale of market. The percentage of gross irrigated area to total cropped area (IRR) implies the intensity of irrigation for feed and fodder production to assist in milk production. The number of veterinary institutes and the number of animal health camps organized per 1000 bovine (VET and AHCO respectively) show the availability of veterinary facilities to maintain healthy bovine stock for better performance in terms of milk production. Surface road length (ROAD) implies the level of basic infrastructure in the study area to facilitate animal transportation and milk marketing.

Table 1 indicates that, on an average, the share of productive buffaloes (48.97%) in total productive bovine stock was higher than that of productive crossbred (11.56%) in the state. The average milk yield was found to be higher for crossbred cows (8.63 kg/day), followed by buffalo (4.61 kg/day) and indigenous cow (3.81 kg/day). The standard deviation among the indicator variables

Table 1. Summary statistics of variables influencing dairy development

Variable	Average	Standard deviation	Maximum	Minimum	Range
YCB	8.63	0.98	10.47	7.36	3.12
YI	3.81	0.79	4.73	1.30	3.43
YB	4.61	0.69	5.74	3.32	2.43
PCM	527.90	267.56	1091.24	138.65	952.59
SPCB	11.56	12.89	49.83	0.30	49.53
SPB	48.97	8.28	57.85	27.89	29.96
FOD	89.92	75.69	318.94	2.52	316.42
PAST	88.26	67.04	233.02	0.00	233.02
IRR	45.08	17.95	80.57	3.26	77.31
AIP	589.46	426.08	1495.67	12.44	1483.23
AIC	0.83	0.53	2.71	0.13	2.58
VET	0.11	0.08	0.43	0.04	0.39
DC	1.86	1.16	4.44	0.08	4.36
MDC	187.48	159.88	567.60	45.61	521.99
MPDC	1707.18	1452.26	4714.18	390.67	4323.51
ROAD	2903.74	1046.03	5388.00	904.33	4483.67
AHCO	0.27	0.13	0.56	0.10	0.46
AUOS	262.13	258.61	950.98	3.77	947.21

YCB is the average per day milk yield of crossbred cattle (kg/day); YI is the average per day milk yield of indigenous cattle (kg/day); YB is the average per day milk yield of buffalo (kg/day); PCM is the per capita milk availability (g/day); SPCB is the share of productive crossbred in productive bovine stock (%); SPB is the share of productive buffalo in productive bovine stock (%); FOD is the area under fodder per 1000 adult female bovine (ha); PAST is the area under pasture per 1000 adult female bovine; IRR is the percentage of gross irrigated area to total cropped area; AIP is the number of artificial inseminations performed per 1000 adult female bovine; AIC is the number of AI centers per 1000 adult female bovine; VET is the number of veterinary hospitals per 1000 bovine female; DC is the number of dairy cooperative societies per 1000 tonnes milk production; MDC is the number of members per primary dairy cooperative society; MPDC is the milk procurement per day per dairy cooperative society (kg); ROAD is the surface road length (km); AHCO is the number of animal health camps organized per 1000 dairy animals, AUOS is the area under oilseeds per 1000 adult female bovine (ha).

was found highest for the milk procurement per day per dairy cooperative society (1452.26), followed by surface road length (1046.03) and number of artificial inseminations performed per 1000 adult female bovine (426.08). The deviation was least for VET, followed by AHCO and AIC. The implication is that there exists a wide gap in milk procurement, surface road facility and AI performed per 1000 adult female bovine across the districts which needs prime policy focus. Interestingly, the average per capita milk productivity for the state was found to be higher (527.90 g/day) than the national average (337 g/day).

The values of the first two principal components causing maximum variability obtained through the PCA are given in Table 2 and the graphical presentation of variability contributed by all principal components expressed in terms of eigenvalues is depicted in Figure 1 as the Scree plot. It is a simple line segment plot showing the fraction of total variance in the data as explained by each principal component for the factors (F1–F18 in our case). It always exhibits a downward sloping curve when eigenvalues are plotted on vertical axis against the resulting factors.

Table 2. Factor loading corresponding to two principal components

	Principal components (PC)	
Variable	PC 1	PC 2
YCB	0.874	0.089
YI	0.884	0.056
YB	0.846	0.079
PCM	0.537	0.542
SPCB	–0.525	0.601
SPB	0.704	–0.191
FOD	0.240	–0.058
PAST	0.543	–0.696
IIR	0.378	0.581
AIP	–0.044	0.927
AIC	–0.664	0.483
VET	–0.739	–0.200
DC	–0.825	–0.083
MDC	0.242	0.859
MPDC	0.373	0.855
ROAD	0.415	–0.295
AHCO	–0.659	–0.284
AUOS	0.577	–0.535

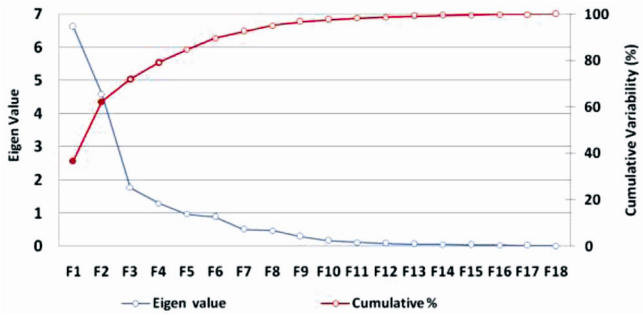

Figure 1. Scree plot of eigenvalues and cumulative variability.

The biplot obtained from the dataset with two principal components comprised 18 variables (vector or column) for 26 districts (row or subject) and is depicted in Figure 2. Geometric concepts are used to interpret the biplot, so as to facilitate the understanding. The basic concepts for interpreting the biplot representation in our case are:

(1) Similarity in the districts (rows or subjects) is the inverse function of distance between them.
(2) The length and angle of the indicators (vector or column) represents the variance and covariance respectively.
(3) The relation between rows and columns must be understood as dots products, that is, the projection of the cases (districts) over the variables.

Considering the above concepts, the distance between districts (subjects) represents the similarity among them; the cosine angle between the vectors represents the correlation between the variables or indicators[12] and the projection of districts over the column vector (variable) approximates the maximum value. The total variation expressed by the two principal components is around 66% which is relatively low, showing the complexity in the relationship among the measured variables[13].

The biplot indicates that those districts that occur in the same quadrants of the four different quadrants have close proximity to each other in terms of dairy development. The districts in the first quadrant of Figure 2 constitute southern Gujarat, the second quadrant comprises northern and central Gujarat, the third quadrant represents the south-eastern part of Gujarat and the fourth quadrant displays the districts in the western part of Gujarat respectively, representing a similar kind of dairy development. The proximity can be probably explained by the similarity in the livestock breeds reared, social and cultural characteristics, availability of resources and access to the technology or information. With AMUL in Anand being nearer to the northern and central Gujarat districts, these districts have a positive outcome on dairying; however, southern and south-east districts which are home to the tribal societies, are falling short in dairy development. As indicated in the biplot, feed and fodder availability are good in western Gujarat where major crops grown such as cotton, groundnut and cereals, i.e. wheat, bajara and sorghum fulfill all the needs of feed and fodder, and south and south-east regions have negligible production of oilseed crops. Proximity of the indicator DC, i.e. the number of primary dairy cooperative societies per 1000 tonnes of milk production, in south-east Gujarat to less developed districts is due to the higher number of cooperatives in these less developed districts when compared to their milk production.

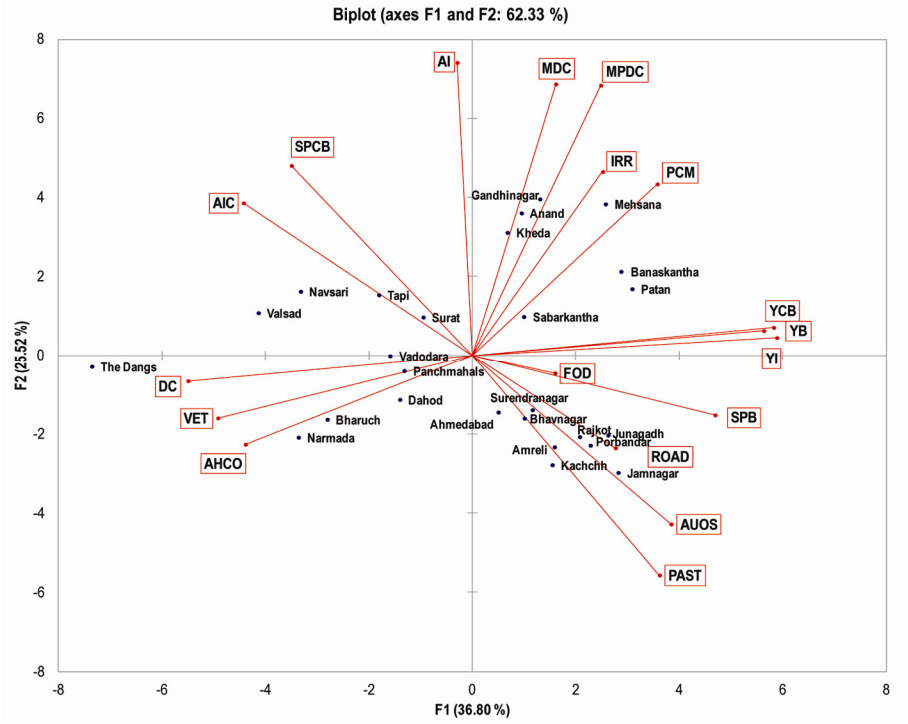

Figure 2. Biplot representation of the dairy development in Gujarat.

Based on the proximity principle of a biplot, the productive buffaloes were found to dominate the central and northern districts of Gujarat, while a majority of productive crossbred cows were kept in the southern part of Gujarat[14]. The nearness of the variable 'yield' of crossbred, indigenous and buffaloes, to the northern and Saurashtra region of Gujarat can be explained by the breeds, as Banaskantha, Sabarkantha, Mehsana, Patan, Ahmedabad, Kheda and Kachchh have high yielding quality cattle and buffalo breeds like Kankrej and Mehsana respectively. Similarly, Bhavnagar, Junagadh, Amreli, Rajkot, Porbandar and Kachchh have quality indigenous cattle and buffalo breed, Gir and Jaffrabadi respectively. The number of animal health care facilities was found to be acceptable with respect to the animal population in the little developed districts. The northern and central regions were found to have high PCM, MDC and MPDC due to high milk production and developed cooperative structure. Irrigation facilities have contributed more to the dairy development in the middle north region of Gujarat.

Overall, the study underlines the regional disparity in Gujarat's dairy development. Based on the selected indicators, the analysis clearly reveals the gap between well-developed vis-à-vis little developed districts. Policies should focus on breed improvement and organized market development in the south and south-east region of the state. The feed deficit in south and south-east region can be met by efficient marketing of oilseeds or its by-products like oilseed cakes for dairying from surplus regions. The insights gained from this study will help policy makers in micro level planning for rational and efficient use of available resources resulting in a balanced dairy development across Gujarat.

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Received 15 July 2017; revised accepted 12 January 2018

doi: 10.18520/cs/v114/i10/2151-2155

Does *Pestalotiopsis royenae* cause leaf streak of large cardamom?

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Leaf streak caused by *Pestalotiopsis royenae* (Guba) Steyaert has been reported as a new disease of large cardamom (*Amomum subulatum*). It is characterized by rectangular spots running parallel to the veins. *P. royenae* was isolated onto potato dextrose agar from the infected portion of the plant. In the pathogenicity test, disease symptoms were not present on inoculated plant and on detached leaf *in vitro* after 20 days. During 2014–2016, a survey in various large cardamom plantations of Sikkim revealed the presence of tea mosquito bugs on the infected parts of *A. subulatum*. The spots did not show any growth. Different sized spots have been noticed on the infected leaf produced by different instars. At the initial stage, these symptoms appear on the young and tender leaves of large cardamom. Tea mosquito bugs were collected from the infested leaves and allowed to feed under controlled conditions, which produced similar type of leaf streak symptoms in large cardamom and also in other non-host crops like maize and turmeric. The results reveal that the cause of leaf streak is due to feeding injury of tea mosquito bugs and rule out *P. royenae* as a pathogen causing leaf streak disease symptoms. *Pestalotiopsis* sp. was also isolated as endophyte from large cardamom.

Keywords: *Helopeltis theivora*, large cardamom, leaf streak, *Pestalotiopsis royenae.*

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LARGE cardamom (*Amomum subulatum* Roxb.), a member of Zingiberaceae under the order Scitaminae is the main cash crop cultivated in the sub-Himalayan state of Sikkim, Darjeeling district of West Bengal[1], Arunachal Pradesh, Nagaland, Mizoram, Manipur, Meghalaya, Assam and parts of Uttarakhand. Large cardamom is also cultivated in Nepal and Bhutan. Diseases like chirkey[2], leaf blight[3,4], leaf streak[5], capsule rot[6], wilt[7] and foorkey[8] have been reported in large cardamom, of which leaf streak caused by *Pestalotiopsis royenae* (Guba) Steyaert has been reported as a new disease of large cardamom from Sikkim[5]. Leaf streak caused by *P. royenae* often results in severe foliar damage and crop loss[9,10]. The disease is characterized by rectangular spots running parallel to the veins and elongated, rectangular, translucent streaks appearing on young leaves along the veins (Figure 1). The streaks turn reddish-brown within 3–4 days with a central straw-coloured necrotic area surrounded by a prominent dark-brown margin[5,11]. Srivastava[12] reported that the variety Golsey with crinkled leaf pattern was more susceptible than variety Sawney having smooth leaf pattern. During 2014–2016, a survey in various large cardamom plantations of Sikkim revealed the presence of tea mosquito bugs (*Helopeltis theivora*) on the infected parts of *A. subulatum* (Figure 2 *a* and *b*). It has been reported that the leaf streak disease of large cardamom is caused by *P. royenae*; however, the presence of tea mosquito bug and various reports on the endophytic nature of *Pestalotiopsis* spp. prompted us to examine the actual cause of leaf streak symptoms in large cardamom.

A study was initiated at ICAR Sikkim Centre (now National Organic Farming Research Institute), Gangtok, during 2014–2016 on leaf streak disease of large cardamom. A survey was conducted in different large cardamom plantations of Sikkim (Figure 3) to assess the incidence of the disease during May to July. Diseased leaves of large cardamom showing typical leaf streak symptoms were collected from the study area for further analysis. Disease incidence was calculated using the formula: per cent disease incidence = (no. of plants infected/total no. of plants assessed) × 100. The pathogen was isolated onto potato dextrose agar (PDA) from the diseased portion of the plant. The infected leaf samples were

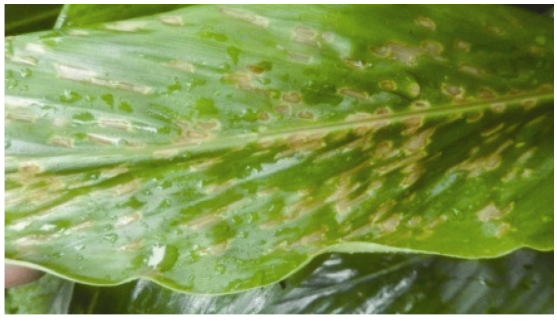

Figure 1. Leaf streak symptoms in large cardamom caused by *Pestalotiopsis royenae*.