



Development and testing of potential indicators for evaluation of dairy production systems

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ABSTRACT

The present study classified the dairy production system of India based on its functional dynamism. The extent of functional dynamism of dairy sector in different states of India was determined using composite dairy production system index which was developed on the basis of optimum combination of 26 indicators by the method of principal component analysis. Twenty states which have major contribution in overall milk production of the country were selected and delineated into three categories, viz. dynamic, transient and subsistence dairy production systems. As per the indices score, the dairy production system of Kerala, Punjab, Goa, Haryana, Gujarat and Rajasthan were delineated as dynamic dairy production system. Tamil Nadu, Karnataka, Himachal Pradesh, Andhra Pradesh, Maharashtra, Madhya Pradesh, were categorized as transient dairy production system while Uttar Pradesh, Uttarakhand, Jammu and Kashmir, Odisha, West Bengal, Bihar, Chhattisgarh and Jharkhand states were grouped as subsistence dairy production system. The study implicates the necessity for increasing the milk production and productivity of bovines in West Bengal, Odisha and Goa by genetic improvement through crossbreeding, selective breeding and upgradation programmes. Increasing the area under fodder and pastures as well as fodder availability need further focus in Uttar Pradesh, West Bengal, Jharkhand and Bihar. States like Chhattisgarh, West Bengal, Bihar and Jharkhand need impetus in improving their veterinary infrastructure. Development of organized milk marketing and value addition network would further strengthen the dairy sector in all the states. Policy makers should concentrate on state-centric interventions to bring more dynamism in the dairy production system on the basis of identified gaps.

Key words: Dairy production system, Functional dynamism, Principal component analysis, State-centric interventions

The Indian dairy sector has achieved several milestones in both milk production and its per capita availability. India ranks first in milk production, accounting for more than 18.5% of global milk production with an annual output of 164 million tonnes during 2016–17 (GoI 2017). Demand for milk and milk products increases steadily on account of the growing population, higher disposable income and more health conscious consumers. Emerging trends indicate that milk demand is likely to be in the range of 200–210 million tonnes by 2021–22. To meet the growing demand, there is a need to increase the annual incremental milk production from 4 million tonnes per year in past 10 years to 7.8 million tonnes in the next 8 years (NDDB 2015). This growing demand for milk can only be met if inter-state disparity is addressed by proper planning and interventions (Kumar *et al.* 2013, Dadhich 2015). The inter-state disparity in dairying can be reduced if all the components of dairy sector work as system. A system approach can provide dairy farmers a

unified focus and direction towards which dairy sector should strive. Dairying is a complex system that includes livestock, housing, feed and fodder, water, climate, people, and other elements. Although it is critical to understand each of these elements individually, it is also equally essential to comprehend their interaction in a system mode. The Dairy Production System works across different components to improve the management systems. The Indian dairy sector has exhibited significant structural and production system changes in the past few decades. In India, the dairy production system is complex but can broadly be divided into 4 categories, viz. pastoral system, semi intensive or crop-livestock production system, peri-urban dairying and intensive or industrial production system (Srivastava *et al.* 2015). This classification was on the basis of input use and market facilities. Kale *et al.* (2016) has grouped 16 states of India into 3 categories namely, highly progressive, moderately progressive and less progressive states based on 20 parameters related to dairy progressiveness index (DPI). Most of the studies have focused on classifying the dairy production systems based on the visible indicators especially the herd size and output. The system interactions have not been taken into account

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while categorizing the production systems at farm level. Since several factors constitute the system influence and make the further progress, they have to be looked into from system perspective as they will generate considerable policy inputs for sustainable development of dairy farming across the country. So there is a need to classify the dairy production systems based on its functional dynamism to promote the future dairying in tune with ecological and emerging socio-economic dimensions.

MATERIALS AND METHODS

Functional dynamism for the present study was operationalized as the level of changes over a period of time in functions and relationships contributing to dairy production system. For classifying dairy production system of India based on its functional dynamism, 20 states namely Andhra Pradesh (including Telangana), Bihar, Chhattisgarh, Gujarat, Goa, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Odisha, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal were included in the study. These states contribute to the tune of 98% in total milk production of India (GoI 2016). The states were selected based on the availability of the secondary data on the selected indicators for assessing the functional dynamism.

Selection of indicators: Keeping this in view, 26 common indicators (Table 1) for measuring the functional dynamism across 20 states were identified based on availability of

secondary data sources, expert discussion and literature review. The per capita availability of milk, milk production, average per day milk yield are the physical or visible indicators for dairy development, as studied by Kale *et al.* (2016) for development of Dairy Progressive Index in India. Area under fodder and pasture, feed and fodder availability in each state is important indicator for its dynamism because dairy cows require a balanced diet for milk production, body maintenance and good health. Feed productivity has been taken as one of the indicator for assessing integrated sustainability index for small-holder dairy farms in Rajasthan (Chand *et al.* 2015). The amount and quality of milk produced by the animal is largely influenced by quality of feed and feeding practices. Moron (2009) has studied the farm forage production and forage quality as Key Performance indicators for diagnosing poor farm performance and profitability of small-holder dairy farmers. Water intake is related to animal size, age, activity, productivity and environment. So water availability per 1000 dairy animals has been taken as one of the indicators. The development level of region is substantially determined by level of infrastructure available in that particular state (Majumdar 2004, Kundu 2010). Veterinary institutions are important for providing treatment to sick animals. It includes veterinary hospital, dispensaries and aid centers. Yadav *et al.* (2014) have also studied veterinary infrastructure and livestock service delivery system across various regions of India. Number of AI centres, number of AI performed buffalo, and cattle breeding farm and semen production

Table 1. Indicator of dairy production system index

Notation	Variables	Source	Description
PCM	Per capita milk availability (g/day)	nddb.coop/information/stats	It was obtained by dividing total milk production of milk of the state of a particular year by estimated human population of the year.
MP	Milk production ('000 tons)	nddb.coop/information/stats	It was measured as average of total milk production of each state in last five years.
AYC	Average milk yield of crossbred cow (kg/day)	Basic Animal Husbandry Statistics for various years (BAHS, 2011-2016)	It was measured as average per day milk produced by crossbred cows during the lactation.
AYI	Average milk yield of indigenous cow (kg/day)		It was measured as average per day milk produced by indigenous cows during the lactation.
AYB	Average milk yield of buffalo (kg/day)		It was measured as average per day milk produced by buffalo during the lactation.
AAH	Average animal holding	www.indiastat.com.	It was obtained by dividing number of dairy animals by total households multiplied by 1000.
PCBI	Proportion of CB to indigenous cattle	Livestock Census-2007 and 2012	It was obtained by dividing total crossbred to total indigenous cattle in particular states.
AI	No. of AI performed per 1000 breedable bovine	Annual Reports of Department of Animal Husbandry, Dairying and Fisheries of the Ministry of Agriculture and Farmers Welfare, Government of India from (2011-2016)	It was obtained by dividing total number of AI performed by total breedable bovines livestock multiplied by 1000.

(Table 1. contd...)

Notation	Variables	Source	Description of variable
AIC	No. of AI center per 1000 breedable bovines	Data from NDDB and National Cooperative Dairy Federation of India Ltd.	It was obtained by dividing total numbers of AI centers by total breedable bovines livestock multiplied by 1000.
SPC	Semen production centre per one million breedable population		It was obtained by dividing total numbers of semen production center by total breedable population multiplied by one million.
CBF	No. of cattle breeding farm per one million breedable cattle		It was obtained by dividing total numbers of cattle breeding farm by total breedable cattle multiplied by one million.
BBF	No. of buffalo breeding farm per one million breedable buffalo		It was obtained by dividing total numbers of buffalo breeding farm by total breedable buffalo multiplied by one million.
DC	No. of Dairy Cooperatives Society (DCS) per 1000 tonne milk production	Annual Reports of DAHD&F, GoI (2011-2016)	It was obtained by dividing total number of dairy cooperative societies by total milk production of concerned states multiplied by 1000.
MPD	Milk procurement per day in DCS		It was obtained by dividing total quantity of milk procured by DCS by total number of DCS.
MDC	No. of members per DCS		It was obtained by dividing total number of members in DCS by total number of DCS.
MPF	No. of milk processing factories per 1000 tonne milk production		It was obtained by dividing total number of milk processing factories by total milk production of concerned states multiplied by 1000.
AFOD	Area under fodder per 1000 adult female bovine	Basic Animal Husbandry Statistics for various years (BAHS, 2011-2016)	It was obtained by dividing total area under fodder crops in hectare by total adult female bovine multiplied by 1000.
APAS	Area under pasture per 1000 adult female bovine		It was obtained by dividing total area under pasture land in hectare by total adult female bovine multiplied by 1000.
FODA	Feed and Fodder availability per 1000 of dairy animals (in '000 tons)	Indian Grassland and Fodder Research Institute, Jhansi (2015-16)	It was obtained by dividing total feed and fodder availability in states in grams by total dairy animals multiplied by 1000.
WA	Water availability per 1 million dairy animals	Annual Report (2016-17), DAHD&F, MoA& FW, GoI	It was obtained by dividing total water availability in states in hectare by total dairy animals multiplied by one million.
VI	No. of veterinary institutions per 1000 bovine	Annual Report (2011-2016) DAHD&F, MoA& FW, GoI	It was obtained by dividing total veterinary institutions in states by total dairy animals multiplied by 1000.
RP	No. of registered practitioner per 1000 dairy animals	www.indiastat.com.	It was obtained by dividing total numbers of registered practitioner by total dairy animals multiplied by 1000.
GAU	No. of Gaushalas (Cow Shelters) per 1000 dairy animals	(BAHS, 2011-2016)	It was obtained by dividing total numbers of Gaushala by total dairy animals multiplied by 1000.
FSPF	No. of fodder seed production farm per one million bovines	Animal Husbandry Department and Dairy Development Departments of respective states	It was obtained by dividing total numbers of fodder seed production farm by total bovines multiplied by one million.
AIN	No. of animals insured during last five years		It was the average number of animals insured during last five years.
SSDD	No. of schemes launched and being implemented for dairy development by respective state		It was the count of schemes launched and being implemented for dairy development by respective state.

centre were also very crucial indicators for functional dynamism as they help in breed improvement which results in increased milk production and productivity and help in considerable reduction in both genital and non-genital diseases in the dairy herd. The above indicators have been used by Kale *et al.* (2016) for assessing resource and infrastructure disparities to strengthen Indian dairy sector. Dairy co-operatives have played an important role in the expansion of milk and dairy production in India and these are the back bone of dairy marketing (Sreenivasiah and Chellakumar 2016). Hence indicators related to dairy cooperative such as number of dairy cooperative societies (DCS), members per DCS, milk procurement, milk processing factories were considered for the study. The same indicators were used by Mahida (2017) to classify the dairy development across districts in Gujarat. Number of schemes and programme implemented by a state for its dairy development is a vital indicator for its functional dynamism, as it shows the activeness of concerned state in dairying.

Development of index: Different indicators were taken from the different population distribution and they were recorded in different units of measurement. Therefore, to bring the values of the indicators within the comparable range, these needed to be normalized. Normalization was done by following formula:

(a) When the indicator has positive influence

$$\frac{(\text{Actual value} - \text{Minimum value})}{(\text{Maximum value} - \text{Minimum value})}$$

(b) When the indicator has negative influence

$$\frac{(\text{Maximum value} - \text{Actual value})}{(\text{Maximum value} - \text{Minimum value})}$$

(Mahida and Sendhil 2017, Sendhil *et al.* 2018).

For testing suitability of indicators, Principal Component Analysis (PCA) was used to identify the significant indicators and eliminate non-significant indicators [Ravindranath *et al.* (2011), Kale *et al.* (2016)]. PCA was employed on transformed data after normalization with 'varimax method' for rotation of the factors in XLSTATA (2017). The result of PCA explained the amount of variance contributed by all the indicators. PCs with Eigen value more than 1 were taken for further analysis. So, only six factors were considered for further analysis. Assignment of weights to the indicators was done as per Mahida (2017) for construction of Dairy Development Index in Gujarat state. The index was computed with the help of following formula:

$$I = \frac{\sum_{i=1}^n X_i W_i}{\sum_i W_i}$$

where, I is the index for each state; X_i is the normalised value of i^{th} indicator; W_i is the weight of the i^{th} Indicator, $W_i = \%L_{ij} \%E_j L_{ij}$, factor loading value of the i^{th} state on the j^{th} factor; E_j is the Eigen value of the j^{th} factor; i represents the 1, 2, 3, ... 26 indicators; and j represents 1, 2, 3 ... factors.

The states were then divided into three categories based on the calculated index score following Kale *et al.* (2016)

method namely dynamic dairy production system ($I_j > \text{Mean} + 1/2\text{SD}$), transient dairy production system ($\text{Mean} - 1/2 \text{SD} < I_j < \text{Mean} + 1/2\text{SD}$), subsistence dairy production system ($I_j < \text{Mean} - 1/2 \text{SD}$)

These 3 dairy production systems were operationalized as dynamic dairy production system (refers to the practices and issues which influence dairy production continuously over a period of time), transient dairy production system (It is the system wherein the practices and issues which are trying to influence the production system from sustainable level to commercial level but not attained the full market oriented production) and subsistence dairy production system (It refers to the practices and issues which just sustain the production system continuously without any remarkable change).

RESULTS AND DISCUSSION

The result of PCA produced main six principal components (PCs) with Eigen value more than 1 is shown in Scree plot (Fig. 1). These six factors together contributed nearly 86.41% of variability in data as indicated in Table 2. The weights assigned to each indicator are represented by the combination of Eigen value and factor loading of first 6 factors. The dairy production system index for each indicator in each state is presented in Table 3. State-wise index value of major indicators of dairy production system index are presented in Table 4.

Major six indicators of Dairy Production System Index

Dairy production: It refers to the factors responsible for producing milk and milk products in the concerned state. Punjab ranked first in dairy production index followed by Haryana and Rajasthan (Table 4). These findings were in concurrence with Kale *et al.* (2016). Punjab had highest index value in individual indicators like per capita milk availability, average milk yield of crossbred, indigenous

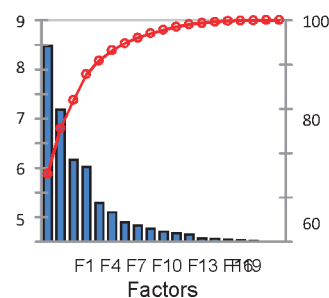


Fig. 1. Screen plot of Eigen value and cumulative variability

Table 2. Eigen value and extraction of variability

PCs	Extraction sums of squared loadings		
	Eigen value	% of variance	Cumulative %
1	7.958	30.608	30.608
2	5.358	20.607	51.215
3	3.325	12.789	64.004
4	3.040	11.691	75.695
5	1.586	6.099	81.794
6	1.200	4.614	86.408

Table 3. Index values of indicator wise functional dynamism across 20 states of India

State	Dairy production						Animal breeding				Value addition, marketing and extension				Resource availability				Veterinary infrastructure				Polices and regulation			
	PCM	MP	AYC	AYI	AYB	AAH	PCBI	AI	AIC	SPC	CBF	BBF	DC	MPD	MDC	MPF	AFO	DAPAS	FODA	WA	VI	RP	GAU	FSPF	AIN	SSDD
Andhra Pradesh*	3.23	4.31	2.85	1.27	3.29	3.55	0.2	2.56	1.37	0.71	0.12	02	0.87	0.84	1.62	0.31	0.27	0.26	0.45	0.96	2.20	11	0.68	0.05	4.69	2.08
	1	2.36	1.56	2.59	2.03	3.69	0.25	0.77	0.62	0.19	00	00	4.41	0.61	1.51	0.01	0.05	0.01	0.13	0.18	0.50	0.58	0.53	0	0.05	2.08
	0.33	0.37	0.56	0	3.59	8.27	0	0	00	0.5	0.17	00	1.76	0.02	0.07	0.2	0.01	1.03	0.21	0.30	0.46	0.12	0.84	0.38	0.17	2.08
	0	0	2.5	0.43	0.92	0.53	0.27	3.03	3.82	0	8.18	2.92	6.33	0.02	0.04	8.12	0	0.11	0.39	1.63	6.15	5.24	4.17	7.98	0	9.37
	3.96	3.55	4.36	4.25	3.25	5.6	0.14	2.73	1.31	0.82	0.29	30	3.19	5.82	5.89	0.41	2.36	0.39	0.39	0.49	00	0.42	3.67	1.05	1.92	5.21
Haryana	6.89	2.4	3.76	6	7.17	5.59	0.78	3.58	1.61	2.48	0.64	30	2.09	0.19	0.57	0.29	2.83	0.03	6.59	40	2.10	0.90	5.77	0.12	2.52	5.21
	3.65	0.36	0	0.59	1.34	6.99	0.54	2.75	2.70	2.25	0.52	00	1.51	0.03	0.06	0.03	0.16	4.925	0.280	0.33	8.3	1.1	3.04	0	0.49	3.12
Jammu and Kashmir	2.43	0.57	1.18	2.42	3.54	7.15	0.71	1.83	1.18	1.88	1.55	0.22	0	0	0	0.22	0.88	0.32	0.29	0.19	5.48	00	0.37	1.28	0	0
	0.52	0.54	1.33	0.62	4.63	6.08	0.01	0.01	0.73	0	0.14	0.13	0.07	0	0	0	0	0.17	0	0.28	0.14	0.35	0.34	0.5	0.04	0
Jharkhand	1.69	1.9	1.43	1.64	0	3.22	0.27	3.97	1.84	1.12	0.34	40	5.05	2.24	4.29	2.08	0.14	0.64	0.56	1.38	1.89	1.17	0.77	0.09	5.46	6.25
	1.13	0.85	4.31	0.13	1.59	0	10.52	9.72	7.14	10.13	2.89	9.61	3.05	0.41	1.66	0.28	0.19	0	0.09	9.30	5.55	9.12	0.04	0.83	2.69	9.37
Madhya Pradesh	2.59	3.18	2.57	1.83	1.94	6.23	0.02	0.01	0.56	0.14	0.15	10	1.59	0.38	0.53	0.08	1.05	0.53	0.4	0.23	0.19	0.36	2.69	0.06	3.98	5.21
	1.24	2.95	2.49	0.81	2.42	2.45	0.19	0.5	0.89	0.7	0.14	10	5.15	1.41	3.38	1.13	2.78	0.63	0.85	0.42	1.19	1.37	0.93	0	1.11	3.12
Maharashtra	0.24	0.57	1.48	0.31	1.44	4	0.07	1.32	2.73	0.44	0.37	00	6.14	0.17	0.49	0.16	0	0.63	0.39	1.95	1.76	0.54	0.26	0.4	1.55	0
	8.69	3.24	6.63	8.27	9.03	6.25	3.67	4.21	1.11	1.11	1.58	20	1.61	0.53	0.76	0.24	3.47	0	1.88	00	2.32	1.36	4.73	0.28	1.07	7.29
Punjab	4.98	4.99	3.18	3.71	4.56	6.85	0.09	0.36	0.67	0.12	0.14	10	2.36	0.99	1.32	0.08	7.8	0.57	0.93	0.26	17	0.50	7.98	0.03	0.57	7.29
	2.3	2.27	2.14	2.16	2.49	1.65	1.66	7.04	2.44	1.66	0.38	0.47	3.47	1.05	4.18	0.47	1.13	0.1	0.54	1.75	2.26	1.95	1.04	1.19	5.84	2.08
Tamil Nadu	2.21	7.85	2.5	2.03	2.67	5.04	0.13	0.75	0.7	0.26	0.17	10	2.09	0.2	1.8	0.11	0.9	0.01	0.42	0.19	0.23	0.33	1.18	0.12	0.28	4.17
	3.09	0.48	2.27	1.04	2.28	4.8	0.2	1	7.17	1.12	0.90	00	0	0	0	0.14	0.66	0.64	0.36	0.15	2.24	0.75	0.86	0.48	0.86	3.12
Uttarakhand	0.49	1.56	0.36	1.37	3.79	3.2	0.12	2.58	1.58	0.79	00	0.28	1.43	0.08	0.42	0.36	0.01	0	0.24	0.76	0.95	0.57	0	0.15	2.8	2.08
	8.69	7.85	6.63	8.27	9.03	8.27	10.52	9.72	7.17	10.13	8.18	9.61	6.33	5.82	5.89	8.12	7.8	4.92	6.59	9.30	8.30	9.12	7.98	7.98	5.84	9.37

*Including Telangana.

Table 4. State-wise index value of six major indicators of dairy production system index

State	Dairy production		Animal Breeding		Value addition and marketing		Resource availability		Veterinary infrastructure		Policies and regulations	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Andhra Pradesh*	0.32	6	0.11	13	0.14	11	0.07	13	0.12	11	0.44	10
Bihar	0.23	13	0.04	15	0.25	7	0.01 ^{\$}	20	0.05	19	0.14	17
Chhattisgarh	0.22	15	0.02 ^{\$}	20	0.08	16	0.05	16	0.05	17	0.15	16
Goa	0.08 ^{\$}	20	0.40	2	0.55	2	0.07	12	0.71 [#]	1	0.62	3
Gujarat	0.42	4	0.12	11	0.59 [#]	1	0.13	7	0.15	9	0.47	9
Haryana	0.55	2	0.19	5	0.12	12	0.33	3	0.27	5	0.51	8
Himachal Pradesh	0.23	14	0.18	6	0.06	17	0.20	4	0.37	3	0.24	15
Jammu and Kashmir	0.30	9	0.15	9	0.01	18	0.06	15	0.21	7	0.00 ^{\$}	20
Jharkhand	0.23	12	0.02	18	0.00 ^{\$}	20	0.02	19	0.04 ^{\$}	20	0.00	19
Karnataka	0.17	18	0.16	8	0.52	3	0.10	10	0.12	12	0.77	2
Kerala	0.31	7	0.88 [#]	1	0.21	8	0.33 [#]	1	0.47	2	0.79 [#]	1
Madhya Pradesh	0.31	8	0.02	19	0.10	14	0.08	11	0.10	14	0.60	4
Maharashtra	0.21	16	0.05	14	0.42	4	0.16	6	0.10	13	0.28	13
Odisha	0.14	19	0.11	12	0.27	6	0.10	9	0.09	15	0.10	18
Punjab	0.77 [#]	1	0.18	7	0.12	13	0.19	5	0.26	6	0.55	5
Rajasthan	0.48	3	0.03	16	0.18	9	0.33	2	0.29	4	0.52	7
Tamil Nadu	0.25	10	0.27	3	0.35	5	0.12	8	0.19	8	0.52	6
Uttar Pradesh	0.38	5	0.03	17	0.16	10	0.05	17	0.06	16	0.29	12
Uttarakhand	0.24	11	0.23	4	0.01	19	0.06	14	0.13	10	0.26	14
West Bengal	0.18	17	0.12	10	0.09	15	0.04	18	0.05	18	0.32	11

*Including Telangana, ^{\$}lowest value, [#]highest value.

and buffaloes which made it first in dairy production index (Table 3). Haryana occupied second position in per capita milk availability and average milk yield of indigenous and buffaloes. However, Maharashtra, West Bengal, Karnataka, Odisha and Goa scored lowest overall dairy production index value which might be due to low genetic potential of cattle and buffaloes in these states and rearing of mostly non-descript cattle and buffaloes which yield very less milk.

Animal breeding: It refers to the availability of animals and services for better improvement of breed. It includes status of AI centers, semen production center and cattle and buffaloes breeding farm of respective states. In the Animal breeding index, Kerala acquired first rank, whereas Goa and Tamil Nadu attained second and third position. It indicates the importance of cross-breeding programmes, genetic improvement of local breed by selective breeding and upgradation. AI services are more preferred than natural services. States like Jharkhand, Madhya Pradesh and Chhattisgarh scored very less in animal breeding aspect. It might be due to less awareness of AI services among farmers. So a reorientation of cattle and buffalo breeding policy with area specific extension approach backed up by appropriate programs would address this issue.

Value addition, marketing and extension: It refers to the status of value addition and promotional avenues for processing and marketing. This aspect includes numbers of Dairy cooperatives societies (DCS), members in DCS, procurement of milk per day and marketing of milk per day. Gujarat ranked first followed by Goa and Karnataka in value addition and milk marketing index (Table 4). It is because that Gujarat has highest members per DCS and

also procures highest quantity of milk per day. It is also due to the fact that Gujarat and Karnataka are having active milk federation AMUL and KMF respectively. People of these states prefer more cooperative dairies rather than private vendors. The activeness of their brands, viz. Amul and Nandini is very widely popular in their adjoining states. However states like Jharkhand, Uttarakhand and Jammu and Kashmir scored lowest in this index, as these states possessed weakest dairy cooperative structure. Farmers do not prefer to sell their milk in cooperative dairies. So there is need to strengthen the milk cooperative structure in these states. New extension models such as public private partnership (Ponnusamy 2013), Pashu Sakhi model (Ponnusamy *et al.* 2017), contract dairy farming and producer companies should be promoted to target the women and market to realize the better remunerative returns.

Resource availability: It refers to the extent to which natural resources are available for profitable dairy farming in the concerned state. It includes area under pasture, fodder, water and availability of feed and fodder in concerned states. Kerala ranked first in resources availability index whereas Rajasthan and Haryana stood 2nd and 3rd position respectively (Table 4). Kerala has highest area under water per million dairy animals. Rajasthan has highest area under fodder per thousand adult female bovine. Himachal Pradesh has highest area under pasture per thousand adult female bovines. Haryana has highest feed and fodder availability per 1000 dairy animals. However states like Bihar, Jharkhand and West Bengal got lowest index value in resources availability index. There is a need to develop

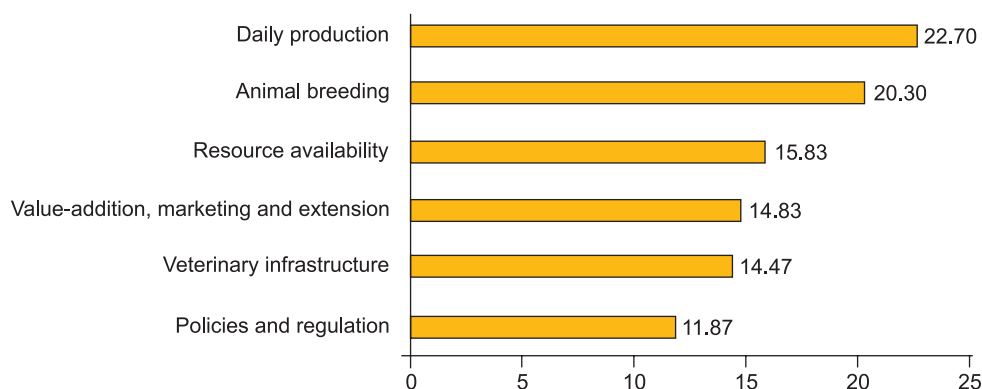


Fig. 2. Prioritization of major indicators of dairy production system based on expert judgement

fodder bank in such areas which are having less resources in fodder and pasture. Fodder availability can be increased by hay and silage making.

Veterinary infrastructure: It refers to the facilities being ensured by state and central government as well as private entities for promoting dairy farming in the concerned state. Goa topped in veterinary infrastructure index followed by Kerala and Himachal Pradesh in this index (Table 4). However Jharkhand, Bihar, West Bengal and Uttar Pradesh had lowest index value in this index. This finding is in line with the findings of Yadav *et al.* (2014) who reported better veterinary infrastructure level of Kerala, Punjab and Karnataka as compared to Jharkhand, Bihar, Odisha. This warrants adequate investment in the dairy sector, strengthening manpower in animal husbandry department and encouraging the participation of private sectors in veterinary infrastructure including veterinary hospitals, dispensaries, Gaushalas in these states.

Policies and regulations: It refers to the continued support of government in the form of directions and regulations for promoting dairy development of the respective state. In this index, Kerala got first position, followed by Karnataka and Goa. However, Jammu and Kashmir, Jharkhand and Odisha secured lowest position in index. These states require government interventions for promoting dairy development on the identified gaps.

Prioritization of major indicators based on expert judgement: The 26 identified indicators were grouped into six major indicators namely dairy production, animal breeding, value addition, marketing and extension, resource availability, veterinary infrastructure and policies and regulations (Table 3). These six major indicators were prioritized for their importance by expert judgement method. Thirty experts from different disciplines were selected and requested to assign weightage to all the six major indicators out of 100. Their response were complied and analyzed by considering the average score (Fig. 2), which indicate that dairy production component is the top prioritized area by experts for dairy production system index with an average score of 22.70. This is probably due to the visible progress of dairy development for indicators like milk production and milk productivity. Animal breeding was prioritized as second, since higher genetic potential of

dairy animals can substantially enhance the milk productivity which could be possible in states which promote and facilitates for dairy development. The third most prioritized aspect is resource availability. Undoubtedly feeding contributes two-third of the cost of milk production. Fodder, pasture and water availability should be made available for improved dairy farming. The other aspects like value addition, marketing and extension, veterinary infrastructure and policies & regulations are also equally important in promoting eco-friendly and economically sustainable dairy production system.

Overall dairy production system index (DPSI) value: Kerala, Punjab, Goa, Haryana, Gujarat and Rajasthan were placed under the dynamic dairy production system category (Fig. 3). States, viz. Tamil Nadu, Karnataka, Himachal Pradesh, Andhra Pradesh, Maharashtra and Madhya Pradesh were grouped under transient dairy production system. Uttar Pradesh, Uttarakhand, Jammu and Kashmir, Odisha, West Bengal, Bihar, Chhattisgarh and Jharkhand were categorized under subsistence dairy production system. Kerala ranked first in overall dairy production system index owing to its highest literacy rate in India, prompting the farmers to acquire more knowledge and awareness about the scientific dairy farming practices and further likely to adopt new technology. The government policies are quite favourable to dairy development. The state has highest crossbred to indigenous cattle ratio and highest AI performed per 1000 breedable population. Punjab ranked as second in the DPSI. The state has highest milk production and milk productivity of all the bovines, viz. indigenous, crossbred and buffaloes. The index also shows that Bihar, Chhattisgarh and Jharkhand had lowest index value in the DPSI. These states have lower level of literacy rate and lower value in milk productivity of bovines. These states mostly were having the non-descript population of dairy animals and also having less number of crossbreeding programmes. The resources such as AI centers and area under fodder are also very less as compared to other states.

Vast differences in functional dynamism of dairy production system based on the analysis of 26 different factors related to 20 selected states provided inputs for planners and policy makers such as; for increasing the milk production and productivity of bovines in West Bengal,

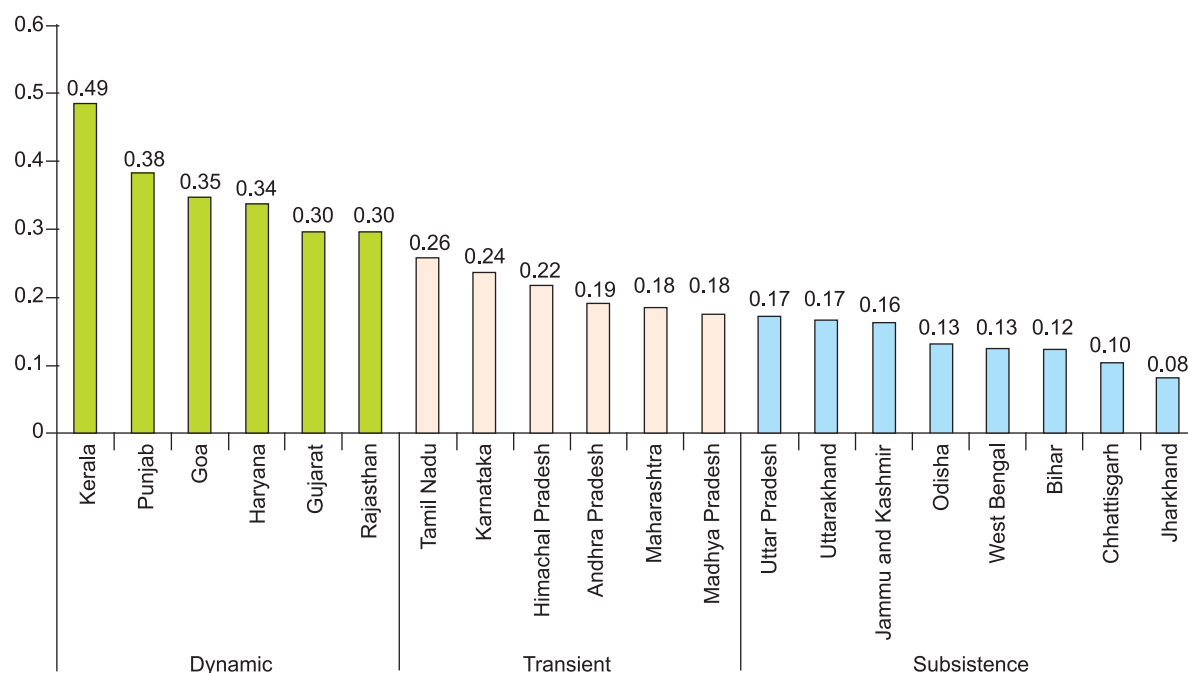


Fig. 3. Categorisation of Dairy Production system based on overall index value.

Odisha and Goa by genetic improvement of bovines through crossbreeding, selective breeding and upgradation programmes. The states where crossbreeding is not possible can be encouraged for indigenous cattle breeding. The pure breed of indigenous cattle like Gir, Sahiwal, Deoni and Tharparkar need to be promoted in hilly states like Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The animal breeding area should be given focus in Uttar Pradesh, Jharkhand, Madhya Pradesh and Chhattisgarh. There is a need to increase the numbers of AI centers and cattle and buffalo breeding farms so that animals with better genetic potential will be available for farmers. Area under fodder and pastures and fodder availability need to be increased in Uttar Pradesh, West Bengal, Jharkhand and Bihar by sensitizing and incentivizing the farmers for quality fodder production and role of green fodder for higher milk productivity. States like Chhattisgarh, West Bengal, Bihar and Jharkhand need to improve veterinary infrastructure in their states. The states, viz. Odisha, Jharkhand and Jammu and Kashmir had lowest index value in policies and regulations area. These states should formulate state specific schemes for dairy development. Development of organized milk marketing network should be strengthened in all the states. The identified issues and strategies as per the varied dairy production systems if addressed in systems perspective would pave way for the development of eco-friendly, equitable and profitable dairy farming across regions.

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