Indian Journal of Animal Sciences **95** (6): 541–546, June 2025/Article
https://doi.org/10.56093/ijans.v95i6.168540

Animal-based food system in India: An analysis of production, consumption and nutritional implications

A SURESH[1]✉, RAJESH I D[1], NEETHU MOL JACOB[1], VIJAYKIRAN VIJAYAN[1] and KHEM CHAND[2]

ICAR-Central Institute of Fisheries Technology, Kochi 682 029

Received: 03 July 2025; Accepted: 20 August 2025

ABSTRACT

This study analyses animal-based food production system, and its consumption and nutrition contribution using data from FAO and National Statistical Office/National Sample Survey Office. Between 2010 and 2021, India saw improved domestic supply of livestock products, with significant growth in exports of marine products and buffalo meat. The value of output from milk, fish, eggs, meat, and other livestock sectors has increased. Poultry, particularly chicken and eggs, drives non-milk-based animal food consumption in India. The total per capita protein supply in India increased from 60.5 g/day to 70.5 g/ day, and in this, the share of animal products increased from 19% to 25%. As of 2021, out of the total daily per capita fat supply of 60.4 g, 36.0% is contributed by animal sources. In case of fat, the share of animal products increased from 31.3% to 36.0%. The study highlights the need for region-specific policies to enhance livestock production and its nutritional contributions.

Keywords: Food consumption pattern, Food and nutritional security, Livestock growth

Although often overlooked, livestock, fish, and aquatic food play an important role in achieving food and nutritional security for several reasons. Over the past few decades, there has been a notable increase in the consumption of animal-based food products such as meat, fish, eggs, and dairy. This trend is evident in developing countries, where economic development and urbanization have led to a dietary shift from plant-based proteins to animal-derived proteins (IFPRI 2024). Animal products are major sources of high-quality proteins and vital micronutrients such as iron, zinc, and vitamins B_{12} and A, commonly deficient in diets in the developing world. Consuming moderate amounts of animal-sourced foods is important for maintaining a balanced diet.

Other than food and nutritional contributions, livestock and fisheries play pivotal roles in sustaining livelihoods, and providing resilience to the rural economy in India (Birthal *et al.* 2006). Livestock are multifunctional through their food and non-food activities and contributes to poverty reduction (Birthal 2022).

As per the latest 20th livestock census (2019), there are about 304 million bovines (cattle, buffalo, Mithun, and yak), 74 million sheep, 149 million goats, 9.1 million pigs, and about 852 million poultry in India. Dairy is the single largest agriculture commodity, contributing 5 percent of the national economy and directly employing more than 8 crore farmers (GoI 2023). Further, India has abundant water resources, with a total coastline of 8118 km and vast inland water resources which provide opportunity for fisheries. In 2022-23, India produced about 16.4 million tonnes of fish- 75% from inland sources. Marine products are the most significant agricultural commodity exported from India, worth Rs 60 thousand crores in 2023-24. Livestock sector also acts as an insurance mechanism against crop sector's income fluctuations (Birthal *et al.* 2006, Suresh *et al.* 2008). To meet future food and nutritional security, promoting growth in the livestock and fisheries sector based on scientific insights and policies is critical.

In this background, the present study aims to explore the growth of animal-based food production in India and its implications by examining two key areas. First, the study assesses the current status of animal-based food production, focusing on its contribution to the economy, consumption trends, and supply of essential nutrients. Second, it analyses the status of livestock and fish holdings among agricultural households and identifies the socio-economic correlates that influence ownership.

MATERIAL AND METHODS

Data sources: The data on domestic supply and its disaggregated elements for the period of 2010 to 2021 were collected from the database of Food and Agricultural Organisation (FAO). The domestic supply is calculated by deducting export, diversion for non-food use, and food losses from domestic production and adding with it the import quantity. This is adjusted for changes in the

Present address: ICAR- Central Institute of Fisheries Technology, Kochi 682 029. [2]National Institute for Agricultural Economics and Policy Research, New Delhi-110012. ✉Corresponding author email: sureshcswri@gmail.com/ suresh.a@icar.gov.in

stock. The per capita availability is calculated by dividing the domestic supply by the total population, the data for which is collected from FAO. The nutritional contribution in terms of protein and fat of animal origin is collected through the Fishstat J software of FAO. The value of output of milk, egg, meat items, and fish were collected from the publications of the National Statistical Office, for the years 2010-2021. The state-wise values of the outputs in constant prices were used for the analysis.

The data on consumption of the food of animal origin (milk, egg, fish, and meat) was collected from the database of the Household Consumption Expenditure Survey of NSSO of the Ministry of Statistics and Programme Implementation. Two rounds of NSSO Surveys are used for the analysis: the data for the year 2022-23 of August 2022- July 2023 (published in June, GoI 2024), and the previous consumer expenditure survey, NSS 58th round of the period of July 2011- June 2012 (GoI, 2015). Besides the data from the Livestock Census and the Handbook of Fishery Statistics, individual farmer-level livestock and fish farming from the database on Situation Assessment Surveys of Agriculture Households of NSO of GoI (2021) were also used.

Research methods: Other than descriptive statistics, the paper utilised estimation of trend growth rate by using the semi-log growth model. Triennial ending data was used to smoothen the data in the case of estimation of trend growth of the value of output. To analyse the correlates of holding of different livestock species, the multivariate probit (MVP) model was used, as follows:

$$B_{ik} = \beta_k X_i + \mu_i$$

Where, k= type of livestock species.

An indicator function was used to translate the unobserved farmer preference into observed binary outcomes for each livestock:

$$Y_{ik} = \begin{cases} 1, B_{ik} > 0 \\ 1, B_{ik} \leq 0 \end{cases}$$

Since farming of any type (species) of animal/ fish is possible, the error terms jointly followed a multivariate normal distribution (MVN) with zero conditional mean and normalised unity variance ((where (U1, U2, . . ., Uk) ≈ MVN (0, Ω)) with the symmetric covariance matrix Ω:

$$\Omega = \begin{vmatrix} 1 & p_{12} & p_{13} \\ p_{21} & 1 & p_{23} \\ p_{31} & p_{32} & 1 \end{vmatrix}$$

The MVP model was used to determine the correlates of correlated dependent variables on a specific set of independent variables. The details of the model can be found in Cappellari and Jenkins (2003).

Model specification: The dependent variables in the model were cattle, buffalo, small ruminants (sheep and goat), poultry, and other livestock. The values of the variables 1 indicate households that hold that particular livestock and 0, otherwise. The generalized model is specified as:

$$Y^*_{Cattle} = \beta_1 \text{ Land} + \beta_2 \text{ MCE} + \beta_3 \text{ HS} + \beta_4 \text{ SG} + \beta_5 \text{ Re} + \varepsilon_i$$
$$Y^*_{Buffalo} = \beta_1 \text{ Land} + \beta_2 \text{ MCE} + \beta_3 \text{ HS} + \beta_4 \text{ SG} + \beta_5 \text{ Re} + \varepsilon_i$$
$$Y^*_{Ovine} = \beta_1 \text{ Land} + \beta_2 \text{ MCE} + \beta_3 \text{ HS} + \beta_4 \text{ SG} + \beta_5 \text{ Re} + \varepsilon_i$$
$$Y^*_{Poultry} = \beta_1 \text{ Land} + \beta_2 \text{ MCE} + \beta_3 \text{ HS} + \beta_4 \text{ SG} + \beta_5 \text{ Re} + \varepsilon_i$$
$$Y^*_{Othe\_Liv} = \beta_1 \text{ Land} + \beta_2 \text{ MCE} + \beta_3 \text{ HS} + \beta_4 \text{ SG} + \beta_5 \text{ Re} + \varepsilon_i$$

The MVP model was estimated using the simulated maximum likelihood method. The variables were ownership of land (Land), monthly consumption expenditure (MCE), size of the household (HS), social groups (SG), and religion of the households (Re).

RESULTS AND DISCUSSION

Structural changes in livestock products' production: The domestic supply of livestock products in India has increased in tandem with the increase in their demand. The trend in livestock production and domestic supply shows a substantial increase in production, particularly in milk, fish, seafood, and poultry. India's domestic livestock

Table 1. Domestic supply of livestock products in India, and its components, across livestock products, 2021 (TE Average) (Million tonnes, mt)

Particular	Milk - excluding butter	Fish, seafood	Eggs	Bovine meat	Mutton and goat meat	Pig meat	Poultry meat	Total meat
Production	206 (5.5)	13.3 (5.11)	6.6 (7.02)	3.5 (3.11)	0.8 (0.96)	0.3 (-0.69)	4.2 (6.02)	8.9 (4.06)
Export	0.1 (4.29)	1.7 (6.45)	0.06 (-3.0)	1.02 (0.19)	0.01 (-2.61)	0	0 (-3.52)	1.0 (0.13)
Import	0.31 (-1.2)	0.13 (13.27)	-	-	-	- (-3.8)	-	- (-0.96)
Non-food uses	0.06	0.33 (-4.09)	-	-	-	-	-	-
Losses	2.38 (5.06)	-	0.58 (6.79)	-	-	-	-	-
Domestic supply	206 (5.5)	11.7 (4.99)	6.5 (7.16)	2.5 (5.2)	0.82 (1.5)	0.33 (0.28)	4.2 (6.5)	7.83 (5.22)

Source: FAO, 2024, and the authors calculation based on the data, Note: Figures in parentheses are the growth rates are respective growth rates 2010-21

Table 2. Per capita availability (Per capita food supply (g/capita/day) in India

Year	Milk - Excluding Butter	Fish, Seafood	Eggs	Bovine Meat	Mutton & Goat Meat	Pigmeat	Poultry Meat	Total Meat
2010	130	12	8	5.74	2.6	1.89	6.79	17
2021	222	16	14	6.15	2.48	1.43	9.98	20

Source: FAO, 2024, and the authors' calculation based on it

supply has grown, with a significant increase in production of milk, fish, seafood, and poultry (Table 1). It can be assumed that 99% of India's domestic consumption comes from domestic production. Dependence on imports is currently minimal. Dairy products (milk excluding butter) lead the sector, followed by fish and egg, with India being the largest milk producer globally, accounting for 22% of the world's total milk production. In 2021, milk production (excluding butter) reached 206 million tonnes (mt), growing at 5.5% annually, with minimal exports at 0.1 mt. The evolution of the dairy sector in India and the key role played by dairy cooperatives since the launch of Operation Flood to leverage the strength of the smallholder milk producers has been widely acknowledged (Birthal *et al*. 2006, Kumar *et al.* 2024). In 1950-51, milk production was just 17 mt. Before the start of Operation Flood, it had risen slightly to 21.2 mt by 1968-69, which touched 206 million tonnes in 2020-21(Kurien 2004, FAO 2024). A series of measures were undertaken to usher in the private and cooperative sectors in dairy development and industry (Birthal 2022, GOI 2023).

Another unsung revolution occurred in India's poultry sector, which transitioned from conventional farming to commercial systems with constant technology upgradation, supply chain expansion, and institutional intervention in the form of vertical integration and contract farming. Consequently, egg and poultry chicken production grew at the rate of 6-7% annually (Table 1). Two-thirds of the country's broilers and eggs are now being produced under contract farming (Birthal 2022, GOI 2023). Fish and seafood production stood at 13.3 mt, with an annual growth of more than five per cent and substantial exports of 1.7 mt, growing annually at 6-7%. The total meat production in the country was 8.9 mt in the year 2021. The meat production has witnessed a drastic structural change since the 1990s with the emergence of the poultry sector.

Livestock and fishery provide livelihood to 20.5 million worldwide and 14.1 million people directly in India (FAO 2025). Livestock sector employs about 80 million people in various capacities (vetextensio.com 2025). Table 2 presents the output values of milk, fish, eggs, and their trend growth rates for the period of 2010-2021, across states. The growth rates of value of output varied significantly among different states for the commodities and highlighted the necessity for state-specific attention (Supplementary Table 1). Livestock and fisheries (except those that involve areas beyond territorial waters in marine fishing) are included under the state list of the constitution, and the states can make the policies.

India's per capita food availability has increased over the past decade due to improvements in production and supply chains, but it still has room for growth in milk, fish, and meat production. The per capita availability of livestock and fish products in India has increased in all cases except for small ruminants (sheep and goat) and pig meat. The total per capita milk availability in 2021 was 222 g/day (Table 2). On a disaggregated basis, the increase in the per capita availability was the highest for egg, followed by milk and bovine meat, at 78% and 57%, respectively. A decline in the per capita availability was noted in the

Table 3. Consumption of livestock items per household (Time span: 30 days)

State		Milk	Chicken	Egg	Beef/buffalo	Mutton	Pork	Fish
% of Household	2012	84.36	23.34	31.85	4.33	7.56	0.92	24.76
	2023	93.85	41.77	51.83	3.36	6.07	0.89	24.08
	Change (Percentage points)	9.49	18.43	19.98	-0.97	-1.49	-0.03	-0.68
Average MCE (In Rs)	2012	134.74	22.91	8.14	5.02	14.87	1.18	26.63
	2023	220.95	40.96	17.44	4.31	15.34	1.33	25.33
	% Change	63.98	78.79	114.25	-14.14	3.16	12.71	-4.88
Average monthly Quantity of Consumption* (In kg, Egg is in Numbers)	2012	-**	0.86	7.42	1.17	0.78	0.96	1.15
	2023	-	0.95	8.09	1.07	0.79	0.94	1.07
	% Change	-	10.47	9.03	-8.55	1.28	-2.08	-6.96

Sources: Authors' calculations based on NSO data on household consumption expenditure (2024 and 2012), * The quantity is calculated only for the consuming households, **Quantity for milk and milk products not available.

Table 4. Trend in protein and fat supply, at disaggregated level

Year	Protein supply (g/ capita/ day)		Fat supply (g/ capita/ day)	
	2010	2021	2010	2021
Total supply in India (g/ per capita/day)	60.46	70.52	48.95	60.36
Vegetable products	48.99 (81.03)	53.19 (75.43)	33.65 (68.74)	38.66 (64.05)
Animal products	11.47 (18.97)	17.33 (24.57)	15.3 (31.26)	21.7 (35.95)
Total meat	1.88 (3.11)	2.74 (3.89)	1.05 (2.15)	1.01 (1.67)
Bovine meat	0.67 (1.11)	1.18 (1.67)	0.34 (0.69)	0.16 (0.27)
Mutton and goat meat	0.3 (-0.5)	0.28 (0.4)	0.15 (0.31)	0.15 (0.25)
Pigmeat	0.11 (0.18)	0.09 (0.13)	0.16 (0.33)	0.12 (0.2)
Poultry meat	0.81 (1.34)	1.19 (1.69)	0.4 (0.82)	0.58 (0.96)
Eggs	0.72 (1.19)	1.28 (1.82)	0.56 (1.14)	0.99 (1.64)
Milk (excluding butter)	7 (11.58)	10.69 (15.16)	5.81 (11.87)	9.94 (16.47)
Fish (seafood)	1.7 (2.81)	2.42 (3.43)	0.53 (1.08)	0.71 (1.18)

Source: FAO (2024) and authors' calculations based on it, Figures in parentheses indicate shares in the total supply

case of the meats of sheep, goat, and pig. The production of small ruminants in India has been stagnating and needs special attention.

Consumption of livestock and fish-based products: The status of households consuming animal and fish-based products, monthly consumption expenditure, and average quantity of consumption are provided in Table 3. The table also provides the change between the consumption expenditure surveys of NSO between 2011-12 and 2022-23. As of 2023, the share of the population consuming milk, egg, and chicken was 94%, 51% and 42%, respectively (on a 30-days basis) (Table 3). On the other hand, beef, mutton, and pork were consumed by only a small section of households, 3.3, 6.1, and 0.9%, respectively. A quarter of the population consumed fish. In about a decade, the share of the population consuming milk, poultry meat, and eggs has increased while those consuming beef, mutton, and pork have declined. The largest changes in the percentage points are noted in the case of eggs and chicken.

The rise in milk consumption highlights its essential role in the Indian diet, especially for vegetarians, as a key source of animal protein. Dairy products are becoming more accessible through organized retail channels. Simultaneously, the affordability, availability, and universal acceptance of chicken, free from religious restrictions and priced lower than red meat, have made it a leading choice across India. Additionally, the average monthly consumption expenditure (MCE) for eggs increased by 114 %**,** further indicating the rising popularity of eggs as a major protein source. Cultural differences further contribute to the variation in meat consumption patterns across the country (Rammohan *et al.* 2012, Ritchie *et al.* 2023).

Implications for nutritional supply: Livestock products provide high-value protein and are important sources of essential micronutrients, particularly minerals such as iron and zinc, and vitamins such as vitamin A (WHO and FAO 2002). Eating animal-sourced foods is vital in achieving a nutritionally balanced diet (Reynolds *et al.* 2015). The improvement in the livestock sector has contributed to nutrient supply in India, which is analyzed by the trends in supply of protein and fat, for two time periods, 2010 and 2021 (Table 4). The total per capita protein supply in India increased from 60.5 g/day to 70.5 g/ day, and in this, the share of animal products increased from 19% to 25% (an increase of 6.6 percentage points). The contribution of milk, egg, meat, and fish has increased. Within the meat products, an increase in the share is noted in all the cases except pig and small ruminant meats. The share of fish stood at 4.34%, and increased by 0.6 percentage points on a per capita basis in 10 years. In case of fat, the share of animal products increased from 31.3% to 36.0%. As of 2021, of the total daily per capita fat supply of 60.4 g, 36.0% is contributed by animal sources. This is an increase of 6.4 g/ day compared to a decade back. In the case of both protein and fat, the share of animal products has increased with a corresponding decline in the share of vegetarian products.

Holding of livestock and fisheries and their correlates: About 71 per cent of the households in India possess one or the other species of livestock, and the count of livestock ownership increases with landholding size. Resource-poor small marginal farmers and landless labourers own most of the livestock resources (GoI 2023). The percentage of households reporting owning livestock at the national level and across states, as noted from the Situation Assessment Survey of Agricultural Households (NSO 2021) is provided in Supplementary Table 2. Cattle farming emerged as a prominent subset, with approximately 29.5% of households participating nationwide. Other than supplying milk, one of the integral contributions of the cattle is supplying draft power for agriculture, though its contributions showing a declining trend (Sharma and Sharma 1990). Buffaloes are primarily valued for dairy production and it has low draft value. Small ruminants and other animals, including sheep, goats, and pigs, were engaged by 14.64% of households.

On average, the size of livestock holdings is relatively

Table 5. Results of multivariate regression

	Ownership of livestock				
Variable	Cattle	Buffalo	Small ruminants	Poultry	Other livestock
Land	0.0006***	0.0004***	0.00008***	0.00006***	-0.00004
	(0.0001)	(0.00001)	(0.00002)	(0.00002)	(0.00008)
MCE	-0.000001***	0.00001***	-0.00001***	0.0000001	0.00001
	(0.000)	(0.0000)	(0.0000)	(0.00000)	(0.0000)
HH size	0.096***	0.086***	0.0694***	0.0694	0.0119
	(0.003)	(0.003)	(0.003)	(0.003)	(0.0123)
	Social group (ST as the base variable)				
SC	-0.283***	0.262***	-0.352***	-0.8001***	-0.397***
	(0.019)	(0.0239)	(0.0204)	(0.218)	(0.0890)
OBC	-0.153***	0.505***	-0.558***	-0.872***	-0.448***
	(0.164)	(0.0205)	(0.017)	(0.021)	(0.073)
Others	-0.084***	0.421***	-0.821***	-0.917***	-0.269***
	(0.018)	(0.022)	(0.020)	(0.0204)	(0.0713)
	Religion (Hindu as the base variable)				
Christian	-0.283***	-0.478***	0.444***	0.686***	-0.0085
	(0.019)	(0.0237)	(0.0208)	(0.0205)	(0.106)
Muslim.	-0.932***	-0.934***	0.277***	0.784***	0.630***
	(0.028)	(0.046)	(0.0254)	(0.024)	(0.066)
Others	-0.0679***	0.243***	0.0286	0.152***	0.528***
	(0.0277)	(0.0305)	(0.032)	(0.0319)	(0.080)
Constant	-0.624***	-1.873***	-0.716***	-0.4800***	-2.667***
	(0.018)	(0.0229)	(0.019)	(0.019)	(0.0746)

Number of observations: 58040, Log likelihood: -111473.65, Wald $chi^2(45)$: 17708.87, Prob > chi^2: 0.0000, Note: Figures in parentheses indicate standard errors, *** p value< 0.001, ** p value< 0.01, * p value< 0.05

small, with cattle being the most commonly held at 0.38 per household, followed by buffalo (0.20), small ruminants (0.18), and poultry (0.17), while other livestock remain minimal at 0.004. This indicates that the mean size of the livestock holding per the owner population is 1.3 for cattle, 1.2 for buffalo, 1.2 for small ruminants & other animals and 1.6 poultry birds, each. The mean household size is about 4.76 members, and the mean monthly consumption expenditure is ₹9,097. Interestingly, the mean landholding size is quite small at 0.23 hectares- many farmers work with limited agricultural land, which may impact their capacity to scale livestock or aquaculture operations. The overall picture, derived from more than 58,000 observations, indicated small-scale livestock farming, with limited landholding and moderate consumption expenditures (The detailed information is provided in Supplementary Table 3.

A multivariable probit model adjusted for various covariates showed that area under the operational holding is associated positively with owning cattle, buffalo, small ruminants, and poultry, but is negatively associated with other livestock (including aquaculture) (Table 5). The aquaculture operation usually happens in open waters, and on leased land by a group of farmers, or on panchayat land. The monthly household consumption expenditure per capita is considered as a proxy for the income status of the households. It was negatively correlated with ownership of cattle and small ruminants (sheep and goat), but was positively correlated with ownership of buffaloes. The household size is considered as a proxy for the household's labour supply (and food demand in the households), and is positively related to ownership of cattle, buffalo, and small ruminants. The social groups and class structure of the society are also strongly associated with the livestock ownership (Suresh *et al*. 2008). Thus, social stratification has a strong correlation with production

The domestic supply was largely determined by production, with very little import. Rather, export was prominent for fish and bovine meat. The per capita availability of all the animal-based products has improved except for small ruminants and pig meat, calling for focused intervention to improve their production. Between 2012 and 2023, the households consuming poultry products, viz. egg and chicken meat, have improved by 20 and 18 percentage points, respectively. The production improvement of animal products has contributed to improved supply of animal-based nutrients, not only on an absolute basis, but also on a per capita basis and shares in total nutritional supply. The holding pattern of livestock varies significantly among states, as it is determined by the extent of land ownership, household labour supply, and income levels. Results of the multivariate probit model revealed that socio-economic factors such as land size, household composition, social group, and religion influence type of livestock ownership at household level. Further, common property/ open access

resource like capture fishery also contributed to animal-based food production. The dominance of the smallholders among the farmers points to the deliberate need for improving access to inputs and services for them.

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