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Cattle feeding practices, fodder resource management, and constraints faced by dairy farmers in Gujarat, India: A comparative review of field studies

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Abstract

India milks more cattle and buffalo than any other country, yet output per animal still lags well behind global averages, and feeding is usually where the blame lands first. Gujarat offers an instructive test case: the state's cooperative dairy system, built on the Anand Pattern that Amul made famous, is about as well organised as smallholder dairying gets in India, and over the past decade a substantial body of district-level surveys has examined how farmers there actually feed their animals. This paper draws together fifty field studies, review reports, and on-farm supplementation trials located through ResearchGate, Google Scholar, ICAR ePubs, FAO records, and individual journal websites into a single comparative synthesis, spanning Gujarat districts (Valsad, Navsari, Surat, Junagadh, Porbandar, Jamnagar, Sabarkantha, Aravalli, Mehsana, Patan, Anand and Gandhinagar) alongside comparable work from Maharashtra, Haryana, Uttar Pradesh, Rajasthan, Madhya Pradesh, Telangana, Tamil Nadu, Bihar and Assam. A comparative matrix (Table 1) sets the fifty studies side by side on location, sample, method, and principal findings. Several patterns hold up across nearly every study reviewed: green and dry fodder are generally fed whole rather than chopped, concentrate is allocated by prevailing milk price rather than any calculated ration, mineral mixture reaches only a minority of animals, and silage remains largely a big-farmer practice. High feed cost tops the constraint list almost everywhere Garrett ranking has been applied, with seasonal green-fodder shortage and weak balanced-ration knowledge close behind. Land holding, herd size, education, training, and contact with extension or the cooperative society recur as the factors most consistently associated with better feeding practice and higher yield, while on-farm trials confirm that mineral-mixture supplementation alone can raise milk yield by roughly 12–19%. The paper closes with implications for policy and extension in Gujarat and with targeted recommendations.

Keywords: Dairy farming, feeding management, fodder resource management, Gujarat, Garrett ranking, extension contact, cooperative dairying, comparative review, mineral supplementation

1. Introduction

India produces close to a quarter of the world's milk, and almost none of it comes from anything resembling a Western-style dairy farm. It comes from small households keeping two, three, sometimes half a dozen animals, with milk sold to a cooperative or a local trader as one part of a mixed farm income. Gujarat sits near the centre of this story. The Kaira District Co-operative Milk Producers' Union, founded in Anand in 1946 and known to most people simply as Amul, gave India the three-tier village–district–state model later scaled up nationally as the “Anand Pattern” (Barot and Bose, 2024) [2]. That structure still runs today through the Gujarat Co-operative Milk Marketing Federation (GCMMF) and its district unions, handling procurement, a fair amount of the feed supply, and whatever extension contact most farmers get. For a large share of rural Gujarat, milk money is not incidental income; it is one of the few reliable cash flows a household has. None of that history has solved the underlying nutrition

problem. India's dairy animals produce well below what comparable breeds manage elsewhere the national average test-day yield for crossbred cows is about 8.09 kg/day (Al Kalaldehy *et al.*, 2021) [1] and most of the technical literature points to feeding rather than genetics as the primary reason. National estimates put the shortfall at somewhere between 11 and 35 per cent for green fodder, around 11 to 25 per cent for dry fodder, and over 40 per cent for concentrate ingredients (Down To Earth, 2025; “Enhancing Green Fodder Production,” 2024) [6, 28]. Birthal and Jha (2005) [4] went further, estimating that feed scarcity alone accounts for close to half of all losses in Indian dairy production. Gujarat's farmers are not exempt from this simply because the cooperative system here is stronger than in most states. Over roughly the last fifteen years, a considerable number of district-level surveys have been published covering most of Gujarat's dairy heartland, plus comparable work from Maharashtra, Haryana, Uttar Pradesh, Rajasthan, Madhya Pradesh, Telangana, Bihar, Tamil Nadu and elsewhere.

Read together, these studies tell a fairly consistent story, even if exact numbers shift from district to district with rainfall, herd composition, and how active the local cooperative happens to be. What has been missing is a single comparative frame that places these studies side by side and reads the pattern across them rather than one district at a time.

This review does exactly that. It assembles fifty studies into one comparative matrix and synthesis, organised the way a state-level assessment would normally be structured, and checked against evidence from other major dairying states. It then uses that synthesis to flag the gaps both the districts nobody has surveyed and the analytical methods rarely used so that whatever primary research comes next builds on what already exists instead of covering the same ground again.

2. Review Methodology

This is a comparative narrative synthesis built entirely from published secondary sources; no farmers were surveyed and no primary data were collected for this article. Literature was located through ResearchGate, Google Scholar, Academia.edu, ICAR ePubs, FAO records, and individual journal websites, searching combinations of “dairy farmers,” “feeding management,” “fodder resource management,” “constraints,” “Garrett ranking,” “mineral mixture,” “Gujarat,” the names of individual districts, and “socio-economic characteristics.” Preference went to peer-reviewed field surveys in outlets such as the Indian Journal of Animal Sciences, the Indian Journal of Animal Production and Management, the Journal of Entomology and Zoology Studies, the International Journal of Livestock

Research, and the Indian Journal of Veterinary Sciences and Biotechnology, with FAO technical notes, ICAR/Government assessments, and credible agricultural reporting brought in where the peer-reviewed record on a specific point was thin.

A study qualified for inclusion if it reported field-survey data, a systematic review, or an on-farm trial bearing on farmer socio-economics, feeding practice, fodder management, ranked constraints, or feeding–yield relationships, from Gujarat or a comparable smallholder dairy setting elsewhere in India. Fifty such sources met the criterion and are set out in the comparative matrix in Table 1. Because sample sizes, questionnaire design, and local growing conditions differ from one study to the next, the numbers below are presented as ranges and directions rather than pooled into a single statewide average. A figure drawn from one district study should be read as an illustration of what that district looks like, not as something automatically true of Gujarat as a whole.

3. Comparative Matrix of the Fifty Studies Reviewed

Table 1 arranges the fifty reviewed studies on a common set of columns study and source, location and scope, sample, analytical method, and principal feeding- or fodder-related findings so that the recurring patterns can be read across them. Roughly nineteen of the fifty are Gujarat-specific field studies; a further set covers comparable smallholder systems in other states; and the remainder are national assessments, reviews, and on-farm supplementation trials that provide a benchmark against which the survey findings can be interpreted.

Table 1: Comparative matrix of the studies reviewed, covering Gujarat district field surveys, comparable multi-state surveys, national assessments and reviews, and on-farm supplementation trials. Sample sizes are reported where the source stated them; “field survey” denotes a study whose exact n was not consistently reported across accessed versions.

Sr. No	Study (author / source, year)	Location / scope	Sample	Method	Key feeding
1	Pata <i>et al.</i> (2018) ^[17]	Junagadh & Porbandar, Gujarat	320	Survey, %	Roughage fed whole; home-made concentrate common; mineral mixture in only ~24–26% of buffalo herds.
2	Jaffarabadi buffalo study, Junagadh (IJVSBT)	Junagadh, Gujarat	320	Survey, %	80% fed green/dry fodder as such; 92% had no scientific basis for concentrate; only 23–26% used mineral mixture/salt.
3	Patel & Sabapara (2023) ^[15]	Valsad, Gujarat	field survey	Garrett ranking	Poor-quality straw treatment (75%), no year-round green fodder (70%), lack of balanced-ration knowledge (61%) top feeding constraints.
4	Patel <i>et al.</i> (2019) ^[14]	Tribal south Gujarat	field survey	Survey, %	Feeding practices in tribal belt; stall feeding common; low chaffing and mineral supplementation.
5	Sabapara & Fulsoundar (2016) ^[22]	Surat, Gujarat	field survey	Survey/correlation	Existing feeding & breeding practices; extension contact and mass-media exposure moderate.
6	Sabapara (2016) ^[21]	Navsari (coastal), Gujarat	field survey	Survey, %	Seasonal fodder calendar: sugarcane tops (Nov–Mar), whole cane (Apr–Jul), green grass/sorghum/maize (Aug–Oct).
7	Jadav <i>et al.</i> (2014) ^[8]	Surat peri-urban, Gujarat	field survey	Survey, %	Peri-urban feeding practices; readymade concentrate widely adopted; green fodder cultivation common.
8	Navsari commercial farms study	Navsari, Gujarat	40	Survey, %	92.5% stall feeding; 80% chaffed green fodder; 82.5% used readymade concentrate; special post-calving feeding (75%).
9	Jamnagar lactating buffalo study (2023)	Jamnagar, Gujarat	~100	Survey, %	Only ~20% chaffed green and ~14% dry fodder; >85% gave no mineral mixture/salt; paddy straw dominant dry fodder.
10	Bharwad <i>et al.</i> (2016) ^[3]	Anand, Gujarat	field survey	Constraint analysis	Constraints to adoption of scientific dairy practices; feed cost and knowledge gaps prominent.
11	Mahera <i>et al.</i> (Middle Gujarat)	Middle Gujarat	320	Garrett	High feed cost ranked 1st in feeding management, ahead

	[11]			ranking	of balanced-ration knowledge and seasonal green fodder shortage.
12	Aravalli commercial farm study	Aravalli, Gujarat	40	RBQ/Garrett	High feed cost, weak balanced-ration knowledge, straw-treatment awareness gaps top feeding constraints.
13	Sabarkantha RBQ study	Sabarkantha, Gujarat	150	RBQ	High feed cost (30.7%), lack of balanced-ration knowledge (24.7%), poor straw-treatment awareness (16.7%).
14	Mehsana progressive-farmer study (2019)	Mehsana, Gujarat	150	Garrett ranking	Inadequate scientific-feeding knowledge (56%); low genetic potential (57%) top breeding constraint.
15	North Gujarat housing study	Banaskantha, Mehsana, Patan, Sabarkantha	field survey	Survey, χ^2	58% pucca housing; district differences significant ($\chi^2=19.55$, $p<0.01$); feeding practices vary by district.
16	Patan buffalo housing study (2019)	Patan, Gujarat	field survey	Survey, %	Housing and feeding practices of buffalo owners; informal storage of dry fodder common.
17	Gir cattle feeding study (Junagadh)	Junagadh, Gujarat	field survey	Survey, %	Over 93% of Gir-owning households grew own green fodder; hybrid Napier, maize, sorghum preferred.
18	Women dairy farmers, Gandhinagar	Gandhinagar, Gujarat	field survey	Profile/correlation	Personal, social, economic, psychological, communication profile of women dairy farmers characterised.
19	Multi-region Gujarat organised vs unorganised	Mehsana, Bharuch, Junagadh, Panchmahal	240	Garrett ranking	Feed/fodder shortage and high concentrate cost top constraints; cooperative (organised) villages fare better.
20	Socio-economic & constraints study (Guj. J. Ext. Edu.)	Gujarat	field survey	Correlation	Herd size, income, scientific orientation significantly linked to milk production and profitability.
21	Prajapati <i>et al.</i> (2021) [19]	Multi-state (incl. Gujarat)	review/survey	Overview	84% stall feeding; 59% fed thrice daily; factory feed replaced home mixes except in UP.
22	Multi-state field assessment (JSRR)	AP, Bihar, Gujarat, Jharkhand, Odisha, Punjab, Rajasthan, UP	multi-state	Survey, %	Mineral supplementation critically low except Punjab/Jharkhand; concentrate ₹14.4–18.8/kg; Gujarat higher regular concentrate use.
23	Kumar <i>et al.</i> (2021) [9]	Hisar, Haryana	field survey	Garrett/correlation	Avg. farmer ~43 yr, ~2.6 acres, 3–5 animals; land holding and occupation tracked milk output.
24	Singh <i>et al.</i> (2017) [30]	Uttar Pradesh	field survey	Correlation	Mass-media/ICT/extension exposure rose with education, land, experience; home mixing of concentrate persists.
25	Vindhyan region study, Mirzapur (2025)	Mirzapur, UP	field survey	Profile	Medium land holdings, medium-large herds; information uptake tied to education and experience.
26	Shyam Babu <i>et al.</i> (2023) [24]	Telangana	field survey	Profile	Standard socio-economic template: education, family, land, herd size, income, extension contact.
27	Maharashtra Garrett-ranking study	Vidarbha & Marathwada, Maharashtra	410	Garrett ranking	Shortage of quality feed/fodder round the year and high concentrate cost top serious constraints.
28	Milk producers' perceptions, Maharashtra	Maharashtra	field survey	Garrett ranking	High feed, fodder, labour, veterinary costs and milk-price/cooperative concerns near top.
29	Rangnekar (FAO, n.d.)	Gujarat, Rajasthan, MP	300+	Participatory	Silage adoption by small farmers virtually nil; promotion assumes a fodder surplus most smallholders lack.
30	Fodder value-chain study, sorghum (2025)	Southern India (Tamil Nadu)	field/value chain	Value-chain	Lean-season fodder scarcity pushes reliance on costly concentrate; multi-cut sorghum & silage proposed.
31	Enhancing Green Fodder Production (2024) [28]	National (India)	review	Review	Net deficit 35.6% green fodder, 11% dry residues, 44% concentrate; maize–cowpea 2:1 intercropping recommended.
32	Assessment of Livestock Feed & Fodder (DES, 2023)	All-India	national	National survey	Napier profitable but low yield (65 q/acre); hay from paddy straw stored up to 220 days; input/extension gaps.
33	TCI / Birthal & Jha (2005) [4]	India	review	Review	Feed scarcity is the single biggest dairy constraint, ~half of all production losses.
34	Down To Earth (2025) [6]	National (India)	report	Report	National deficits 11–32% green fodder, 23% dry, >40% concentrate; climate & land-use pressures worsening.
35	IASPOINT dairy fodder crisis (2025)	National (India)	report	Report	Erratic monsoons, rising temperatures damage berseem/maize; distress herd sales destabilise procurement.
36	Forage Production bottlenecks (AJDFR)	India	review	Review	Non-commercial nature of fodder crops depresses farmer interest; forage development lags food-crop research.
37	Fodder Market in Bihar	Bihar	field survey	Exploratory	Large demand–supply gap in green & dry fodder; fodder markets vital for landless/land-poor keepers.
38	Socio-economic profile, Vidarbha (MTC)	Vidarbha, Maharashtra	240	Correlation	Education, land holding, social participation, information source positively linked to knowledge; herd size weak.
39	Socio-economic status & constraints, MP	Shahdol, Madhya Pradesh	field survey	Correlation	Economic motivation, scientific orientation, knowledge highly correlated with adoption of improved practices.
40	Akola socio-economic status study	Akola, Maharashtra	field survey	Correlation	Land holding, income, herd size, scientific orientation highly significant with socio-economic status.
41	Kapurthala age/education study	Kapurthala, Punjab	80	Correlation	Age and education level shape knowledge, information

					source and adoption of recommended practices.
42	Tamil Nadu ASCI training impact	Tamil Nadu	150	SPSS/correlation	Education, herd size, contact frequency, information behaviour significantly linked to scientific dairy farming.
43	Uttar Pradesh knowledge determinants (Hardoi)	Hardoi, UP	field survey	Regression	Education, training participation, social participation, scientific orientation predict knowledge level.
44	AP digital vs traditional media study	Andhra Pradesh	field survey	Correlation	Medium scientific orientation & economic motivation; high knowledge of scientific practices in 46%.
45	Uttarakhand hill-region constraints	Uttarakhand hills	field survey	Constraint	Green fodder shortage the leading feeding constraint; low productivity leading breeding constraint.
46	Northern Bihar Garrett study	North Bihar	180	Garrett ranking	High feed cost, weak AI/vet access, poor scientific-practice knowledge among leading constraints.
47	Area-specific mineral mixture trial, Assam	Dima Hasao, Assam	20	RCT (on-farm)	50 g/day mineral mixture raised milk yield by 1.36 L/day (+18.7%) and improved reproduction and B:C ratio.
48	Mineral mixture trial, Rajasthan	Jaisalmer, Rajasthan	20	On-farm trial	Mineral mixture + salt raised milk production ~11.8% over farmer practice.
49	Mineral mixture trial, crossbred cows (IJVSBT)	India (crossbred)	trial	On-farm trial	120-day supplementation raised yield ~1.45 L/day (+13.5%), ~₹1,092/animal/month extra income.
50	KAP gaps in buffalo husbandry (2024)	India	field survey	Cluster/logistic	Education (OR=3.4) and herd size (OR=2.4) strongest KAP predictors; smallholders adopt ~25% vs 90% commercial.

4. Socio-Economic Characteristics of Dairy Farmers

Taken together, the district surveys describe a fairly recognisable person: middle-aged, literate, running a small mixed farm where dairying sits alongside crop cultivation rather than replacing it. Surveys from Surat and Valsad found most dairy-owning households were nuclear families, a good share drawn from Scheduled Tribe or Other Backward Class communities, with moderate extension contact and moderate exposure to radio, television, or newspapers (Sabapara and Fulsundar, 2016; Patel and Sabapara, 2023) ^[22, 15]. Land holdings tend toward marginal and small, herd sizes toward small and medium, which is more or less what one would expect given how the two are linked.

The pattern is not unique to Gujarat. In Hisar district of Haryana, the average farmer was about 43 years old, mostly literate, farming around 2.6 acres and keeping three to five animals; land holding and occupation tracked milk output there, though age and education did not (Kumar *et al.*, 2021) ^[9]. In the Vindhyan belt of Uttar Pradesh, medium land holdings and medium-to-large herds were typical, and information uptake through mass media, ICT, or extension contact rose with education, land, and experience (Singh *et al.*, 2017; Mirzapur study, 2025) ^[25, 1]. A Telangana study used almost the identical variable set education, family structure, land, farming system, herd size, income, social participation, extension contact which by now looks less like one researcher's questionnaire than the standard template for this kind of survey across India (Shyam Babu *et al.*, 2023) ^[24].

Where studies ran correlation or regression, the same handful of variables kept surfacing as significant. Education, land holding, social participation and information source were positively correlated with knowledge of improved practices in Vidarbha, while herd size was only weakly related there; economic motivation, scientific orientation and knowledge were highly correlated with adoption in Madhya Pradesh and Maharashtra; and in a national KAP analysis of buffalo husbandry, education (OR = 3.4) and herd size (OR = 2.4) emerged as the strongest predictors, with income pivotal for practice adoption. Training is the weak point almost everywhere: several studies put formal training in animal husbandry or feeding at under a third of

respondents, and this holds whether the district is a well-studied one like Valsad or Junagadh or one barely surveyed at all.

5. Cattle Feeding Practices

5.1 Roughage Feeding: Green and Dry Fodder

Chopping fodder before feeding it is the exception rather than the rule across much of Gujarat. Roughly four in five Jaffarabadi buffalo owners surveyed in Junagadh fed roughage whole, and a similarly high share used home-mixed rather than properly formulated concentrate (Junagadh study, IJVSBT). Jamnagar was worse on this measure: only about a fifth of farmers chaffed green fodder and about a seventh chaffed dry fodder (Jamnagar study, 2023), despite chaffing being a well-established, low-cost way to cut wastage and improve intake. Navsari's commercial peri-urban farms were the clear exception, with about 80 per cent practising chaffing a reminder that where dairying is more commercialised, the practice does take hold.

What farmers actually feed shifts with the season and the crop calendar. Around coastal Navsari, sugarcane tops carried the dry-fodder ration from November through March, whole sugarcane took over almost completely from April to July, and green grass, sorghum and maize filled in from August to October (Sabapara, 2016) ^[21]. In Gujarat's central and northern irrigated belts, wheat and paddy straw plus jowar stover form the backbone, topped up seasonally with green maize, sorghum and hybrid Napier wherever irrigation allows, while cotton stalk and groundnut haulm feature more in Saurashtra's cotton and groundnut country. This is very much a district-by-district story shaped by what happens to be growing locally, not one uniform Gujarat diet.

5.2 Concentrate Feeding

Almost every study describes concentrate feeding as need-based tied to what the animal is currently yielding and what milk is fetching rather than worked out against any calculated ration. In Junagadh, roughly 92 per cent of buffalo owners followed no scientific criterion for how much concentrate they fed. Concentrate typically goes in at milking time, and factory-compounded feed has mostly replaced home-made mixes everywhere except Uttar

Pradesh, where home mixing persists (Prajapati *et al.*, 2021; Singh *et al.*, 2017) ^[19, 25]. A recent multi-state assessment found regular concentrate feeding somewhat more common in Gujarat, Maharashtra and Punjab than further east, with cost running roughly ₹14.4 to ₹18.8 per kilogram depending on state and season (multi-state assessment, JSRR).

Concentrate is also the one feed variable that tracks milk yield most reliably across this literature, which makes sense: it is the component farmers can adjust most easily when they want more milk, and the fastest lever for pushing up the fat and SNF that cooperative pricing rewards. It is worth being careful, though this is an association across cross-sectional surveys, not proof of a causal yield response in any one place, since breed, feed quality and general management all move together with concentrate use in ways a simple cross-tab cannot untangle.

5.3 Mineral Mixture and Salt Supplementation

Of everything covered in this literature, mineral mixture and salt supplementation come off worst. Only about a quarter of buffalo owners in Junagadh gave mineral mixture or salt at all; in Jamnagar, over 85 per cent gave neither. A multi-state assessment described mineral supplementation as critically low almost everywhere it looked, Punjab and Jharkhand being the partial exceptions. The reasons are consistent: farmers rarely recognise sub-clinical mineral deficiency, mineral mixture is an extra purchase on top of compound feed, and veterinary contact that might reinforce the habit is thin on the ground. Yet the return is well documented controlled on-farm trials in Assam, Rajasthan and elsewhere show that supplementing 50–55 g of mineral mixture per day raises milk yield by roughly 12 to 19 per cent and improves reproductive performance and benefit-cost ratio (area-specific mineral-mixture trial; Niwas *et al.*, 2021; IJVSBT crossbred trial) ^[13]. Where GCMF unions supply fortified compound feed, animals may get some mineral intake without the farmer ever buying mineral mixture separately, but standalone supplementation stays a minority practice everywhere reviewed here.

5.4 Silage and Hay Making

Silage is the clearest case of a technology pushed hard for decades with little to show for it among small farmers. Rangnekar (FAO), working with more than 300 farmer families across Gujarat, Rajasthan and Madhya Pradesh, found adoption of ensiling by small farmers to be virtually nil outside institutional and larger commercial operations. His explanation is blunt: silage promotion assumes a seasonal fodder surplus most small farmers simply do not have, and even those who might have some rarely have the storage or working capital to build a pit or bunker; the fact that chopping is uncommon in western India adds further time and hassle. Later Maharashtra work echoes this, with lack of awareness of silage and urea-treated straw recurring among the ranked constraints. Value-chain studies from southern India now propose multi-cut fodder sorghum and low-cost silage as a route out of the lean-season crunch (sorghum value-chain study, 2025). Hay making follows a similar, slightly less extreme pattern, mostly limited to farmers who catch a monsoon surplus and have somewhere covered to keep it dry.

5.5 Balanced Ration Awareness

Farmers generally know they should be feeding something roughly right, but formal knowledge of balanced-ration formulation is thinner. In Valsad, lack of balanced-ration knowledge came up as a major constraint for between 61 and 75 per cent of respondents across related studies, and it turns up near the top of Garrett and RBQ rankings from Middle Gujarat, Sabarkantha, Mehsana and Maharashtra alike. Education and training are the two things most consistently linked to better awareness which fits the wider pattern that formal training reaches only about a fifth to a third of Indian dairy farmers.

6. Fodder Resource Management

Fodder management here covers how much land goes toward growing fodder, what farmers choose to grow, when it is available, whether there is water for irrigation, and how it is stored. Over 93 per cent of Gir-cattle-owning households surveyed in Junagadh grew their own green fodder rather than relying on the market or crop residue alone, which suggests that wherever irrigation is available, Gujarat's dairy farmers do commit land to fodder rather than buying their way out of the problem. Hybrid Napier, along with maize and sorghum, comes up repeatedly as the preferred green-fodder crop in irrigated areas, largely because it can be cut several times and needs comparatively less water than some alternatives.

Summer is the recurring problem. Green-fodder shortage between April and June is about as consistently reported as anything in this literature, showing up as a top or near-top constraint in Garrett-ranking studies from Valsad, Middle Gujarat and Aravalli alike, usually made worse by water scarcity that hits both fodder irrigation and, in some places, drinking water for the animals. The national picture frames the local one: an all-India assessment and several reviews estimate a net deficit on the order of 11 to 35 per cent for green fodder and 11 to 25 per cent for dry fodder, driven by shrinking grazing land, crop residue diverted to industry, and erratic monsoons (Department of Agriculture and Farmers Welfare, 2023; Down To Earth, 2025) ^[5, 6]. Gujarat cooperative guidance typically recommends about 25–30 kg green fodder, 5–7 kg dry fodder and 4–6 kg balanced compound feed per animal per day; few of the academic surveys report actual quantities precisely enough to check practice against that benchmark, which is itself a gap worth noting.

Storage gets less attention than feeding, but what evidence exists points to informal storage dry fodder stacked in the open, exposed to monsoon damp being the norm among small and marginal farmers, with covered storage more common on medium and large holdings. This tracks the same size-related pattern seen in silage adoption, and for much the same reason: proper storage is close to a precondition for both hay making and silage, and it costs money smaller operations are less likely to have spare.

7. Major Constraints Faced by Dairy Farmers

A good number of these studies use Henry Garrett's ranking method, or the closely related relative belief quotient (RBQ), to turn farmers' own ranked problem lists into a single comparable score, and the results line up remarkably

well across different parts of Gujarat and beyond. A Middle Gujarat study of 320 dairy farmers found feed cost the single biggest problem within feeding management, ahead of poor balanced-ration knowledge and seasonal green-fodder shortage. A Vidarbha–Marathwada study of 410 milk producers placed round-the-year shortage of quality feed and fodder and high concentrate cost at the top; a north Bihar Garrett study of 180 farmers, a Sabarkantha RBQ study of 150, and a Mehsana study of 150 all reproduced the

same feed-cost-first ordering.

Table 2 pulls together the constraint themes that recur across these Garrett and RBQ studies, with where each was reported. How consistently this ordering shows up across coastal Saurashtra, tribal south Gujarat, irrigated central Gujarat, and several other states suggests high feed cost and seasonal fodder shortage are close to structural features of India's smallholder dairy sector, not something specific to any one corner of Gujarat.

Table 2: Recurring feeding- and fodder-related constraint themes across the Garrett/RBQ-ranking studies reviewed. Rank position is approximate and drawn qualitatively from the cited studies rather than recalculated from pooled scores, since Garrett scores from studies with different problem lists are not directly comparable.

Rank tendency	Constraint theme	Districts / states reporting theme among top-ranked constraints
1 st –2 nd	High cost of feed and concentrate	Valsad, Middle Gujarat, Aravalli, Sabarkantha, Mehsana (Gujarat); Maharashtra; Haryana; north Bihar; MP
2 nd –3 rd	Seasonal / year-round green fodder scarcity	Valsad, Aravalli (Gujarat); Maharashtra; Uttarakhand; national deficit estimates (11–35% green)
3 rd –4 th	Limited knowledge of balanced ration formulation	Middle Gujarat; Valsad; Sabarkantha; Maharashtra (RBQ); Mehsana
4 th –5 th	Lack of awareness of straw treatment / silage preparation	Middle Gujarat; Maharashtra; Gujarat–Rajasthan–MP silage-adoption study (FAO)
Lower-mid	Non-remunerative milk price / weak cooperative payment	Valsad (Gujarat); Maharashtra; multi-region Gujarat; north Bihar
Lower-mid	High veterinary / healthcare cost & limited service access	Valsad (Gujarat); MP; Uttarakhand; multi-state review

8. Association Between Feeding Practices and Milk Production

Formal regression of milk yield against feeding variables is rare in the Indian smallholder literature, but the cross-tabs and correlations that exist point the same direction fairly often, and the international feeding-management literature supplies the mechanism. Concentrate level and consistency track yield positively in nearly every study that looks unsurprising given that concentrate is the most energy-dense, easiest-to-adjust part of the ration. Buffalo-heavy herds generally get more concentrate than cattle-heavy ones, which fits buffalo milk's higher fat content and the stronger price incentive that comes with it. Herd-level work from freestall systems abroad shows that even feeding frequency matters: feeding twice rather than once daily was associated with about 2.0 kg more milk per cow per day (freestall feeding-management study), a reminder that management detail, not just ration composition, moves yield.

Breed matters on its own, independent of feeding: crossbred cows consistently out-yield indigenous breeds under similar feeding regimes, with national test-day averages around 8.09 kg/day for crossbreds and a wide spread (4.6–9.6 kg/day) across low, medium and high production environments (Al Kalaldehy *et al.*, 2021) ^[1]. Land holding, and to a lesser degree herd size, tends to track both milk output and adoption of better feeding practice, plausibly because bigger holdings mean more land for fodder and more cash to keep concentrate and mineral supplementation going through lean months. Training is perhaps the most policy-relevant thread: trained farmers show up across several studies with noticeably better balanced-ration awareness and mineral-mixture use than untrained ones, even once land and herd size are accounted for. Controlled trials close the loop by showing a direct causal yield response to mineral supplementation (+12 to +19%), which the observational surveys can only hint at.

For anyone planning a district-level study anywhere in Gujarat, concentrate feeding level, breed, herd size, land holding and training exposure look like the variables most

worth testing formally against milk yield, given how much prior evidence already sits behind each of them.

9. Discussion

9.1 Nutritional and Economic Dimensions

Feed cost topping the constraint list in study after study, across very different districts and states, says something important: feeding management in Indian smallholder dairying is fundamentally a household-economics problem, not just a knowledge gap. Concentrate prices follow national commodity markets for oilcake, bran and grain by-products, which no individual farmer or even a district cooperative really controls, while farm-grown green fodder is cheaper but limited by land, water and season. That probably explains why concentrate feeding stays need-based rather than properly rationed: farmers treat it as a top-up justified by whatever milk is fetching that week, rather than a year-round commitment they can plan and pay for in advance.

9.2 Fodder Availability and Climate Sensitivity

The seasonal green-fodder crunch, and the water scarcity that goes with it, is not just a Gujarat problem; it fits a wider, climate-linked pattern seen nationally, with erratic monsoons and rising temperatures hurting seasonal fodder crops such as berseem and maize, on top of longer-running pressures like shrinking grazing land and crop residue diverted to industry (Down To Earth, 2025) ^[6]. Within Gujarat this plays out unevenly. The canal- and groundwater-irrigated tracts of central and northern Gujarat, including the Kheda–Anand belt, are better placed to ride out a poor monsoon than the drier stretches of Kutch, north Gujarat and Saurashtra, where summer fodder scarcity and competition for drinking water are likely considerably worse. That unevenness is a good reason not to assume one district's findings apply everywhere.

9.3 Extension, Training, and Technology Adoption

Low training participation generally under a third of farmers across the studies reviewed sits alongside moderate

extension contact that in Gujarat runs mostly through cooperative societies rather than government veterinary staff. This matters for the silage and mineral-mixture story: both need more than a one-off awareness campaign. Silage pits need construction guidance, mineral mixture needs dosage guidance, and that kind of sustained follow-up is exactly what occasional radio or newspaper exposure cannot provide. The national KAP analysis makes the case for segmented rather than blanket extension: smallholders adopting only about a quarter of recommended techniques need different support from commercial farmers already at 90 per cent. Digital and ICT-based advisory is gaining ground, particularly among younger, better-educated farmers, and there is an obvious opening for mobile-based advisory riding on the cooperative network Gujarat already has in place.

9.4 Government Support and Cooperative Structures

Gujarat's cooperative structure GCMF and its district unions already functions as a de facto feed-supply chain, delivering compound cattle feed, and in some unions fortified feed, at real scale. That is a genuine advantage over states with weaker cooperative reach, and it likely explains why regular concentrate feeding shows up higher in Gujarat than in several other states in multi-state assessments. But mineral mixture and silage adoption staying low even inside this relatively well-supported system tells us something too: simply making inputs available has not been enough on its own to shift these two practices, and targeted extension aimed specifically at them would probably do more good than general feed-supply expansion at this point.

10. Gaps in the Existing Gujarat Literature

Four things stand out from reading the fifty studies together. First, coverage across Gujarat's districts is lopsided. Valsad, Navsari, Surat, Junagadh, Porbandar, Jamnagar, Sabarkantha, Mehsana, Patan and Anand recur in the literature, while this review turned up no dedicated, published field study of feeding or fodder management specifically for Kheda district, nor for Kutch, or Mahisagar, among others. Given how central Kheda is to Gujarat's cooperative dairy story, that gap looks like a genuine opening rather than ground already well covered.

Second, most of these studies stop at frequencies, percentages and Garrett or RBQ rankings. Few push into regression or ANOVA to test the relationship between feeding practice, socio-economic variables and milk yield while controlling for confounders. A Gujarat study pairing the usual descriptive tables with a properly specified regression of milk yield against concentrate level, breed, herd size, land holding and training would add something the existing literature does not really have.

Third, storage practice and the actual farm-level economics behind why individual farmers skip silage, as opposed to the aggregate policy-level explanation Rangnekar offers remains thin across every Gujarat district reviewed. More granular work, including farmers' own cost-benefit reasoning, would be useful. Fourth, nobody has run a single study comparing feeding practice or constraint rankings across Gujarat's different agro-climatic zones using one consistent design; what we have instead is inference across separately conducted district studies. A stratified, multi-

district survey built explicitly around Gujarat's agro-climatic zones would put that inference on much firmer ground.

11. Conclusion

Put together, the fifty studies describe a fairly consistent feeding-management profile across Gujarat and comparable states: roughage fed whole rather than chopped, concentrate allocated by milk price rather than calculated ration, mineral mixture and salt reaching only a minority of animals, and silage staying largely a large-farmer practice. Fodder management is shaped above all by a recurring summer shortage of green fodder, made worse by water scarcity, against the backdrop of a national fodder deficit now drawing real policy attention. Feed cost, seasonal shortage and weak balanced-ration knowledge are the constraints that keep coming out on top in Garrett and RBQ studies from Gujarat and elsewhere, while land holding, herd size, education and training are the factors most reliably linked to better practice and higher yield and on-farm trials confirm that even a simple intervention like mineral supplementation delivers a measurable yield gain.

Across Gujarat as a whole, the cooperative system probably does give farmers better concentrate access than they would have in a state with weaker cooperative reach, but it has not, on the evidence reviewed here, closed the mineral-mixture and silage gap even in well-studied, well-supported districts like Valsad, Navsari and Junagadh. These patterns hold up reasonably consistently across the districts with published evidence, though real agro-climatic differences mean nothing here should be assumed to travel automatically to every district. These are literature-derived expectations meant to guide future research design and near-term extension planning, not a substitute for actual field research in Gujarat's less-studied districts, which remains the necessary next step.

12. Recommendations

Based on the comparative patterns above, the following are worth consideration by GCMF and its district milk unions, the Gujarat Department of Animal Husbandry and Dairying, ICAR and state veterinary institutions, and extension agencies working across Gujarat's dairy districts:

1. Balanced-ration training delivered through the village cooperative network that already reaches most dairy households, to close the persistent gap in balanced-ration awareness seen across districts.
2. Silage and hay promotion pitched at smallholder realities low-cost bag or pit silage and shared community facilities rather than individual investment given the mismatch FAO's own review identified between silage promotion and small-farmer fodder surplus.
3. Hybrid and climate-resilient fodder cultivation: continued distribution of hybrid Napier, maize and sorghum planting material, plus drought-tolerant multi-cut varieties, to ease the April–June green-fodder shortfall.
4. Mineral-mixture supplementation drives: subsidised or cooperative-distributed mineral mixture paired with basic farmer education on deficiency symptoms, given trial evidence of a 12–19% yield gain from supplementation.
5. Wider training reach through short, practical modules at

the village cooperative level, since training exposure keeps showing up alongside better feeding practice yet reaches well under half of farmers.

6. Feed-cost mitigation via bulk concentrate procurement, feed-subsidy schemes, or cooperative-financed feed credit, aimed at the single constraint that ranks highest almost everywhere.
7. Digital advisory: mobile or SMS-based feeding and fodder advisory built on the cooperative's existing farmer contact, particularly given younger farmers' openness to ICT.
8. Segmented rather than blanket extension, targeting smallholders and commercial farmers differently, as the national KAP evidence recommends.
9. Primary field research in under-studied districts Kheda, Kutch, Banaskantha and others combining descriptive analysis with proper regression testing of feeding practice, socio-economics and milk yield.
10. An agro-climatic zone-stratified state survey run with one consistent questionnaire, to test directly the cross-zone contrasts this review can only infer.

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