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Original Article**Whole-Farm Feed Efficiency in Dairy Farming: A New Approach****Digvijay Singh¹, Sandeep Bana², Uma-kant Verma¹, Narendra Kumar¹, Upendra Singh¹ and Deepesh Bharat Mishra¹**¹*College of Veterinary and Animal Sciences, Banda University of Agriculture and Technology, Banda -121001*²*Technical Manager, Kemin, India, Pvt. Ltd.***Corresponding Author: singhdigvijay2712@gmail.com**Received: 15/10/2026**Accepted on: 20/10/2026***ABSTRACT**

Whole-farm feed efficiency (WFFE) evaluates how effectively the entire dairy enterprise converts feed produced or purchased into saleable milk. Unlike cow-level feed efficiency, it includes lactating cows, dry cows, replacement stock, forage use and feed losses, while recognizing the effects of fertility, health, longevity, replacement rate and stocking rate. A published study of 21 British dairy farms representing five production systems reported mean WFFE values of 0.99–1.13 kg energy-corrected milk (ECM) per kg feed dry matter (DM) across the systems. WFFE was positively associated with stocking rate, milk yield per hectare and milk from forage. These findings support a practical message: profitable efficiency is created by better utilisation of forage and land, healthy productive cows, controlled replacement rearing and reduced avoidable feed loss—not simply by feeding more concentrate. For Indian farms, WFFE should be used as a management and benchmarking framework rather than as a universal numerical target. Feed should be measured on a DM basis, milk should preferably be expressed as ECM for comparison, and WFFE should be interpreted alongside feed cost/kg milk, milk/ha, replacement rate, age at first calving, fertility, health and body-condition trends.

Keywords: Feed utilization, Forage productivity, Milk output, Profitability, Replacement efficiency, Sustainability

INTRODUCTION

Feed is a major variable cost of dairying and feed use is closely linked with nutrient losses and enteric methane (NRC, 2021). Conventional feed-efficiency measures usually focus on the milking cow, such as kg milk or kg milk solids per kg DMI (ICAR, 2013). This is useful for ration evaluation but may hide enterprise-level losses. A herd may show good cow-level efficiency while losing substantial feed through poor forage utilisation, excessive replacement numbers, delayed first calving, long dry periods, disease or feed wastage. WFFE addresses this limitation by relating total milk output to total feed produced or purchased for all animals (Garnsworthy et. al., 2019). It connects biological efficiency with economic performance and resource use.

Definition and calculation

$$\text{WFFE} = \text{Total energy-corrected milk (kg ECM)} \div \text{Total feed used (kg DM)}$$

The denominator should represent the whole-enterprise feed use over the same accounting period. It can include purchased concentrates, purchased forage, home-grown conserved forage and estimated grazed forage on a DM basis, with feed use by lactating cows, dry cows and replacement stock. The accounting boundary should be kept consistent when comparing farms or years.

Component	What to record	Practical point
Milk output	Milk volume, fat and protein	Use ECM when comparing different milk compositions.
Lactating cows	Feed DM, DMI and refusals	Group cows by production where practical.
Dry cows	Feed DM and dry-period days	Support transition health without unnecessary overfeeding.
Replacement stock	Feed DM, numbers, growth and first-calving age	Make the non-producing feed burden visible.
Forage	Area, yield, DM%, quality and utilisation	Measure home-grown feed as carefully as purchased feed.
Wastage	Storage, mixing, feeding and refusal losses	Avoid increasing the denominator without increasing milk output.

Evidence from the 21-farm study

Garnsworthy et. al., (2019) studied 21 British farms representing five dairy production systems. Farms were visited quarterly over approximately one year and records included animal numbers, milk production and composition, feed purchases, stocking rate, grass and forage use and youngstock rearing. ECM was calculated and feed use was estimated on a DM basis. There was wide variation in WFFE both between and within systems. Overall, WFFE was positively associated with stocking rate ($r=0.585$; $P=0.014$), milk yield per hectare ($r=0.759$; $P<0.001$) and milk from forage ($r=0.530$; $P=0.029$). WFFE was also positively associated with gross margin per forage hectare ($r=0.557$; $P=0.025$).

System	Grazing days	Herd size	Milk (kg ECM/cow)	Concentrate (t DM/cow)	Stocking rate (LSU/ha)	WFFE
1	>274	257	6,306	0.91	2.45	0.99
2	183–274	260	7,721	2.29	2.50	1.04
3	91–182	161	9,322	3.06	1.95	1.07
4	0–90	274	9,406	3.65	2.57	1.08
5	0	362	8,945	3.59	2.19	1.13
All farms (mean)	142	276	8,190	2.85	2.37	1.07

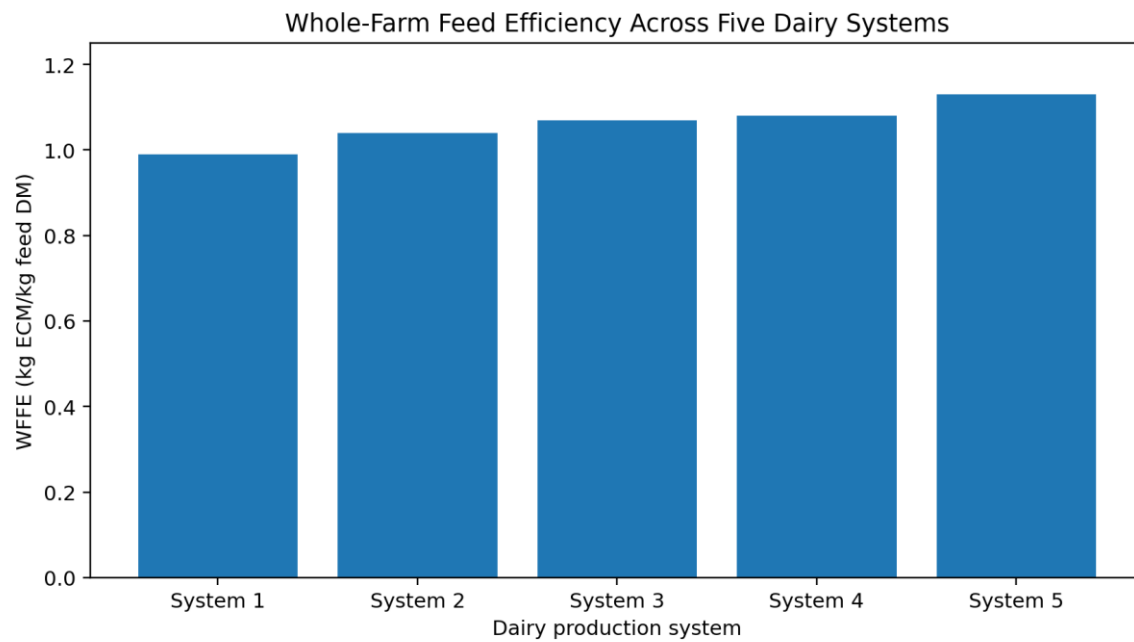


Figure 1. WFFE across the five British dairy production systems reported in the 21-farm study.

Main Drivers of WFFE

Driver	Why it affects WFFE
Forage quality	High-quality forage supports more milk from home-grown feed and can reduce purchased-feed dependence.
Milk yield/ha	Links milk output to the land resource supporting the herd.
Stocking rate	Appropriate stocking makes better use of forage; excessive stocking can create feed deficits.
Replacement rate	Replacements consume feed before producing milk and increase the youngstock burden.
Age at first calving	Delayed calving lengthens the non-productive rearing period.
Fertility	Long calving intervals and reproductive failure increase non-productive days and culling.
Health and longevity	Disease and premature culling increase replacement demand and reduce lifetime productivity.
Dry-cow management	Feed should support transition health without unnecessary nutrient expenditure.
Feed wastage	Spoilage, sorting, spillage and excess refusals increase feed input without increasing output.
Ration balance	Energy, protein, fibre, minerals and vitamins must match animal requirements and available feeds.

Milk Yield per Hectare: A Key Indicator

Milk yield per hectare is an important whole-farm measure because it connects animal output with the land resource. In the 21-farm study, WFFE showed a strong positive relationship with milk yield per hectare. The objective is not simply to maximise stocking rate or milk yield, but to obtain more saleable milk from available forage and land without creating feed deficits, excessive purchased-feed dependence or health problems.

- Calculate annual milk or ECM per forage hectare.
- Measure how much output is supported by home-grown forage.
- Track the quantity and cost of purchased feed needed to achieve the output.
- Match stocking rate to realistic forage production.
- Track the cost and usable yield of conserved forage.

Forage Quality and Utilisation

Forage is the foundation of WFFE in grazing and conserved-forage systems. The goal is not simply to grow more forage, but to harvest, conserve and feed a greater proportion of high-quality forage with minimum losses.

- Harvest at an appropriate maturity stage to maintain digestibility and nutrient density.
- Measure forage DM regularly and formulate rations on a DM basis.
- Reduce field, harvesting, storage and feeding losses.
- Manage silage rapidly and hygienically, with good compaction and sealing.
- Chaff forage appropriately to reduce selection and wastage.
- Use forage analysis for DM, crude protein, fibre, ash and energy where available.
- Match forage quality to the nutrient requirements of different animal groups.
- Manage grazing to avoid both excessive maturity and severe under-supply.

NDDB (2026) recommends balanced feeding with locally available resources and practical measures such as chaffing, appropriate mineral supplementation, gradual feed changes and suitable use of mixed rations. Such measures can improve utilisation of available feed resources and control feeding cost.

Replacement Heifers: The Hidden Feed Burden

Replacement heifers are necessary for herd continuity but consume feed before generating milk revenue. Their contribution to WFFE becomes particularly important when replacement numbers are high, growth is inefficient or age at first calving is delayed.

Heifer KPI	Management direction	WFFE implication
Replacement rate	Reduce avoidable involuntary replacement	Less feed required for non-producing stock.
Age at first calving	Breed at appropriate body weight and farm-appropriate age	Shorter non-productive rearing period.
Growth rate	Steady, healthy growth without excessive fattening	Efficient use of rearing feed and better lifetime performance.
Morbidity/mortality	Strong colostrum, hygiene, vaccination and preventive care	Less feed and capital lost through disease.
Heifer feed cost	Track DM and cost from birth to calving	Shows the true cost of generating replacements.

The goal is not to minimise heifer feed by underfeeding. Underfeeding can delay breeding and compromise immunity and future performance. The goal is efficient growth to appropriate breeding and calving targets.

Fertility, Health and Longevity

Fertility and health affect WFFE through milk yield, days in milk, culling, replacement demand and feed consumed by non-producing animals. A healthy cow that remains productive for more lactations spreads the investment in her rearing and maintenance over greater lifetime milk output.

- Monitor conception rate, services per conception, calving interval and days open.
- Record reasons for culling and distinguish planned from involuntary culling.
- Track mastitis, lameness, metabolic and reproductive disorders.
- Strengthen transition-cow management to reduce metabolic and postpartum disease.
- Avoid excessive body-condition loss in early lactation and excessive condition at calving.
- Investigate whether disease or fertility problems are increasing replacement demand.

Feed Wastage: The Simplest Denominator to Reduce

WFFE can improve when avoidable feed losses are reduced without reducing nutrient intake. Important losses occur during storage, silage management, mixing, feeding, sorting and refusals.

Loss point	What to check	Corrective action
Storage	Wet feed, mould, damaged bags or silage	Improve roofing, pallets, sealing and stock rotation.
Silage face	Heating, mould, slow removal	Improve sealing and daily face management.

Mixing	Ingredient separation or inconsistent particle size	Review loading order and mixing time.
Feed-out	Spillage and uneven distribution	Calibrate equipment and improve feeding route.
Sorting	Long particles left behind	Review chop length, moisture and ration structure.
Refusals	Excessive leftovers	Adjust quantity and monitor actual DMI.
Purchased feed	Contamination or unusable batches	Use specifications and receiving quality checks.

Cow-Level Feed Efficiency: Interpret with Care

High milk output per unit of DMI can be desirable, but it must be interpreted with body reserves, health and reproduction. A cow can appear highly efficient during early lactation because she is mobilising excessive body tissue. Therefore, feed efficiency should be interpreted with body-condition score, milk composition, health records and reproductive performance.

Likewise, more concentrate can increase milk output and calculated cow-level efficiency while increasing purchased-feed dependence and feed cost. Decisions should consider marginal milk response, feed price, milk value, forage availability, health and the whole-enterprise objective.

APPLICATION TO INDIAN DAIRY FARMS

Indian dairy farms vary greatly in herd size, breed, climate, forage availability and market conditions. WFFE should therefore be introduced as a farm-accounting framework rather than a single fixed target. NDDDB's Ration Balancing Programme uses animal-specific information including animal type, age, milk production, milk fat and feeding regime to balance locally available feed resources (Garg et al., 2016). NDDDB (2026) reports improvements in milk production and feeding economics from the programme and has also reported reductions in enteric methane intensity. WFFE can extend this approach by adding whole-herd and whole-farm measurements.

Farm type	WFFE priority	Practical focus
Smallholder, 2–10 animals	Feed cost and wastage	Accurate weighing, ration balancing, mineral mixture and fodder planning.
10–50 animal dairy	Forage and cow grouping	DM-based rationing, forage analysis, refusals and fertility monitoring.
50–200 animal commercial dairy	Whole-herd accounting	WFFE, milk/ha, replacement cost, inventory and health KPIs.
Large commercial dairy	Integrated benchmarking	Milk/feed records, TMR quality, youngstock efficiency and economic/environmental KPIs.

Farmer WFFE Dashboard

Indicator	Calculation	Why it matters	Management response
WFFE	$\text{Annual ECM} \div \text{total feed DM}$	Whole-enterprise feed conversion	Audit youngstock, forage, wastage and fertility.
Cow feed efficiency	$\text{ECM} \div \text{lactating-cow DMI}$	Ration/cow utilisation	Check forage, ration balance and BCS.
Milk/ha	$\text{Annual milk} \div \text{forage area}$	Land/feed productivity	Improve forage yield and utilisation.
Feed cost/kg milk	$\text{Total feed cost} \div \text{milk sold}$	Economic control	Review formulation, ingredient price and wastage.
Income over feed cost	$\text{Milk income} - \text{feed cost}$	Economic response	Compare milk value with marginal feed cost.
Replacement rate	$\text{Replacements} \div \text{herd size}$	Youngstock feed burden	Improve fertility, health and longevity.
Age at first calving	Average age at first calving	Non-productive rearing period	Improve growth and breeding management.
Feed wastage	$\text{Lost/refused feed} \div \text{feed offered}$	Denominator control	Improve storage, mixing and feed-out.
Forage utilisation	$\text{Usable forage DM} \div \text{forage produced}$	Value of home-grown feed	Improve harvest, conservation and grazing.

Practical 90-Day WFFE Improvement Programme

Period	Actions	Output
Days 1–30: Measure	Milk yield/composition; feed purchases; forage DM; animal numbers; refusals; replacements; culling reasons; feed costs.	Baseline WFFE and supporting KPIs.
Days 31–60: Correct	Improve forage quality; rebalance rations; control feed-out losses; review heifer growth; identify fertility/health bottlenecks.	Prioritised intervention list.

Days 61–90: Verify	Recalculate WFFE and cow-level efficiency; compare milk/ha and feed cost/kg milk; review BCS, fertility and replacements.	Documented change and next-quarter targets.
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Feed Industry and Dairy-Processor Implications

Feed manufacturers and dairy organisations can use WFFE to shift the focus from selling more feed to delivering measurable feed value. A ration that increases milk yield but substantially increases feed cost or purchased-feed dependence is not automatically the most efficient whole-farm solution.

- Provide reliable nutrient specifications and quality-control data.
- Evaluate forage first and formulate concentrates around the nutrient deficit.
- Support routine milk, feed and reproductive data recording.
- Train farmers to use DM-based quantities rather than fresh-weight assumptions.
- Integrate feed inventory, milk recording, health and youngstock data on larger farms.
- Use WFFE alongside milk/ha, feed cost, methane intensity and nutrient-use indicators in sustainability programmes.

Common Mistakes

- Comparing farms with different accounting boundaries.
- Using fresh feed weight instead of DM.
- Using litres of milk without considering fat and protein.
- Ignoring dry cows and replacement animals.
- Ignoring storage and feeding losses.
- Trying to improve WFFE simply by increasing concentrate feeding.
- Applying a benchmark from a different climate or production system as a universal target.
- Interpreting high cow-level efficiency without checking body-condition loss, fertility and health.

Key Messages for Farmers

- Measure the whole farm, not only the milking cow.
- Calculate feed on a dry-matter basis.
- Use ECM when comparing milk output across different milk compositions.
- Make high-quality forage the foundation of the feeding programme.
- Reduce avoidable feed wastage before buying more feed.
- Control replacement rate and rear heifers efficiently to an appropriate first-calving target.

- Protect fertility, health and longevity because they influence feed required per kg of lifetime milk.
- Use WFFE with feed cost/kg milk, milk/ha, income over feed cost and animal-health KPIs.
- Benchmark against comparable farms and production systems.
- Repeat the calculation regularly to verify whether management changes are working.

Suggested Farm Data Sheet for Monthly Recording

Item	Month 1	Month 2	Month 3	Annual/rolling value
Milk sold (kg)				
Milk fat (%)				
Milk protein (%)				
Total feed DM used (kg)				
Purchased concentrate (kg DM)				
Home-grown forage DM (kg)				
Grazed forage DM (kg, estimated)				
Feed refusals/wastage (kg DM)				
Average lactating cows				
Average dry cows				
Average replacements				
Replacement rate (%)				
Age at first calving (months)				
Feed cost (₹)				
Feed cost per kg milk (₹)				
WFFE (kg ECM/kg DM)				

CONCLUSION

Whole-farm feed efficiency provides a practical framework for understanding how efficiently a dairy enterprise converts its complete feed resource into milk. The British evidence demonstrates substantial variation among farms and positive associations with stocking rate, milk yield per hectare and milk from forage. At farm level, however, the objective should not be to chase a single numerical WFFE target; it should be to identify where feed is being consumed without adequate productive or economic return. For Indian dairy farms, the strongest strategy is to combine balanced ration formulation with better forage production and utilisation, accurate feed measurement, lower

wastage, efficient replacement rearing, good fertility, preventive health management and longer productive herd life. When these components are monitored together, WFFE becomes a management tool for improving profitability, resource efficiency and sustainability.

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