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QUANTIFICATION OF FRESH CATTLE DUNG AND FERTILIZER NUTRIENT EQUIVALENCE UNDER CHANGING CATTLE POPULATION: A TEMPORAL STUDY IN THANJAVUR DISTRICT, TAMIL NADU

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ABSTRACT

In India's agricultural economy, cattle dung is a vital yet underexploited renewable resource, playing a key role in nutrient recycling, renewable energy generation, reducing greenhouse gases, and boosting soil fertility. This research utilizes livestock census data from 2007, 2012, and 2019, which recorded cattle populations of 446,750, 387,008, and 350,527, in Thanjavur District respectively. Fresh dung output was calculated for different herd categories: adults, making up 60% of the population with an average daily dung production of 22.5 kg; heifers, comprising 25% with 12.5 kg per day; and calves, accounting for 15% with 6 kg per day. Adult cattle consistently produced the majority of the total average daily fresh dung. This production dropped from 7,829.31 tonnes in 2007 to 6,782.32 tonnes in 2012, and further to 6,142.98 tonnes in 2019. This approximately 21.5% reduction over the period aligns with national and regional trends showing a decline in native animal populations and increased mechanization.

The Farmyard Manure (FYM) examined has a typical nutrient composition of 0.5% Nitrogen (5 kg per tonne), 0.2% Phosphorus pentoxide (2 kg per tonne), and 0.5% Potassium oxide (5 kg per tonne). Based on 2019 production levels, this translates to an annual supply of about 11,200 tonnes of Nitrogen, 4,480 tonnes of P_2O_5, and 11,200 tonnes of K_2O, derived from daily data. The fertilizer equivalence per tonne of FYM is roughly 10.9 kg of urea (46% N), 12.5 kg of Single Super Phosphate (16% P_2O_5), and 8.3 kg of Muriate of Potash (60% K_2O). This substitution could potentially lead to annual savings of over 24,000 tonnes of urea-equivalent and corresponding amounts of phosphorus and potassium fertilizers in the study area. These savings help lower input costs, reduce dependency on imports, and decrease emissions linked to synthetic fertilizer production.

Effective management techniques, such as aerobic composting or anaerobic digestion in biogas plants, can cut methane (CH_4) emissions by 50-90% compared to unmanaged dung piles.

These methods also generate renewable energy and nutrient-rich digestate. The use of farmyard manure (FYM) significantly improves soil health by raising soil organic carbon (SOC) levels by 0.1-0.5% annually with regular application (5-10 t/ha). This practice enhances soil structure, water retention, microbial diversity, and long-term productivity, thus counteracting the degradation caused by intensive chemical fertilizer use. These varied benefits underscore the importance of integrated nutrient management (INM) strategies. The study suggests policy actions to improve collection and processing systems and raise awareness to boost environmental and economic benefits as livestock patterns change. Better dung use aids climate-smart farming, the circular bioeconomy, and sustainable rural growth in India.

KEYWORDS: Cattle dung, farm yard manure, nutrient equivalence, livestock census, organic manure, sustainable agriculture.

1. INTRODUCTION

Livestock has been an integral component of Indian farming systems for centuries, providing draught power, milk, meat and, importantly, organic manure that sustains soil fertility. Cattle dung, in particular, constitutes a renewable nutrient resource that recycles nitrogen, phosphorus, potassium and micronutrients back into agricultural soils, thereby reducing reliance on synthetic fertilizers and improving soil physical and biological properties. With the intensification of chemical fertilizer use since the Green Revolution, soil organic carbon levels in many parts of India have declined, making the reintroduction of organic amendments such as farm yard manure (FYM) increasingly important for long-term soil health and crop productivity. The quantity of dung generated by a cattle population is not static; it depends on herd size, age structure and management practices, all of which change over time due to mechanisation of agriculture, urbanisation, and shifting livestock rearing preferences. Periodic Livestock Census reports provide a reliable basis for tracking these changes, but translating raw population figures into usable estimates of dung availability and nutrient equivalence requires a systematic calculation framework. Such estimates are valuable for planners, extension agencies and farmers seeking to quantify the organic nutrient resource base available within a region and to plan biogas, composting or direct-application programmes accordingly

The present study was undertaken to (i) estimate the category-wise (adult, heifer and calf) fresh dung production from cattle population data for the years 2007, 2012 and 2019, (ii) compute the total average fresh dung production per day for each reference year, and (iii) determine the nutrient composition of FYM derived from this dung and its equivalent value in terms of common chemical fertilizers, namely urea, single super phosphate (SSP) and muriate of potash (MOP).

REVIEW OF LITERATURE

A substantial body of literature underscores the agronomic and environmental significance of cattle dung and FYM in Indian agriculture. Studies on organic farming have consistently highlighted FYM as a balanced, slow-release source of macro- and micro-nutrients that also improves soil structure, water-holding capacity and microbial activity. Ramesh, Singh and Subba Rao (2005) reviewed the relevance of organic farming to the Indian context and observed that integration of organic manures with chemical fertilizers improves nutrient use efficiency and sustains yields over the long term.

Meena, Sharma and Yadav (2016) reviewed FYM as a resource for sustainable crop production and reported that well-decomposed FYM typically supplies about 0.5 per cent nitrogen, 0.2 per cent phosphorus and 0.5 per cent potassium on a fresh weight basis, figures that are widely used as standard reference values in Indian soil fertility and manure management literature. Tandon (1992) and Motsara (2002) similarly documented standard nutrient content assumptions for FYM used in fertilizer recommendation and soil testing programmes across the country.

Studies on dung yield per animal category are comparatively fewer, but general livestock management literature places adult cattle dung output in the range of 20 to 25 kg per day, with proportionately lower output from young and immature animals. Singh, Suman, Singh and Srivastava (2007) examined methods for improving FYM quality through biological additives, noting that nutrient losses during storage can be substantial if manure is not managed properly, which has direct implications for the effective nutrient equivalence realised in the field.

At the national level, successive Livestock Census reports (Government of India, 2007, 2012, 2019) document a gradual decline in indigenous cattle populations in several states, attributed to mechanisation of farm operations, a shift towards crossbred and higher-yielding dairy animals, and rural-to-urban migration reducing smallholder cattle rearing. FAO (2013, 2018) reports on manure recycling emphasise that declining ruminant populations in transitioning agricultural economies reduce the organic nutrient base available to farms, reinforcing the importance of monitoring dung availability over time. Devi, Gupta, Jat and Parmar (2017) and Chesti, Ali and Bhat (2013) further reviewed organic residue recycling practices and concluded that judicious use of FYM alongside crop residues and biogas slurry (Kumar et al., 2014) can substantially offset chemical fertilizer requirements while improving soil quality indicators, as also corroborated by field evaluations of cattle manure application on soil biochemical properties (Bhattacharyya et al., 2003; Reddy and Reddy, 2005). Collectively, the literature establishes two consistent points that inform the present study: first, standard dung-yield coefficients (20–25 kg/day for adults, 10–15 kg/day for heifers, 5–7 kg/day for calves) and standard FYM nutrient percentages (0.5% N, 0.2% P2O5, 0.5% K2O) are widely accepted approximations suitable for regional-level estimation exercises; and second, declining cattle populations directly translate into a shrinking organic nutrient resource base, an important consideration for regional nutrient management planning (Prasad and Power, 1997; Savci, 2012; Palaniappan and Annadurai, 1999; Yadav and Verma, 1996; Rajput et al., 2010).

MATERIALS AND METHODS

1.1 Data Source

Secondary data on total cattle population were obtained for three reference years corresponding to successive Livestock Census enumeration periods: 2007, 2012 and 2019. The total cattle population figures used were 446,750 (2007), 387,008 (2012) and 350,527 (2019).

1.2 Population Categorisation

In the absence of disaggregated age-wise census data, the total cattle population for each year was partitioned into three standard physiological categories using fixed proportions commonly adopted in livestock planning exercises: adult cattle (60 per cent of total population), heifers (25 per cent of total population) and calves (15 per cent of total population).

1.3 Dung Production Coefficients

Category-wise daily dung excretion was estimated using standard ranges reported in livestock management literature: adult cattle, 20–25 kg/day (average 22.5 kg/day); heifers, 10–15 kg/day (average 12.5 kg/day); and calves, 5–7 kg/day (average 6 kg/day). Both the lower and upper bounds were used to compute a range, and the arithmetic mean of the two bounds was adopted as the representative daily dung yield for each category.

1.4 Computation of Total Fresh Dung Production

For each reference year, the population of each category was multiplied by the corresponding lower-bound, upper-bound and average daily dung yield coefficients to obtain category-wise dung production in tonnes per day (t/day). The average category-wise values were then summed to arrive at the total average fresh dung production for the entire cattle population in each year.

1.5 FYM Nutrient Composition and Fertilizer Equivalence

The nutrient composition of one tonne of decomposed FYM was assumed at standard reference levels of 0.5 per cent nitrogen (5 kg/tonne), 0.2 per cent phosphorus as P2O5 (2 kg/tonne) and 0.5 per cent potassium as K2O (5 kg/tonne), consistent with values widely reported in Indian soil fertility literature. These nutrient quantities were then converted into their chemical fertilizer equivalents using standard nutrient content percentages of commercial fertilizers: urea (46% N), single super phosphate (16% P2O5) and muriate of potash (60% K2O). The equivalent fertilizer quantity was calculated as: Equivalent fertilizer (kg) = Nutrient quantity in FYM (kg) ÷ Nutrient percentage in fertilizer.

2. RESULTS AND DISCUSSION

2.1 Population Distribution by Category

Table 1 presents the estimated cattle population distributed across adult, heifer and calf categories for the three reference years. The total cattle population declined steadily from 446,750 in 2007 to 387,008 in 2012 and further to 350,527 in 2019, representing an overall reduction of about 21.5 per cent over the twelve-year period. This decline was proportionally reflected across all three categories, since fixed percentage shares were applied.

Year	Total Population	Adults (60%)	Heifers (25%)	Calves (15%)
2007	446,750	268,050	111,688	67,013
2012	387,008	232,205	96,752	58,051
2019	350,527	210,316	87,632	52,579

Table 1. Estimated cattle population by category, 2007–2019

2.2 Category-wise Dung Production

Tables 2, 3 and 4 present dung production estimates for adults, heifers and calves respectively, at the lower-bound, upper-bound and average excretion rates. Adult cattle contributed the overwhelming majority of total dung output in every year, consistent with their larger body size and higher feed intake relative to heifers and calves. In 2019, for instance, adults contributed 4,732.11 t/day out of a total average of 6,142.98 t/day, or approximately 77 per cent of the total, closely mirroring their 60 per cent share of the population but amplified by their higher per-head excretion rate.

Year	Adults	20 kg (t/day)	25 kg (t/day)	Avg 22.5 kg (t/day)
2007	268,050	5,361.00	6,701.25	6,031.13
2012	232,205	4,644.10	5,805.13	5,224.61
2019	210,316	4,206.32	5,257.90	4,732.11

Table 2. Adult cattle dung production, 2007–2019

Year	Heifers	10 kg (t/day)	15 kg (t/day)	Avg 12.5 kg (t/day)
2007	111,688	1,116.88	1,675.32	1,396.10
2012	96,752	967.52	1,451.28	1,209.40
2019	87,632	876.32	1,314.48	1,095.40

Table 3. Heifer dung production, 2007–2019

Year	Calves	5 kg (t/day)	7 kg (t/day)	Avg 6 kg (t/day)
2007	67,013	335.07	469.09	402.08
2012	58,051	290.26	406.36	348.31
2019	52,579	262.90	368.05	315.47

Table 4. Calf dung production, 2007–2019

2.3 Total Average Fresh Dung Production

The combined average fresh dung production across all three categories (Table 5) shows a clear declining trend: from 7,829.31 t/day in 2007, to 6,782.32 t/day in 2012, and further to 6,142.98 t/day in 2019. This represents a loss of approximately 1,686.33 tonnes of fresh dung per day, or roughly 615,510 tonnes annually, between 2007 and 2019 — a substantial reduction in the organic nutrient resource potentially available for composting, FYM production or biogas generation within the region.

Year	Adult Avg (t/day)	Heifer Avg (t/day)	Calf Avg (t/day)	Total Avg (t/day)
2007	6,031.13	1,396.10	402.08	7,829.31
2012	5,224.61	1,209.40	348.31	6,782.32
2019	4,732.11	1,095.40	315.47	6,142.98

Table 5. Total average fresh dung production, 2007–2019

2.4 Nutrient Composition and Fertilizer Equivalence of FYM

Table 6 shows the standard nutrient composition of one tonne of decomposed FYM, containing 5 kg nitrogen, 2 kg phosphorus (P2O5) and 5 kg potassium (K2O). Table 7 translates these nutrient quantities into their chemical fertilizer equivalents: approximately 11 kg of urea, 12.5 kg of single super phosphate and 8.3 kg of muriate of potash per tonne of FYM applied. Applying these ratios to the 2019 total average dung production of 6,142.98 t/day suggests that the region's cattle population could, if all dung were efficiently collected and converted to FYM, generate nutrients equivalent to roughly 67.6 tonnes of urea, 76.8 tonnes of SSP and 51.0 tonnes of MOP per day in potential fertilizer replacement value (Senthilkumar and Thavaprakaash. 2025).

Nutrient	Percentage	Quantity per tonne
Nitrogen (N)	0.5%	5 kg
Phosphorus (P2O5)	0.2%	2 kg
Potassium (K2O)	0.5%	5 kg

Table 6. Nutrient composition of one tonne of FYM

Fertilizer	Nutrient Content	Equivalent per tonne FYM
Urea	46% N	10.9 kg (≈11 kg)
Single Super Phosphate	16% P2O5	12.5 kg
Muriate of Potash	60% K2O	8.3 kg

Table 7. Fertilizer equivalent of one tonne of FYM

The declining trend in total dung production across the census years parallels the broader national pattern of shrinking indigenous cattle herds, as documented in successive Livestock Census reports and corroborated by FAO assessments of manure recycling potential in transitioning agricultural systems. From a soil fertility standpoint, this decline implies a proportionate reduction in the organic nutrient resource base available to farmers in the region, which, if not compensated through improved dung collection efficiency, composting practices or alternative organic sources such as crop residues and biogas slurry, may accelerate dependence on chemical fertilizers and contribute to further deterioration of soil organic carbon status.

It is also important to recognise that the estimates presented here represent theoretical maximum availability based on total cattle inventory; actual collectible dung and realisable FYM nutrient value are typically lower due to losses during grazing (dung dropped in fields and not collected), storage and handling. Improving collection efficiency and adopting better composting techniques, as recommended in the reviewed literature, would help farmers and planners capture a larger share of this available nutrient resource.

3. CONCLUSIONS

This study estimated fresh cattle dung production and its FYM nutrient equivalence across three Livestock Census reference years using standard population categorisation and dung-yield coefficients. Total average fresh dung production declined from 7,829.31 t/day in 2007 to 6,142.98 t/day in 2019, a reduction of approximately 21.5 per cent, mirroring the corresponding decline in total cattle population. Adult cattle remained the dominant contributor to total dung output across all years, owing to both their large population share and higher per-head excretion rate. One tonne of FYM derived from this dung was estimated to contain nutrients equivalent to approximately 11 kg urea, 12.5 kg SSP and 8.3 kg MOP, underscoring the substantial fertilizer replacement value embedded in properly collected and composted cattle dung.

The declining cattle population and associated dung availability observed over this twelve-year period highlight an emerging challenge for organic nutrient management in the region. Sustaining soil fertility under a shrinking livestock base will require concerted efforts to improve dung collection efficiency, minimise storage losses, and integrate alternative organic sources such as crop residues and biogas slurry with FYM application. These findings can assist agricultural planners and extension agencies in quantifying the organic nutrient resource base of a region and in designing integrated nutrient management strategies that reduce dependence on chemical fertilizers while conserving long-term soil health.

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