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Manure Management as Key Contributor towards Rural India's Climate Strategy and Sustainable Livelihood

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ABSTRACT

With approximately 300 million dairy animals in India, the dung they produce is a substantial, yet often overlooked, resource for clean energy and fertilizer. Efficient management of this dung could potentially meet 50% of India's liquefied petroleum gas (LPG) needs and 44% of its NPK fertilizer requirements. The National Dairy Development Board (NDDB) has pioneered an innovative Manure Management model that establishes a manure value chain. This approach enables rural households to use biogas for cooking and sell the resulting nutrient-rich slurry to a cooperative for further processing. This slurry is then processed into organic fertilizers. A pilot project conducted in Anand,Gujarat, successfully demonstrated this "prosumer" model, where farmers both produce and consume the output, saving on fuel costs, earning income from slurry sales, and improving soil health. The model has since been replicated in nine other locations across various states, including Assam, Sikkim, West Bengal, Maharashtra, Rajasthan, Uttar Pradesh, and Jharkhand, to assess its scalability. This initiative offers multiple benefits, such as reduced dependency on imported energy and fertilizers, enhanced farmer livelihoods, and cleaner dairy farms and villages. The strong network of India's dairy cooperatives is well-positioned to replicate this model and contribute significantly to sustainable dairying and rural development.

Key Words : Manure Management, Sustainable Livelihood, Biogas, Rural India, Organic Fertilizer, Dairy Cooperatives.

INTRODUCTION

India, as per the 20th Livestock Census, is home to a vast livestock population of 536 million, with bovines alone accounting for 303 million (Livestock Census 2019). The livestock sector is a crucial component of the Indian economy, contributing 5.5% to the total Gross Value Added (GVA) at current prices in 2022–23 (National Accounts Statistics, 2023). Dairying, in particular, plays a vital role in enhancing the socio-economic status of farmers by providing a steady income source and creating entrepreneurial opportunities. India has emerged as the world's largest milk producer, with a production of 221 million tonnes in 2021-22, representing about 24% of global output (FAOSTAT, 2023).

Despite this impressive growth, the dairy sector is characterized by a smallholder production system with small herd sizes.

With 303 million bovines, an estimated 1,653 million metric tonnes (MT) of dung is produced annually. Traditionally, this dung has been collected and either converted into compost or dried into cakes for use as fuel. The use of cattle manure as a fertilizer has a long history, dating back over 8,000 years (Bogaard *et al.,* 2013). Various ancient texts and traditional practices have documented the use of cow dung to enhance crop yield, preserve fruits, and even control pests (Balasubramanian *et al.,* 2009).

As per the Household Consumption Expenditure Survey (HCES) 2022-23, approximately half of rural households still rely on solid fuels like firewood and cow dung for cooking. While government initiatives have increased access to LPG, a significant portion of the population is projected to remain dependent on solid fuels by 2030 (International Energy Agency, 2017). The burning of solid fuels is a leading cause of indoor air pollution, which contributes to chronic illnesses and accounts for an estimated 2 million premature deaths annually, disproportionately affecting women and children (Kankaria*et al*., 2014). This dependency also leads to environmental degradation and places a significant burden on women and children, who spend an average of 374 hours per year collecting firewood (Bloomfield,2015). Providing access to clean and affordable cooking fuel is a critical solution to these challenges.

BIOGAS AND BIO-SLURRY: A SUSTAINABLE FUEL AND FERTILIZER

Anaerobic digestion (AD) technology offers a sustainable solution for efficient manure management. This technology, which involves the anaerobic digestion of organic matter to produce biogas and biofertilizer, has a long history in India, with one of the first plants installed in Mumbai in 1897 (Chandel and Sukumarn, 2017). The use of biogas plants has been shown to reduce reliance on agricultural residues, thereby limiting deforestation and forest degradation over the long term (Agarwala *et al.,* 2017). With the potential to recover 60% of the produced dung, India could generate enough biogas to meet 50% of its LPG consumption and 40% of its NPK fertilizer needs.

Bio-slurry, the by-product of the biogas production process, is a nutrient-rich organic material that significantly improves soil health, enhances crop yields, and reduces environmental impact. It is a good source of nutrients and beneficial microbes for the soil (Malav *et al.,* 2015).

MANURE MANAGEMENT INITIATIVE

Various manure value chain models have emerged in India, ranging from household-level biogas plants to industrial-scale compressed biogas (CBG) facilities. The National Dairy Development Board (NDDB) initiated a large-scale manure management model in Zakariyapura, Anand, Gujarat. This model involved installing biogas plants in all 368 animal-owning households in the village. A central slurry processing plant was established to manufacture biogas slurry-based organic fertilizers. India's first all-women manure cooperative was created to manage the value chain, providing manifold benefits to farmers, including biogas for cooking, slurry for field application, and additional income from selling surplus slurry. The solid and liquid fertilizers produced

replace chemical alternatives, leading to improved soil health.

The basic framework of this Manure Management Model is depicted in Figure 1.

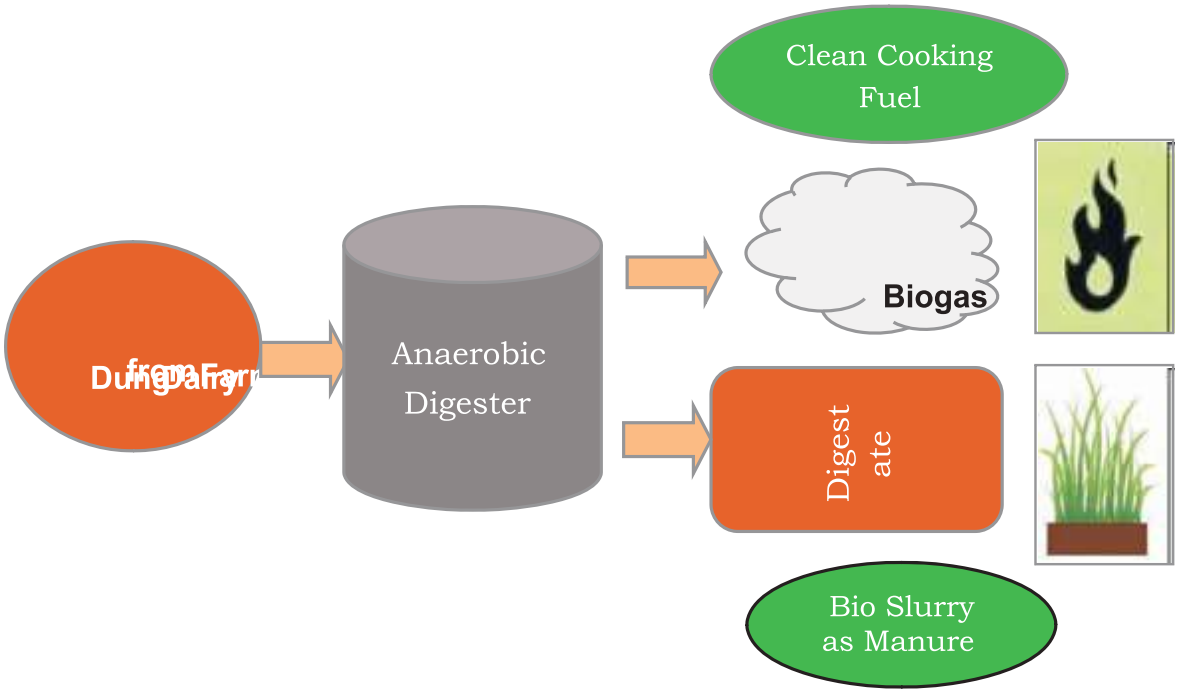


Figure 1: Basic framework of Manure Management Model

Till date, over 35,000 household-level biogas units have been installed under various government schemes as part of this initiative.

DEVELOPMENT OF UNIQUE MANURE VALUE CHAIN

Biogas Plant Installation at Household Level: The model involves installing 2-cubic-meter flexi biogas plants in the backyards of dairy farmers with a minimum of 2-3 animals (Plate 1). These plants are fed with 45-50 kg of dung and an equal quantity of water daily, which produces enough biogas for a family of 6-8 members and generates 80-100 liters of slurry per day. This amount of biogas is equivalent to 1.5-2 LPG cylinders, saving beneficiaries approximately Rs 1,800-2,000.



Plate 1: Flexi Biogas Plant of 2 cubic meter size

Slurry Procurement: Surplus slurry is procured by the women's manure cooperative. All household biogas plants in a cluster are geo-tagged, and a unique pick-up number is assigned to each member to ensure fair procurement (Fig. 2). Each member can sell up to 1,000 liters per instance.

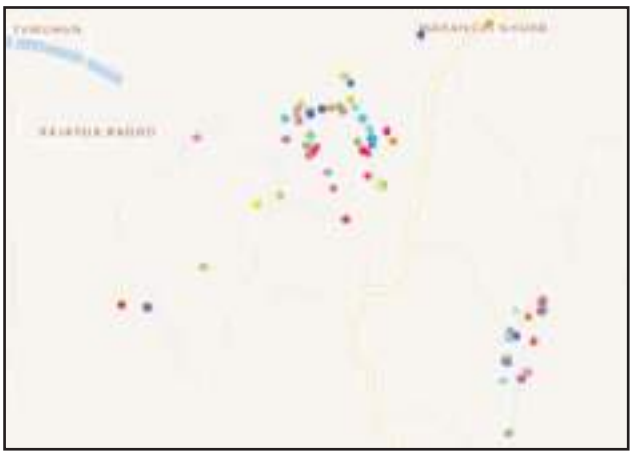


Figure 2: Geo-Tagged Biogas Plants

Slurry Testing at Farmer's Doorstep: Before procurement, the slurry is tested for quality using an Electrical Conductivity (EC) meter and a Brix meter (Plate 2). Based on the readings, a price of Rs 0.50 to Rs 2 per litre is paid. Payments are made directly to the members' bank accounts at the end of each month (Plate 3).





Plate 2: Slurry Testing in the Field



Plate 3: Passbook for slurry payment

Slurry Processing at a Central Location: Surplus slurry is processed at a central facility, where it is separated into solid and liquid components. The solid part is mixed with Rock Phosphate and other bacteria to produce Phosphate Rich Organic Manure

(PROM). The liquid is enriched with various salts and inputs to create value-added liquid products are now commercially available in the market.

EFFECT OF SLURRY-BASED ORGANIC FERTILIZERS

A study by Anand Agricultural University (AAU) on the use of slurry-based products on wheat and maize crops showed a more than 20% increase in grain and straw yield (Table 1) (Patel *et al*., 2021). A similar study by Banaras Hindu University (BHU) indicated a promising 25% reduction in the use of chemical fertilizers. Systematic feedback from 650 farmers also confirmed yield improvements across various crops, with demonstration studies showing a 14-36% improvement (Fig. 4).

Table 1 : Effect of application of SuDhan products on yield of maize (*Kharif*-2019) and wheat (*Rabi*-2019-20)

Treat. No.	Treatment Details	Maize Grain Yield (kg/ha)	Maize Straw yield (kg/ha)	Wheat Grain Yield (kg/ha)	Wheat Straw yield (kg/ha)
1	100%RDF-Control	2731	4050	5533	7331
2	75%RDF+PROM	3408	5133	6739	8665
3	75%RDF+ RG	3266	4648	6542	7707
4	75%RDF+MRL	3278	4932	6592	8251
5	75%RDF+PROM + RG	3617	5467	6856	8833
6	75%RDF+RG+ MRL	3304	4975	6706	8343
7	75%RDF+PROM + MRL	3300	4928	657	7769
8	75%RDF+PROM + RG + MRL	3356	5050	6722	8617
S. Em.±		151	238	238	338
C.D.at 5%		445	701	701	995

RDF: Recommended Dose of Fertilizers (Maize 100-50-0; Wheat 120-60-0)
RG: Root Guard MRL: Micronutrients Rich Liquid

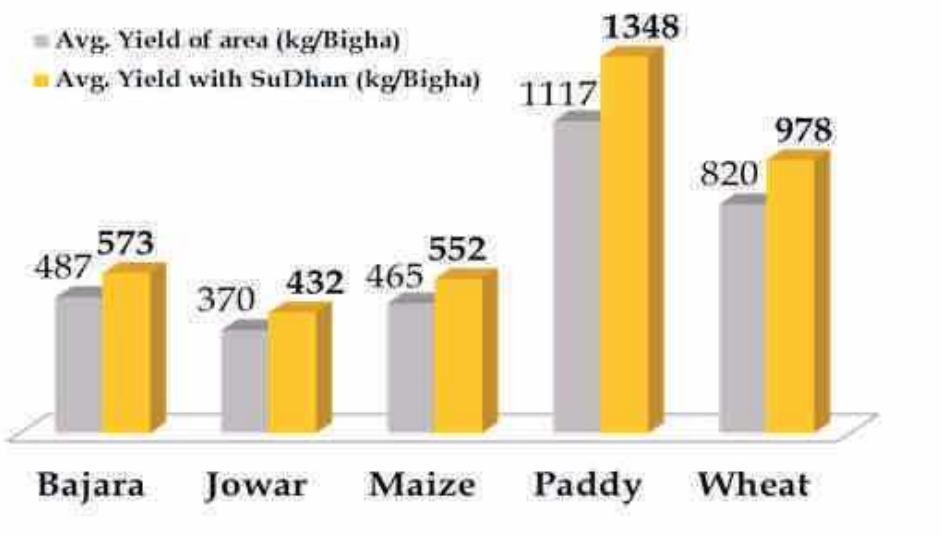


Figure 4: Demonstration study conducted at Farmers' field

PROPAGATION OF ZAKARIYAPURA MODEL

Building on the success of the Zakariyapura model, NDDB partnered with Sustain Plus Energy Foundation (SPEF) to replicate the initiative in nine additional locations across states like Sikkim, Assam, West Bengal, Jharkhand, Uttar Pradesh, Rajasthan, and Maharashtra. These projects involve setting up 100-120 household biogas plants and a slurry processing center in each location. To date, over 1,000 biogas plants have been installed, and processing activities have commenced, leading to the production of 167 MT of PROM and other liquid fertilizers in the first year of operation.

NDDB and SPEF have also registered a carbon project with Verra to generate carbon credits. The income from the sale of these credits is passed on to the women members, providing an additional source of income. The Zakariyapura model has now been included in the Government of India's GOBARDhan scheme, with NDDB serving as a technical partner.

CONCLUSION

The agriculture and dairy sectors continue to play a crucial role in India's socio-economic development. With its strong network of 1.9 lakh village-level dairy cooperative societies, 245 milk unions, and 22 milk marketing federations, reaching 17 million dairy farmers, India is well-positioned to leverage these resources for the replication and propagation of efficient manure management practices. This is the need of the hour for sustainable dairying, as it has immense potential to improve socio-economic and environmental sustainability, thereby contributing to the goal of making India a developed nation or Viksit Bharat by 2047.

The success of the Manure Management initiative, as demonstrated by the Zakariyapura model and its replication across various states, offers a real possibility of scaling up low-cost technologies to utilize manure as both an energy source and a fertilizer for agriculture. By implementing scientific and efficient manure management, the rural economy can be significantly

transformed, contributing to environmental sustainability, enhanced soil health, renewable energy generation, and improved livelihoods for millions in rural India.

This journey to a "new revolution- this time cantered around dung" can draw inspiration from India's remarkable achievement of milk self-sufficiency. The success of these pilot projects involving small and marginal farmers can provide useful lessons for other similarly placed dairying nations, demonstrating the power of visionary interventions and collective action in creating a more sustainable and prosperous future.

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