Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 02 (MAR-APR, 2026)
Available online at http://www.agriarticles.com

From Waste to Worth: Turning Cow Dung into Clean Energy and Sustainable Fertilizer

*Sanchit Pal Singh and Shruti Gupta
ICAR-IVRI, Izatnagar, India
*Corresponding Author's email: sanchit000singhdr098@gmail.com

Livestock farming generates billions of tonnes of manure globally each year, most of which is either mismanaged or wasted. Yet this organic material holds remarkable potential, when properly managed through anaerobic digestion, cow dung can produce clean biogas for cooking and electricity, while simultaneously yielding bio-slurry which is a nutrient rich organic fertilizer that rivals and often outperforms chemical alternatives. Evidence suggests that households adopting biogas technology save significant quantities of conventional fuel daily, while farmers using bio-slurry achieve benefit-cost ratios exceeding 3:1. Sustainability assessments place integrated dung management systems at a high level of satisfaction across economic, social, and environmental dimensions.

Keywords: Manure, Bio-slurry, sustainability, biogas.

Introduction

Every day, the world's 1 billion cattle produce an almost unimaginable quantity of dung. Globally, livestock are responsible for roughly 14.5% of all human caused greenhouse gas emissions, with manure management alone accounting for a significant share of that figure (FAO, 2013). For decades, the dominant response to this challenge has been either to spread manure on fields untreated with variable results and real pollution risks or simply to let it decompose in open pits, releasing methane into the atmosphere and creating unsanitary conditions around farms. Yet cow dung is not merely a waste problem. It is, when properly understood, an organic resource of extraordinary versatility. Through anaerobic digestion, a natural biological process that breaks down organic matter in the absence of oxygen, cattle manure can be converted into biogas, a clean-burning fuel that can replace wood, charcoal, and fossil fuels for cooking and heating. The residue of this process, known as bio-slurry, is a nutrient-dense fertilizer that improves soil health, reduces dependence on expensive chemical inputs, and supports sustainable crop production.

The Problem with Wasted Manure

On most farms around the world, cattle manure follows one of several undesirable paths. It is burned as fuel, releasing toxic pollutants including carbon monoxide, sulfur oxides, nitrogen oxides, fine particulate matter, and methane, all of which damage human health and the climate (Abdurrahman et al., 2020). It is stockpiled in open pits where it emits methane during uncontrolled decomposition. It is spread on fields in raw form, where misapplication leads to nitrogen loss through evaporation and phosphorus runoff into waterways. Or it is simply left to accumulate, fouling the environment around the farm. Field evidence from dairy farming communities confirms the typical breakdown. In a study of ten large scale dairy operations, researchers found that cow dung was used as follows: roughly 36% went to composting, 28% to biogas production, 19% to direct field application, 10% was burned as fuel, and approximately 8.5% was simply wasted outright (Shaibur et al., 2025). Burning and wasting together accounted for nearly one-fifth of all manure produced which is a significant lost opportunity, both economically and environmentally. What the evidence makes clear is that the hierarchy of cow dung use matters enormously. Not all management practices are equal. Composting is better than burning; biogas production is better than composting; and the integration of biogas production with bio-slurry agriculture represents the most sustainable and economically rewarding approach of all.

Biogas: Clean Energy from the Cowshed

Anaerobic digestion is a well-established technology. Biogas plants in which manure is mixed with water, fed into a sealed digester chamber, and broken down by naturally occurring bacteria have been operating at commercial scale in Germany, Sweden, China, India, and the United States for decades (Mustafi and Agarwal, 2020). The methane-rich gas produced can be burned directly for cooking, used to generate electricity, or upgraded to biomethane for injection into natural gas grids. The energy yields are meaningful. Research indicates that 2.4 kg of cattle manure can generate between 0.41 and 0.82 cubic metres of biogas per day (Møller et al., 2004). A plant generating 2 cubic metres of biogas daily can theoretically replace 5-7 kg of firewood, depending on wood quality, a substantial reduction in biomass fuel consumption. Across the farms studied by Shaibur et al. (2025), biogas plant owners saved an average of 8.5 kg of firewood per household per day after installation. Liquid petroleum gas consumption fell by 0.29 kg per day. In total, each household saved the equivalent of approximately 1.67 kg of chemical fertilizer daily through bio-slurry alone.

Beyond fuel savings, biogas adoption translates into tangible time savings particularly significant for women in rural and peri-urban communities who typically manage cooking and fuel collection. Net time savings of around 40 minutes per household per day have been documented, freeing up hours each week that can be redirected to income-generating activities, childcare, or education (Shaibur et al., 2025). Climate benefits are equally real. When manure is processed through a biogas plant rather than burned directly, CO2-equivalent emissions are substantially reduced. Research estimates a saving of approximately 3.62 kg of CO2 per tonne of manure processed through biogas compared to direct combustion (Saha et al., 2022). Across millions of cattle producers worldwide, this arithmetic translates into a significant contribution to global emissions reduction without requiring any change in agricultural production levels.

Bio-Slurry: The Undervalued Byproduct

If biogas is the headline product of anaerobic digestion, bio-slurry is its quietly remarkable co-star. The semi-liquid residue that remains after gas extraction retains most of the nitrogen, phosphorus, potassium, and micronutrients from the original manure but delivers them in a far more plant-available form. Crucially, the digestion process destroys weed seeds and most pathogens, problems that limit the effectiveness of raw manure and compost (Bahauddin and Salahuddin, 2012). The result is a fertilizer that is safer, more nutrient-dense, and easier for crops to utilise than either farmyard manure or conventional compost. Farmers who have adopted bio-slurry report consistently positive experiences. In field studies, crop yields on bio-slurry-treated soils compared favourably to those receiving chemical fertilizers, and satisfaction rates among bio-slurry users were high with over 80% of farmers expressing full satisfaction with the results (Shaibur et al., 2025). Those who expressed partial dissatisfaction largely cited the lack of crop-specific application guidance, pointing to an extension and education gap rather than any fundamental problem with the product itself. Application methods are diverse. Bio-slurry can be applied as a semi-liquid directly to fields before planting, delivered through drip or flood irrigation systems, used as fish pond fertilizer, or diluted and sprayed as a foliar feed. Seeds soaked in diluted bio-slurry prior to planting germinate more rapidly and produce stronger early seedlings, a technique with implications for crop establishment and yield potential (Yuan et al., 2011). Across fruit crops, vegetables, oil seeds, pulses, and fodder grasses, the evidence for bio-slurry's effectiveness is broad and consistent.

The Economics of Circular Dung Management

For farming households operating on tight margins which describes the majority of the world's 600 million smallholder farms, economic viability is non-negotiable. No sustainability solution that fails the financial test will achieve lasting adoption. Bio-slurry passes this test with room to spare. Financial analysis from field research reveals an average benefit-cost ratio of 3.34 for bio-slurry use in agriculture, meaning that for every unit of currency invested in managing and applying bio-slurry, farmers recoup more than three units in savings on chemical fertilizer costs (Shaibur et al., 2025). The highest-performing farms achieved ratios as high as 6.00. Average annual fertilizer cost savings per acre of cropland significantly outpaced the modest costs of maintaining a bio-slurry system. These economics are particularly compelling given global trends in chemical fertilizer pricing. Synthetic nitrogen and phosphorus fertilizers are energy-intensive to produce and subject to volatile commodity markets. Farmers who substitute bio-slurry for purchased chemical inputs are insulating themselves from price shocks while simultaneously improving their soil's long-term fertility which is a compounding advantage that grows with each season of application.

Sustainability by the Numbers

Rigorous sustainability assessment of integrated cow dung management systems using composite indices that weigh economic, social, and environmental outcomes, places these systems firmly in a high-performance category. Shaibur et al. (2025) calculated an overall Sustainable Development Index (SDI) of 0.73 for general cow dung waste management, and 0.81 for bio-slurry agricultural use both classified as indicating a higher level of satisfaction. More than 90% of sampled households achieved the sustainable development benchmarks recommended by the Food and Agriculture Organization (FAO, 2014) for sustainable agriculture.

Environmental sustainability scores were among the strongest dimensions, with the best-performing farms reaching the FAO's recommended threshold of 0.91. Economic sustainability indices reflected the robust financial returns documented above. Social sustainability covering worker welfare, community engagement, and access to information was the area showing most room for improvement, a finding that mirrors sustainability assessments in agricultural systems globally. Taken together, these metrics paint a picture of a farming practice that is not merely tolerable from a sustainability perspective, but genuinely exemplary delivering triple dividends across energy, agriculture, and environmental management simultaneously.

Barriers and What It Takes to Scale

Despite the compelling evidence, biogas adoption and bio-slurry use remain far below their potential globally. Several barriers consistently impede uptake. The upfront capital cost of installing a biogas plant digging digester chambers, connecting piping, purchasing gas stoves can be prohibitive for smallholder farmers, even when the long-term payback period is short. Financing programmes by governments and development organisations have proven effective where they exist, but coverage remains patchy in most low- and middle-income countries.

Technical knowledge is a second constraint. A biogas plant that is poorly maintained will underperform, produce odours, and generate user dissatisfaction that discourages neighbours from adopting the technology. Training in basic operation, troubleshooting, and seasonal management is essential but often absent. Similarly, farmers need guidance on optimal bio-slurry application rates and methods for different crops and soil types, a gap that agricultural extension services are well-placed to fill if adequately resourced.

Finally, awareness remains low in many farming communities. Farmers who have never seen a biogas plant in operation or observed the effects of bio-slurry on crop yields are understandably cautious. Peer-to-peer demonstration, successful farmers sharing results with neighbours is one of the most powerful tools for overcoming this inertia, and should be built into any programme seeking to scale these technologies.

Conclusion

The case for rethinking cow dung as a resource rather than a waste problem is now supported by robust evidence across multiple dimensions. Biogas production from cattle manure offers clean, affordable energy that reduces dependence on wood fuel and fossil energy sources, cuts greenhouse gas emissions, and frees up time particularly for women, that was previously consumed by fuel collection and smoky kitchens. Bio-slurry, the inevitable byproduct of that same process, delivers high-quality organic fertilization that improves soils, reduces chemical input costs, and raises crop productivity, often at a benefit-cost ratio exceeding 3:1. Together, these outcomes constitute a genuine circular economy at the farm level, one where what enters the system as waste exits as fuel and fertilizer, with benefits cascading across energy security, food security, climate resilience, and rural livelihoods. This is not a niche solution for particular geographies or farming systems. The principles apply wherever cattle are kept and organic waste is generated which is to say, across virtually every agricultural society on earth. Achieving this potential at scale will require coordinated action: financing for biogas plant installation, training for farmers in operation and bio-slurry application, supportive policy frameworks, and sustained investment in agricultural extension services. The technology exists. The economics are favourable. The environmental imperative is clear. What remains is the political and institutional will to treat cow dung not as an inconvenient byproduct of feeding the world, but as one of the most underutilised resources available to it.

References

1. Abdurrahman, M.I., Chaki, S., & Saini, G. (2020). Stubble burning: effects on health & environment, regulations, and management practices. Environmental Advances, 2, 100011.
2. Bahauddin, K.M., & Salahuddin, T.M. (2012). Prospect and trend of renewable energy and its technology towards climate change mitigation and sustainable development. Sustainability, 12(11), 7082.
3. FAO. (2013). Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations, Rome.
4. FAO. (2014). Building a common vision for sustainable food and agriculture: Principles and approaches. FAO Publishing, Rome.
5. Møller, H.B., Sommer, S.G., & Ahring, B.K. (2004). Methane productivity of manure, straw, and solid fractions of manure. Biomass and Bioenergy, 26(5), 485–495.
6. Mustafi, N.N., & Agarwal, A.K. (2020). Biogas for transport sector: current status, barriers, and path forward for large-scale adaptation. Alternative Fuels and Their Utilization Strategies in Internal Combustion Engines, 229–271.
7. Saha, C.K., Nandi, R., Rahman, M., Alam, M., & Møller, H.B. (2022). Biogas technology in commercial poultry and dairy farms: present scenario and prospect. Biomass Conversion and Biorefinery, 1–12.
8. Shaibur, M.R., Al Helal, A.S., Siddique, A.B., Husain, H., Khan, M.W., Sarwar, S., … & Sakib, M.N. (2025). Cow dung management, biogas production and the uses of bio-slurry for sustainable agriculture. Cleaner Waste Systems, 10, 100201. https://doi.org/10.1016/j.clwas.2024.100201
9. Yuan, D., Liu, C., Pu, G., & Wu, D. (2011). Effects of seed soaking with biogas slurry on seed germination and seedling growth of tagetes erecta. China Journal of Chinese Materia Medica, 36, 817–822.