International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18(23s) 2026 pp. 569-582
https://doi.org/10.70917/ijcisim-2026-5625
Article

Biogas and Biofertilizer from Organic Waste in the APMC Network of Maharashtra: An Assessment

Vishal Vasudeo[1],*, Sanjay Rama Dayare[2], Supriya Sanjay Nikam[3], Satyanarayan K. Kothe[4]

[1,2,3,4]Mumbai School of Economics & Public Policy, University of Mumbai, Mumbai, INDIA
* Corresponding author: E-mail address: kothesk@gmail.com

Abstract: Agricultural Produce Marketing Committees (APMC), known as Bazaar Samitis, have played a key role in marketing agricultural produce in Maharashtra, India, for decades. They deal with a wide range of commodities; and while grading, sorting and handling these commodities, a proportion of produce is deemed unmarketable; the discarded produce becomes organic waste. This paper reviews the literature on organic waste with a specific focus on its conversion into biogas, electricity and biofertilizer for revenue generation. The shortage of organic manure is a key issue in Maharashtra's agriculture. To address this issue, this study has looked at government initiatives like SATAT and GOBARdhan to outline a pilot organic waste-to-biogas, electricity, and biofertilizer conversion project for Maharashtra's five main APMCs: Vashi (Mumbai), Gultekdi (Pune), Kalamna (Nagpur), Nashik City and Kalyan (Thane). For better insight, this study has taken inferences from a survey of 400 tomato farmers in Pune and Nashik districts and a survey of 400 banana farmers in the Jalgaon district of Maharashtra. This assessment found that the five APMCs can generate 1958 tonnes of biogas/or 7.29 GWh of electricity and 6095 tonnes of biofertilizer concentrate annually. For the implementation of this assessment study, the paper suggests three business models: (i) Supply, Installation, Testing & Commissioning, (ii) Hybrid Annuity Model and (iii) Public–Private Partnership. In conclusion, this study recommends scaling up all APMCs in Maharashtra after the initial rollout in the leading five APMCs.
Keywords: Solid Waste Management; Organic waste-to-energy; Biogas generation; Biofertilizer production; Circular economy in agriculture; Waste valorization; Public–Private Partnership (PPP); Maharashtra agriculture

1. Introduction

Agricultural Produce Marketing Committees play a pivotal role in marketing agricultural commodities in Maharashtra (World Bank, 2010; NITI Aayog, 2015; and RBI, 2019). They trade large quantities of fresh produce daily. During the primary survey conducted by us, we visited Maharashtra's most important APMC, Vashi (Mumbai), which handles 8000 tonnes of fresh produce daily, annualized sums up to 2.92 million tonnes (Vasudeo, 2026). This produce is graded and sorted by the laborers employed by the traders; during this process, some produce is deemed unmarketable and this unmarketable produce is discarded. Currently, discarded produce is considered organic waste and is handed over to an appointed contractor. APMC Vashi's officials claim that about 1% of their daily fresh produce is unmarketable and is considered organic waste; this 1% works out to 80 tons per day (NIAM, 2013). This unmarketable discarded produce can be converted into a revenue stream by APMCs themselves via its conversion into compressed biogas, electricity and biofertilizer (Patel, Gami, Patel *et al.*, 2024).

Another important pain point in Maharashtra agriculture is the reduction in animal labor usage by farmers (Mehta *et al.*, 2019; Shrivastava *et al.*, 2021; Natarajan *et al.*, 2016). Recently, farmers have replaced animal labor with mechanized labor, such as power tillers and tractors. On one hand, farmers' drudgery has reduced in agriculture via mechanisation, but this has led to a reduction in livestock, which in turn has led to a reduction in the production of organic manure at the farm level. The paucity of organic manure has led farmers to rely on chemical inputs, such as fertilizers and crop chemicals with increasing gusto. These chemicals did give good immediate results to farmers, but now they have entered diminishing marginal utility territory; increased application of chemicals is not giving the farmers the desired return, hence many of them would like to turn to organic manure once again (Kumar, 2026 and Gup, Benbi *et al.*, 2021). Organic equivalents of chemical inputs are available, but they are substantially more expensive and their use completely obfuscates farm economics for agriculturalists (Patil, 2023 and Velayudhan, Singh *et al.*, 2021). In short, there is a demand for organic manure at the farm level, but the supply is lagging behind.

This study relies on a survey of 400 tomato farmers in the Pune and Nashik districts of Maharashtra and 400 banana farmers in the Jalgaon district of Maharashtra. As part of this survey data, this study relied on interactions with and additional data from officials of the Maharashtra State Agriculture and Marketing Board, Pune and APMC Vashi for organic waste to energy/fertiliser computations and government policies in the study area (Vasudeo, 2026). This paper format is of a feasibility study — literature review on organic waste conversion into biogas, electricity and biofertilizer and on organic manure shortage in India (Section 2), creates a ground level rationale from primary survey (Section 3), applicable policies in this area (Section 4), examines APMCs in Maharashtra and selects main markets for the pilot proposal (Section 5), forecasts daily and annual output plus revenue (Section 6), estimates capital expenditure required for pilot proposal at the five selected APMCs (Section 7), assesses the pilot proposals for impact on the prospective APMCs financials (Section 8), business models evaluation (Section 9) and concludes with a discussion on wider pan Maharashtra roll out across all APMCs.

2. Literature Review

2.1 Compressed Biogas and Biogas in India

India is a large country with a large agricultural output and an equivalent generation of large agricultural waste residue output, estimated at 500 million tonnes annually. India has many urban cities and the highest livestock population in the world. Such a substantial and strong base makes India a compelling case for biogas and Compressed biogas production (Chauhan *et al.*, 2022; Singh, 2021; Kumar and Agrawal, 2020; CPCB, 2025; Dikshit and Birthal, 2010; Fasake and Dashora, 2021).

Agricultural waste residue is a rich source of compressed biogas. If the entire 500 million tonnes of residue is converted, it can yield an estimated 20 million tonnes of compressed bio gas annually, provided that the proper channels and methods are set up with scientific accuracy from the sourcing of feedstock to the pre-treatment of the organic waste to anaerobic digestion to purification to compression to storage of the produced gas. Special efforts must be made to address the environmental and economic challenges impeding the commercial success of such initiatives (Singh and Kalamdhad, 2024; Mittal, Ahlgren *et al.*, 2018; Ghag, Shedage *et al.*, 2025).

The Government of India has been trying to promote the adoption of Compressed biogas for a while. In 2018, they introduced the Sustainable Alternative Towards Affordable Transportation Scheme (SATAT), which envisaged 5000 compressed biogas plants and 15 million tonnes of annual production by 2023/24. This SATAT Scheme would also generate a valuable by-product in organic manure totalling 50 million tonnes annually and would warrant an investment of INR 2 lakh crore. Revisiting the SATAT Scheme in 2026 reveals that various entities in India have signed thousands of letters of intent, but the implementation and execution have been poor. There are many estimates of the number of compressed biogas plants in India, ranging from the mid-20's to 120–150, well short of the 500 plants target (Singh, Tembhare *et al.*, 2023). In 2025, a SWOT analysis was conducted on this subject, which revealed many bottlenecks, ranging from social to political to financial to technical in nature. Low stakeholder awareness, impediments to sourcing and aggregating feedstock, inadequate technical competence and logistical barriers were identified as key challenges (Garkoti and Thengane, 2025). A Global Methane Initiative study of 11 operational compressed biogas plants was conducted in northern India it was found that only seven were actually operational and the remaining four were closed down due to financial and operational difficulties, highlighting that just commissioning a compressed biogas plant does not work and running it efficiently is essential too (Global Methane Initiative, 2025; and Kulkarni, Shastri *et al.*, 2025).

The Government of India reviewed the SATAT Scheme in 2025/26 and revised the compressed biogas plant target to 750, with a timeline set for 2028. The government noted that the ecosystem for such business activity is still evolving and there is sustained interest among the investor community, which has operationalized many plants in India and plans to commission and run many such large-scale compressed biogas plants in the future. This literature review of compressed biogas plants highlights their importance in India, along with the negative nuances of feedstock availability, technical capability and financial viability. This study assesses the Maharashtra APMC network for a smaller-scale compressed biogas case, which can then be scaled up, first statewide, and then nationwide (Yadav and Sircar, 2022; Organizer, 2024).

2.2 Electricity from Biogas via Organic Waste in India

Moving on from the discussion of compressed biogas, we turn to electricity from organic waste. It is a simpler way of extracting commercial value from biogas, as it does not require investment in physical infrastructure for gas purification and compression, thereby reducing capital costs. The Indian government has accepted both electricity generation and compressed biogas manufacturing as outputs from organic waste; however, this largely depends on localized factors such as proximity to an electricity network, gas grid, or CNG retail outlets (Singh and Kalamdhad, 2022; Kaur, Sharma *et al.*, 2022). This study examined compressed biogas and electricity generation simultaneously, presenting both scenarios for the APMC network in Maharashtra (Sections 6.1–6.3 below).

2.3 BioFertiliser and Organic Manure Scarcity in India

Digestate or bio-slurry is a byproduct of anaerobic digestion. It has been labelled as Fermented Organic Manure (FOM) in solid or liquid form, and is considered a parallel product rather than a by-product of compressed biogas by the government. Since 2023, the government has appointed authorized manufacturers of this FOM to sell it directly in bulk to the farming community. The Indian Biogas Association has estimated an annual saving of USD 1.5 billion in our fertilizer foreign exchange bill if this FOM market can be developed and evolved judiciously (Chavan, 2025; Mordor Intelligence, 2025; and Fairfield Market Research, 2026).

Organic manure shortage has been a key driver in this study's field-level study; and a literature review of organic manure has also been conducted. India has the largest livestock population in the world; however, ownership of this livestock is highly fragmented and dispersed. An estimated 65 million households in India own livestock; however, very few dairy or livestock entities own the animals. A huge amount of organic manure is produced daily in India, but its collection, aggregation and distribution from surplus to scarce areas is severely constrained. Another key observation is that chemical fertilizers have been receiving regular subsidies, which make them more economically accessible to small and medium farmers. Chemical inputs also show an immediate impact on the farmer in the initial phase, which has encouraged their adoption. Consequently, many farmers in India have replaced organic manure with chemical inputs (Bakshi and Gupta, 2026; and Ghosh, 2026).

Farmers across India are keen to adopt more organic manure in cultivation. For Kharif 2026, the government has estimated farmers to procure 1.7 million tonnes of organic manure, a three-fold increase over the previous year, but it is way short of the actual estimated demand of 38.9 million tonnes. There is still a long way to go for organic manure to be a compelling, economically viable alternative to chemical inputs on a large scale (Chavan, 2025; Mordor Intelligence, 2025; and Fairfield Market Research, 2026). This literature review is consistent with the on-field survey findings of farmers wanting to use organic manure regularly, but its availability is a big issue, hence they are forced to depend repeatedly on synthetic alternatives. India is import-dependent on chemical fertilizers and crop chemicals in both finished and raw material forms; hence, we are always exposed to external shocks such as geopolitical disturbances and currency volatility. These externalities usually directly affect farmers, negatively affecting their cost of cultivation. In the most recent fiscal year alone, India imported 10 million tonnes of urea and phosphate-based fertilizers, and is totally dependent on imported inputs (Juneja, Nand *et al.*, 2026; Ramachandran, Nithiyanandam *et al.*, 2026; and Suri, 2026). This backdrop builds a convincing case for utilising the APMC network to generate BioFertiliser for our farmer, this paper has made an attempt in this direction.

2.4 GOBARdhan Initiative and Institutional Efforts

Under the Swachh Bharat Mission (Grameen) Phase II, the Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) initiative provides the institutional foundation for this study's assessment (Ministry of Jal Shakti, 2021). The GOBARdhan initiative is an umbrella under which all government schemes for compressed biogas, electricity and organic manure from organic waste can be congregated. It covers models for households, communities, and clusters, along with applicable financial provisions for village-level infrastructure (Press Information Bureau, 2025 and 2026). Recent data from their portal indicate that commissioned compressed biogas plants across India collect and process thousands of tonnes of organic and agricultural waste daily and convert them into several hundred tonnes of compressed biogas and organic manure (Chandrashekhar and Pandey, 2018; and Deloitte Touche Tohmatsu India LLP, 2025). GOBARdhan's community and cluster guidelines offer a welcome corollary to this study's APMC network-based assessment. Both want to collect and aggregate organic waste from their catchment area and convert the organic waste via anaerobic digestion into compressed biogas, electricity and biofertilizer at certain pre-selected locations — at the village cluster level under GOBARdhan and at the APMC network in this paper.

2.5 Positioning of the Present Study

Summarizing the literature review for compressed biogas, electricity and biofertilizer generation from organic waste. This study observes that there is sufficient feedstock and potential for this sector in India, and there is good policy support from the government; however, it is still early days for this sector and implementation is expected to improve with time, once the drawbacks of feedstock aggregation and financial viability are addressed (Kulkarni, Shastri *et al.*, 2025; and Singh, Tembhare *et al.*, 2023). Along these lines, structurally persistent issues such as organic manure shortage due to fragmented livestock ownership and farmer preference for subsidized chemical inputs are examined (Bakshi and Gupta, 2026; and Ghosh, 2026). This study contributes to the body of work by assessing the Maharashtra APMC network, which trades thousands of tonnes of fresh produce and simultaneously generates hundreds of tonnes of organic waste daily. This study aims to address the agriculture sector's long pending issues of aggregation of organic waste in the local vicinity, more accurately than village-level clusters and simultaneously attempt to set up a solution for the organic manure demand–supply gap identified in the survey findings in Section 3 below.

3. Background and Rationale

3.1 Survey Methodology

A ground-level survey of 200 tomato farmers in Pune district, 200 tomato farmers in Nashik district and 400 banana farmers in Jalgaon district (total farmers = 800) was conducted with the research objective of estimating production and profit functions for tomato and banana farmers (Vasudeo, 2026). This survey was guided by the Maharashtra State Agriculture Marketing Board, Pune and APMC Vashi, Mumbai.

3.2 Note-worthy Observations from the Ground Level Survey

The biogas and biofertilizer assessment in Maharashtra APMC network was duly motivated by the following five noteworthy observations from the conducted ground level survey —

- Sinking water table: Maharashtra state regulations mandate a maximum well depth of 60 m or 197 ft. In certain villages of the Jalgaon district, to provide sufficient irrigation to banana crops, well depth has crossed 700 feet, which is way beyond the permissible limit. The government allows the use of up to 7.5 horse power output electricity motors for groundwater extraction, but to extract from a level above 700 feet, 25 horse power plus output electricity motors are required. This, in turn, overloads the electricity grid, leading to frequent power outages in rural areas (Kapoor and Anand, 2024; Sayre and Taraz, 2019; and Fishman, Lall et al., 2016).

- Climate change-compliant planting material: Seed and sapling companies are geared up to produce maximum output within a minimum time frame. This operational focus has weakened tomato and banana plants, making them more susceptible to climate shocks. With the rise in unseasonal rainfall, heat waves, and cold shocks, planting material needs to be more resilient to climate change (Sural, 2025; Rao, 2025; Yadava, Singh et al., 2025; Nath, Dutta et al., 2025; and Boraiah, Basavaraj et al., 2023).
- Labor availability: Labour is available in rural areas for agricultural work. Free foodgrain distribution to the poor sections of society and direct cash transfers to the needy have substantially disincentivised them from taking up gainful employment. Farmers have to make special transport arrangements for them so they report to work, and they are of the view that labor only needs money today for mobile recharge and alcohol consumption (Evans and Popova, 2017; Jumrani and Birthal, 2017; and Vasudeo, 2026).
- Structural oversupply: Tomato and Banana prices are usually in a depressed zone for most months of the year. They see surges in prices when effective demand exceeds effective supply. Government initiatives such as UPaJ and eNAM and private initiatives such as IoT and AI in farming are all on the supply side; none of them even attempt to match demand and supply in agricultural markets. Hence, certain crops, such as wheat, sugarcane, and rice, are in systemic oversupply and certain crops, such as pulses and oilseeds, are in perpetual undersupply, leading to perpetual disequilibrium in agricultural output markets (Thapa et al., 2026; Neogi and Ghosh, 2022; Rathore and Chauhan, 2025; and Selvaraj and Karunakaran, 2022).
- Organic manure shortage: Excessive use of chemical inputs and monocropping has taken its toll on soil quality in rural areas of Maharashtra. Soil hardening is a significant issue. Farmers are keen to reduce the usage of chemicals, and although organic equivalents are available in the marketplace, they are substantially more expensive than the chemical options, which turns the economics of the farm topsy turvy. Increased application of organic manure is beneficial to soil health, but its availability is a major problem; the reduction in the use of livestock in farming makes organic manure unavailable to farmers in the desired quantities (Mehta, Chandel et al., 2019).

3.3 Fertiliser Import Dependence Issue

The fifth and final observation of organic manure shortage is an essential component of this study. India's fertilizer industry is highly dependent on imported raw materials and finished products. Almost all of India's muriate of potash must be imported, 86–95% of India's rock phosphate requirement needs to be imported, 75–78% of the ammonia and natural gas feedstock needed to make urea in India must be imported, and there is significant dependence on imported phosphoric acid and sulfur. If we try to calculate India's fertilizer industry's dependence on imports, factoring in raw materials, intermediate goods and finished products, the number reaches 68–70%. This import dependence easily transmits the impact of global geopolitical uncertainty, energy price volatility and foreign exchange rate depreciation directly to farmers' costs of cultivation (Juneja, Nand *et al.*, 2026; Ramachandran, Nithiyanandam *et al.*, 2026; and Suri, 2026). These external shocks have led to the practice of 'linking' in Pune, Nashik and Jalgaon districts of Maharashtra (Vasudeo, 2026). The Government of India and the Government of Maharashtra have shown significant intent to augment the production and marketing of organic manure, but it is still early days for it and will take some time to scale up in any meaningful way. This study directly assesses the pressing issue of organic manure.

4. Policy and Regulatory Framework

Six policy tools from the central and state levels of government apply to compressed biogas, electricity and biofertilizer generation from organic waste. These provide the regulatory framework for the assessment in this study.

- Maharashtra CBG Policy 2026 (Urban Development Department, Government of Maharashtra, 2026)
- Solid Waste Management Rules 2026 (Government of India, 2026)
- Fertiliser Control Order 1985 (Ministry of Chemicals and Fertilizers, Government of India, 1985)

- Galvanising Organic Bio-Agro Resources Dhan (GOBARdhan) Scheme (Ministry of Jal Shakti, Government of India, 2021)
- Sustainable Alternative Towards Affordable Transportation (SATAT) Scheme (Ministry of Petroleum and Natural Gas, Government of India, 2018)
- Public Private Partnership (PPP) Policy for APMC Reforms in Maharashtra, 2025 (Co-operation, Marketing and Textiles Department, Government of Maharashtra)

Collectively, these six instruments cover waste segregation and processing commitments, compressed biogas production incentives, fertilizer quality regulation, and the PPP institutional apparatus through which the APMCs in Maharashtra can attract private investors and operational expertise for such ventures.

5. Maharashtra APMC Network and the Current Assessment

The APMC network of Maharashtra comprises 306 main markets and 624 submarkets spread across eight administrative divisions (Vasudeo, 2026), making it one of India's largest agricultural produce marketing infrastructures, which generates copious amounts of organic waste, which in turn is feedstock for the biogas, electricity and biofertilizer businesses. To give a nationwide thrust or even a Maharashtra state-wide thrust to such ventures will require substantial operational and financial muscle; hence, this study assesses only the five leading APMCs of Maharashtra to make a sound and assured beginning. These are Vashi (Mumbai), Gultekdi (Pune), Kalamna (Nagpur), Nashik City and Kalyan (Thane).

5.1 Modal Daily Arrivals and Estimated Wastage

Table 1: Modal daily arrivals and estimated organic wastage at the five assessed APMCs

APMC	Daily Arrivals (tonnes)	Wastage (tonnes)
Vashi	8,000	80
Gultekdi	4,500	45
Kalamna	2,000	20
Nashik City	1,200	12
Kalyan	1,000	10

Source: Various APMCs

Table 1 lists out daily modal arrivals of produce at the five assessed APMCs, with organic waste assumed at 1% of arrivals (Vasudeo, 2026).

5.2 Waste to Output Conversion Metrics

Based on standardized conversion metrics, one metric ton of organic waste yields 32 kg of Compressed Bio-Gas, 120 KWh of Electricity, and 100 kg of biofertilizer concentrate (Patel, Gami, Patel *et al.*, 2024). These numbers form the basis of this assessment for extrapolating waste volumes into physical and financial outputs.

6. Output and Financial Analysis

6.1 Daily Physical Output

When conversion metrics from Section 5.2 are applied to daily wastage numbers from Table 1 yields the daily physical output as shown in Table 2.

Table 2: Daily biogas, electricity and biofertilizer output at the five assessed APMCs

APMC	Waste (t)	Biogas (kg)	Electricity (kWh)	Biofertilizers (kg)
Vashi	80	2,560	9,600	8,000
Gultekdi	45	1,440	5,400	4,500
Kalamna	20	640	2,400	2,000
Nashik City	12	384	1,440	1,200
Kalyan	10	320	1,200	1,000

Source: Authors' estimation

6.2 Daily Revenue Estimates

Certain assumptions were made. The price of CBG is set at INR 70 per kilogram, Electricity at INR 8 per KWh and biofertilizer concentrate at INR 50 per kilogram (Indian Oil Corporation Limited; Central Electricity Regulatory Commission, 2024; and Business Standard, 2023). Based on these numbers, daily revenue for the five selected APMCs was projected with two combinations — biogas plus biofertilizers and Electricity plus biofertilizers.

Table 3: Consolidated daily revenue by product combination

APMC	Biogas + Biofertilizers (INR/day)	Electricity + Biofertilizers (INR/day)
Vashi	5,79,200	4,76,800
Gultekdi	3,25,800	2,68,200
Kalamna	1,44,800	1,19,200
Nashik City	86,880	71,520
Kalyan	72,400	59,600

Source: Authors' estimation

6.3 Annual Output and Revenue Projections

Annualising the information contained in Table 2 gives us the physical output as shown in Table 4 and corresponding revenue is shown in Table 5.

Table 4: Annualized waste processing and physical output

APMC	Waste (t/yr)	Biogas (t/yr)	Electricity (GWh/yr)	Biofertilizers (t/yr)
Vashi	29,200	934	3.50	2,920
Gultekdi	16,425	525	1.97	1,642
Kalamna	7,300	233	0.87	730
Nashik City	4,380	140	0.52	438
Kalyan	3,650	116	0.43	365

Source: Authors' estimation

Table 5: Annualized revenue by product mix in INR

APMC	Biogas Revenue (INR)	Electricity Revenue (INR)	Biofertilizers Revenue (INR)
Vashi	6,53,80,000	2,80,00,000	14,60,00,000

Gultekdi	3,67,50,000	1,57,60,000	8,21,00,000
Kalamna	1,63,10,000	69,60,000	3,65,00,000
Nashik City	98,00,000	41,60,000	2,19,00,000
Kalyan	81,20,000	34,40,000	1,82,50,000

Source: Authors' estimation

Table 6 aggregates the revenue from the two product mixes in Table 5. The assessment revealed that combining the five selected APMCs revenues — (i) for the biogas plus biofertilizer product mix, the estimated revenue is INR 44.11 crore per annum, and (ii) for the electricity plus biofertilizer product mix, the estimated revenue is INR 36.31 crore per year.

Table 6: Consolidated revenue by product mix

APMC	Biogas + Biofertilizers (INR/yr)	Electricity + Biofertilizers (INR/yr)
Vashi	21,13,80,000	17,40,00,000
Gultekdi	11,88,50,000	9,78,60,000
Kalamna	5,28,10,000	4,34,60,000
Nashik City	3,17,00,000	2,60,60,000
Kalyan	2,63,70,000	2,16,90,000

Source: Authors' estimation

6.4 Aggregate Output for APMC Assessment

Summarising the assessment for the selected five APMCs, projected annual yield is as follows.

- 1,958 tonnes of compressed biogas — equating to roughly 1,39,126 domestic LPG cylinders; or

7.29 GWh of electricity

- The 6,095 tonnes of biofertilizer concentrate was diluted at a ratio of 1:7 with water to yield 48,760 tonnes of finished biofertilizer.

7. Capital Expenditure Needed

The capital expenditure on plants and machinery is estimated at INR 35 lakhs per tonne of organic waste (Entrepreneur India, 2026). Applying this INR 35 lakh per tonne number to the five selected APMCs in Maharashtra gives us the following table.

Table 7: Capital expenditure by APMCs

APMC	Investment per Tonne (INR)	Waste (t/day)	Investment at APMC (INR)
Vashi	35,00,000	80	28,00,00,000
Gultekdi	35,00,000	45	15,75,00,000
Kalamna	35,00,000	20	7,00,00,000
Nashik City	35,00,000	12	4,20,00,000
Kalyan	35,00,000	10	3,50,00,000

TOTAL			58,45,00,000

The above total capital expenditure of INR 58.45 crore is for plant and machinery only. Land acquisition and civil work are additional expenditures. The vacant land issue is mainly restricted to Vashi, while the remaining four — Gultekdi, Kalamna, Nashik City and Kalyan — have less of a land constraint.

8. Impact on APMCs Financials

APMC markets in Maharashtra are supposed to be self-sufficient and manage their day-to-day operations from market fees charged. Table 8 lists the revenue, expenditure and profit for the year 2024/25. This forms the baseline for gauging the impact of the biogas, electricity, and biofertilizer ventures on finances (Vasudeo, 2026).

Table 8: Revenue, expenditure and profit for FY 2024/25 (INR crore)

APMC	Revenue (INR cr.)	Expenditure (INR cr.)	Profit (INR cr.)
Vashi	132.96	121.41	8.44
Gultekdi	106.25	72.26	33.99
Kalamna	50.55	44.09	6.45
Nashik City	23.79	16.77	7.01
Kalyan	11.70	13.28	-1.57

Source: Authors' estimation

Table 9 below shows the impact of the biogas, electricity, and biofertilizer project on the respective APMCs 2024/25 topline, if the respective APMCs were to own 100% of the infrastructure. Under the biogas plus biofertilizer product mix, the expected revenue jump ranges from 10.4% for Kalamna to 22.5% for Kalyan. Under the electricity plus biofertilizer product mix, the expected revenue jump ranges from 8.6% for Kalamna to 18.5% for Kalyan.

Table 9: Projected topline impact of 100% APMC owned infrastructure, marked to 2024/25

APMC	2024/25 Revenue (INR cr.)	Rev. + Biogas+Biofert. (INR cr.) [Δ%]	Rev. + Elec.+Biofert. (INR cr.) [Δ%]
Vashi	132.96	154.09 [+15.89%]	150.36 [+13.08%]
Gultekdi	106.25	118.13 [+11.18%]	116.03 [+9.20%]
Kalamna	50.55	55.83 [+10.44%]	54.89 [+8.58%]
Nashik City	23.79	26.96 [+13.32%]	26.39 [+10.92%]
Kalyan	11.70	14.33 [+22.47%]	13.86 [+18.46%]

Source: Authors' estimation

The above scenario is for a fully APMC-owned project; it is not essential that the respective APMC must bear the entire cost. Realized revenue for the respective APMC will depend on the business model adopted for this venture (see Section 9).

9. Available Business Models

This assessment observed that the APMCs need not have full ownership of the projects mentioned. Three popular business models used in Indian infrastructure projects are available for such ventures; they are —

- Supply, Installation, Testing and Commissioning (SITC) is combined with a separate Operations & Maintenance (O&M) contract, typically involving upfront APMC or government-funded capital expenditure with a private contractor executing and subsequently maintaining the created infrastructure (Solid Waste Management Department, Municipal Corporation of Greater Mumbai, 2022).

- Hybrid Annuity Model (HAM) — capital expenditure shared between the APMC and a private investor, with the investor recovering their investment through annuity payments over the contract agreement (Khan *et al.*, 2026).
- Public Private Partnership (PPP) — private investment, construction and operational risk borne substantially by a private investor under the Maharashtra PPP Policy for APMC Reforms, 2025, with revenue or output sharing defined by contract (Department of Economic Affairs, Government of India, 2026).

Top officials of the Maharashtra State Agriculture Marketing Board, Pune and Vashi APMC have shown good enthusiasm for the assessment of the selected five APMCs for the biogas, electricity, and biofertilizer project from organic waste. They listed three main concerns: (i) land allotment within the APMCs for commissioning of the processing plants, (ii) financing and capital sources for this project and (iii) revenue sharing of biogas, electricity and biofertilizer between the private investor and the respective APMC (Vasudeo, 2026).

10. Discussion: Scalability and Broader Implications

The assessment of the selected five APMCs — Vashi, Gultekdi, Kalamna, Nashik City and Kalyan — showcases biogas, electricity and biofertilizer from the organic waste project and its viability for a much larger scale at a later date. These five APMCs have adequate feedstock of organic waste to make a strong beginning, where we can show that instead of just discarding the market unworthy produce, it can be converted into something of value, which can generate a revenue stream for the APMCs in the state of Maharashtra. Apart from marketing services to farmers, the APMC can also give back to their farming community by providing them with much-needed valuable biofertilizer concentrate at affordable rates. Once successful at these five APMCs, this project can be scaled up to all the APMCs across Maharashtra's eight administrative divisions.

Moving beyond the APMC network, organic waste from municipal corporations and councils can be processed into biogas, electricity and biofertilizer. The generated compressed biogas can be filled into cylinders and distributed as vehicle-grade CNG, and the generated electricity can be used captively by the APMC, with residual electricity transferred to a grid. Finally, the prepared biofertilizer concentrate can be reverse-marketed back to farmers via the APMC pan-Maharashtra network.

Finally, at a national level, well-planned conversion of organic waste into biogas, electricity and biofertilizers would address five distinct policy objectives simultaneously —

- Reduced dependence on imported natural gas for cooking and other uses
- Improved on-ground availability of organic fertiliser, enabling wider adoption of organic farming
- Potential public health gains from higher organic produce consumption by our population
- Improved soil health from sustained organic fertiliser use
- A reduction in India's fertilizer raw-material and finished-product import bills.

11. Conclusion

This study evaluated five lead APMC markets in Maharashtra to derive more commercial value from their generated discard-worthy unmarketable produce, which is generally labelled as organic waste, by converting it into biogas, electricity and biofertilizer via commissioned projects. Financial mathematics reveals that the five selected APMCs would require an investment of INR 58.45 crore in plant and machinery to operationalize such initiatives, which would provide them with an additional annual revenue of INR 44.11 crore. There are three business models available to the APMC for the execution of these ventures: SITC, HAM, and PPP. The organic waste conversion project is well aligned with the Government of India and Government of Maharashtra's policy direction, and the Maharashtra State Agriculture and Marketing Board, Pune is happy to work on this once their reservations are addressed.

The next step from this assessment is to prepare a detailed project report, followed by a phased scale-up across Maharashtra's eight administrative divisions for a wider rollout among the APMC network.

Author Contributions

Conceptualization, V. V. and S.K.K.; methodology, V.V. and S.R.D.; validation, V.V., S.R.D. and S.S.N.; formal analysis, V.V.; investigation, V.V.; resources, V.V.; data curation, V.V.; writing—original draft preparation, V.V.; writing—review and editing, S.R.D., S.S.N. and S.K.K.; visualization, V.V.; supervision, S.K.K. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Data Availability Statement

The data supporting the reported results were obtained from a primary field survey conducted by the authors and from officials of the Maharashtra State Agriculture and Marketing Board, Pune and APMC Vashi, Mumbai. Aggregated data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors gratefully acknowledge the guidance and support of the Maharashtra State Agriculture and Marketing Board, Pune and the officials of APMC Vashi, Mumbai, during the field survey and data compilation for this study.

REFERENCES

1. Annual Report 2024-25. (2025). Central Pollution Control Board (CPCB). https://cpcb.gov.in/
2. Bakshi, P., & Gupta, P. Operationalising the India–Japan Cooperative Biogas for Growth Initiative. Observer Research Foundation. https://orfme.org/expert-speak/operationalising-the-india-japan-cooperative-biogas-for-growth-initiative/
3. Bhoi, B., Kundu, S., Kishore, V., & Suganthi, D. (2019). Supply chain dynamics and food inflation in India. RBI Bulletin.
4. Boraiah, K. M., Basavaraj, P. S., Kakade, V. D., Harisha, C. B., Khapte, P., Halagundegowda, G. R., Kulshreshtha, N., et al. (2023). Abiotic stress-tolerant crop varieties in India: Status and a way forward. In Recent Trends in Plant Breeding and Genetic Improvement. IntechOpen. https://doi.org/10.5772/intechopen.1001916
5. Central Electricity Regulatory Commission – Renewable Energy Tariff Regulations, 2024. (2024). https://cercind.gov.in/regulations/189-Noti.pdf
6. Chandrashekhar, K., & Pandey, S. (2018). GOBAR-DHAN – Re-emphasizing India's traditional practices. TERI. https://www.teriin.org/article/gobar-dhan-re-emphasizing-indias-traditional-practices
7. Chauhan, A., Upadhyay, S., Saini, G., & Senthilkumar, N. (2022). Agricultural crop residue based biomass in India: Potential assessment, methodology and key issues. Sustainable Energy Technologies and Assessments, 53(Part B). https://doi.org/10.1016/j.seta.2022.102552
8. Chavan, S. (2025). India organic fertilizer market size, share and growth forecast for 2025–2032. Persistence Market Research. https://www.persistencemarketresearch.com/market-research/india-organic-fertilizer-market.asp
9. Compendium of frequently asked questions on compressed biogas and SATAT scheme. Indian Oil Corporation Limited. https://iocl.com/download/Frequently_Asked_Questions_on_CBG.pdf
10. Compressed Biogas (CBG) plant: ₹30 crore business with 4–6 year payback. (2026). Entrepreneur India. https://www.entrepreneurindia.co/blogs/compressed-biogas-cbg-plant/
11. Department of Economic Affairs, Government of India. (2026). Gobardhan Bio CNG plant. https://www.pppinindia.gov.in/bestpractices/best-practice-detail/gobardhan-bio-cng-plant
12. Dikshit, A. K., & Birthal, P. (2010). Environmental value of dung in mixed crop-livestock systems. Indian Journal of Animal Sciences, 80(7). https://www.researchgate.net/publication/292638807

13. Evans, D., & Popova, A. (2017). Cash transfers and temptation goods. Economic Development and Cultural Change, 65(2). https://doi.org/10.1086/689575
14. Fasake, V., & Dashora, K. (2021). A sustainable potential source of ruminant animal waste material (dung fiber) for various industrial applications: A review. Bioresource Technology Reports, 15. https://doi.org/10.1016/j.biteb.2021.100693
15. Fishman, R., Lall, U., Modi, V., & Parekh, N. (2016). Can electricity pricing save India's groundwater? Field evidence from a novel policy mechanism in Gujarat. JAERE. http://dx.doi.org/10.1086/688496
16. Fix fair, remunerative price of Rs 5.5/kg for fermented organic manure: IBA. (2023). Business Standard. https://www.business-standard.com/india-news/fix-fair-remunerative-price-of-rs-5-5-kg-for-fermented-organic-manure-iba-123082700199_1.html
17. Garkoti, P., & Thengane, S. (2025). Identifying and overcoming barriers to large-scale biogas dissemination in India through stakeholder-led SWOT analysis. Sustainable Energy Technologies and Assessments, 83. https://doi.org/10.1016/j.seta.2025.104610
18. Ghag, N., Shedage, S., Sonar, H., & Jagtap, S. (2025). Unveiling the hurdles confronting compressed biogas plants: A comprehensive research analysis for sustainable energy solution. Applied Sciences, 7. https://doi.org/10.1007/s42452-025-07213-9
19. Ghosh, S. (2026). From biogas plants to climate-resilient farms. Global Agriculture. https://www.global-agriculture.com/ag-tech-research-news/from-biogas-plants-to-climate-resilient-farms/
20. GOBARdhan Scheme. (2026). Press Information Bureau. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2222150&reg=3&lang=1
21. GOBARdhan Waste to Wealth. (2021). Ministry of Jal Shakti. https://tnrd.tn.gov.in/project/go_files/4_595_2021_S18017.pdf
22. Gupta, R., Benbi, D. K., & Abrol, I. P. (2021). Indian agriculture needs a strategic shift for improving fertilizer response and overcome sluggish foodgrain production. Journal of Agronomy Research, 4(3). https://doi.org/10.14302/issn.2639-3166.jar-21-4018
23. Handling of Agricultural Waste in APMCs. (2013). National Institute of Agricultural Marketing. https://ccsniam.gov.in/img/2013_agri_waste_mgmt_by_dr_saswati_bose.pdf
24. India Organic Fertilizer Market. (2026). Fairfield Market Research. https://www.fairfieldmarketresearch.com/report/india-organic-fertilizer-market
25. India Organic Fertilizer Market Size & Share Analysis – Growth Trends and Forecast (2025–2030). (2025). Mordor Intelligence. https://www.mordorintelligence.com/industry-reports/india-organic-fertilizer-market
26. India's compressed biogas and the SATAT scheme: A pathway to net-zero emissions by 2070. (2024). Organiser. https://organiser.org/2024/10/05/259038/bharat/indias-compressed-biogas-and-the-satat-scheme-a-pathway-to-net-zero-emissions-by-2070/
27. Jumrani, J., & Birthal, P. S. (2017). Does consumption of tobacco and alcohol affect household food security? Evidence from rural India. Food Security, 9, 255–279. https://doi.org/10.1007/s12571-017-0660-8
28. Juneja, R., Nand, S., Johny, E. T., & Gulati, A. (2026). De-risking fertiliser supplies for India amid rising geopolitical risks. Indian Council for Research on International Economic Relations. https://icrier.org/pdf/De-risking-Fertiliser-Supplies-for-India-amid-Rising-Geopolitical-Risks.pdf
29. Kapoor, A., & Anand, M. (2024). Addressing groundwater depletion crisis in India: Institutionalizing rights and technological innovations. Economic Advisory Council to the Prime Minister. https://eacpm.gov.in/wp-content/uploads/2024/05/Addressing_Groundwater_Depletion_in_India.pdf
30. Kaur, G., Sharma, N. K., Kaur, J., Bajaj, M., Zawbaa, H., Turky, R., & Kamel, S. (2022). Prospects of biogas and evaluation of unseen livestock based resource potential as distributed generation in India. Ain Shams Engineering Journal, 13. https://doi.org/10.1016/j.asej.2021.101657
31. Khan, A., Mishra, S., Das, R., & Singh, P. (2026). Organic waste circular economy for Viksit Bharat: Jobs, investment, and emissions pathways to 2047. Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/organic-waste-managemen-powering-jobs-and-growth-for-viksit-bharat-2047.pdf
32. Kulkarni, A., Shastri, Y., & Kumar, M. (2025). Compressed biogas production from agricultural residues in India: A techno-enviro-economic overview. Renewable and Sustainable Energy Reviews, 219. https://doi.org/10.1016/j.rser.2025.115888
33. Kumar, A., & Agrawal, A. (2020). Recent trends in solid waste management status, challenges, and potential for the future Indian cities – A review. Current Research in Environmental Sustainability. http://dx.doi.org/10.1016/j.crsust.2020.100011
34. Kumar, R. (2026). Paying more, getting less: India's fertilizer subsidy paradox. The Secretariat. https://thesecretariat.in/article/paying-more-getting-less-india-s-fertilizer-subsidy-paradox
35. Maharashtra Agricultural Competitiveness Report. (2010). World Bank. https://documents1.worldbank.org/curated/en/400941468259132423/pdf/545320PAD0P1201Official0Use0Only191.pdf
36. Maharashtra State Compressed Biogas (CBG) Policy, 2026. (2026). https://uncomplycate.com/wp-content/uploads/2026/05/Maharashtra-State-Compressed-Biogas-CBG-Policy-2026-may052026.pdf

37. Mehta, C. R., Chandel, N. S., Jena, P. C., & Jha, A. (2019). Indian agriculture counting on farm mechanization. Agricultural Mechanisation in Asia, Africa and Latin America, 50(1). https://www.researchgate.net/profile/Narendra-Chandel-2/publication/331633501
38. Methane mitigation: Lessons learned from India's compressed biogas (renewable natural gas) projects, January 2025. (2025). Global Methane Initiative. https://www.globalmethane.org/documents/CBG_Report_January2025.pdf
39. Mittal, S., Ahlgren, E., & Shukla, P. R. (2018). Barriers to biogas dissemination in India. Energy Policy, 112. https://doi.org/10.1016/j.enpol.2017.10.027
40. Natarajan, A., Chander, M., & Bharathy, N. (2016). Relevance of draught cattle power and its future prospects in India: A review. Agricultural Reviews, 37(1), 49–54. https://doi.org/10.18805/ar.v37i1.9264
41. Nath, I., Dutta, P. L., Kumar, M., Vairagar, V. G., Mahawar, P., Shashidhar, K. S., Mahiboobsa, M., et al. (2025). Multi-stress-tolerant varieties: The future of agronomic crop breeding in India. International Journal of Research in Agronomy. https://doi.org/10.33545/2618060X.2025.v8.i8Sc.3510
42. Neogi, S., & Ghosh, B. K. (2022). Evaluation of crop diversification on Indian farming practices: A panel regression approach. Sustainability. https://doi.org/10.3390/su142416861
43. Patel, A., Gami, B., Patel, B., Parmar, V., & Patel, P. (2024). Cost benefit and environmental impact assessment of compressed biogas (CBG) production from industrial, agricultural, and community organic waste from India. Biomass Conversion and Biorefinery, 14, 4123–4137. https://doi.org/10.1007/s13399-022-02780-y
44. Patil, S. (2023). India's move to organic fertilizer: Ambitions and realities. S&P Global. https://www.spglobal.com/energy/en/news-research/blog/agriculture/051023-fertecon-india-organic-farming-chemical-fertilizers
45. PPP Policy for APMC Reforms in Maharashtra, 2025. https://cdnbbsr.s3waas.gov.in/s392c5ad73d34a8c18d276a0f0b60ea745/uploads/2025/11/20251112495453780.pdf
46. Raising agricultural productivity and making farming remunerative for farmers. (2015). NITI Aayog. https://www.niti.gov.in/sites/default/files/2022-11/Raising-Agricultural-Productivity-and-Making-Farming-Remunerative-for-Farmers.pdf
47. Ramachandran, N., Nithiyanandam, Y., & Manur, A. (2026). Geopolitics of fertiliser supply in India. The Takshashila Institution. https://takshashila.org.in/content/publications/assets/20260402-Fertilizer-Geopolitics.pdf
48. Rao, S. U. (2025). The seed of India's future: Why procuring quality seeds is crucial for agricultural resilience. The Fourth Plate. https://thefourthplate.com/2025/10/17/the-seed-of-indias-future-why-procuring-quality-seeds-is-crucial-for-agricultural-resilience/
49. Rathore, S., & Chauhan, S. (2025). Implementation, impact, and challenges of eNAM in agricultural markets – A systematic literature review (SLR). International Journal of Scientific Research in Engineering and Management. https://doi.org/10.55041/IJSREM41224
50. Report on CBG in India: Demand-supply outlook and pipeline connectivity with CGD. (2025). Deloitte Touche Tohmatsu India LLP. https://pngrb.gov.in/pdf/CaseStudies/20251003_CSAUTH_CBG.pdf
51. Sayre, S. S., & Taraz, V. (2019). Groundwater depletion in India: Social losses from costly well deepening. Journal of Environmental Economics and Management, 93. https://doi.org/10.1016/j.jeem.2018.11.002
52. Selvaraj, K. N., & Karunakaran, K. R. (2022). Agricultural marketing reforms in India: Future challenges and opportunities. FFTC Agricultural Policy Platform. https://ap.fftc.org.tw/article/3256
53. Shrivastava, A. K., Khandelwal, N. K., Dubey, R. K., & Guru, P. K. (2021). Long term study of declining animal usage in Indian agriculture. CIGR Journal, 23(1).
54. Singh, A. (2021). Assessment of bioenergy generation potential of agricultural crop residues in India. Circular Economy and Sustainability. https://www.academia.edu/119916620
55. Singh, D., Tembhare, M., & Kumar, S. (2023). Compressed biogas plants in India: Existing status, technological advances and challenges. Biomass and Bioenergy. https://doi.org/10.1016/j.biombioe.2023.106964
56. Singh, P., & Kalamdhad, A. (2022). Assessment of agricultural residue-based electricity production from biogas in India: Resource-environment-economic analysis. Sustainable Energy Technologies and Assessments, 54. https://doi.org/10.1016/j.seta.2022.102843
57. Singh, P., & Kalamdhad, A. (2024). Unravelling barriers associated with dissemination of large-scale biogas plant with analytical hierarchical process and fuzzy analytical hierarchical process approach: Case study of India. Bioresource Technology, 413. https://doi.org/10.1016/j.biortech.2024.131543
58. Solid Waste Management Department, Municipal Corporation of Greater Mumbai. (2022). Supply, installation, testing & commissioning (SITC) of 09 nos. (2 MT/day capacity each) of bio-methanation plants with its operation & maintenance for the period of 5 years at various locations within BMC limits. https://www.mcgm.gov.in/irj/go/km/docs/documents/Tenders/ETH/ETH_7000018982_060722.pdf
59. Solid Waste Management Rules 2026. (2026). https://data.opencity.in/dataset/0726dd20-6d63-46fa-8c95-c41c20019cdf/resource/f9ba12fc-f9e6-4847-95e3-e7b64a2221a8/download/new-swm-rules.pdf
60. Sural, S. (2025). Climate-resilient crops: Viable solution that needs a stronger push. Down To Earth. https://www.downtoearth.org.in/agriculture/climate-resilient-crops-viable-solution-that-needs-a-stronger-push
61. Suri, S. (2026). Impact of the Middle East crisis on the Indian agricultural sector. Observer Research Foundation. https://www.orfonline.org/expert-speak/impact-of-the-middle-east-crisis-on-the-indian-agricultural-sector
62. Sustainable Alternative Towards Affordable Transportation (SATAT) Scheme. (2018). https://satat.co.in/satat/#/

63. Thapa, B., Goyal, R., Mathur, A., Khandelwal, A., & Jha, C. (2026). AI in agriculture: Unlocking new frontiers for crop diversification in India. Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/how-can-ai-in-agriculture-drive-crop-diversification-in-india.pdf
64. The Fertiliser Control Order 1985. (1985). https://faolex.fao.org/docs/pdf/ind129935.pdf
65. Vasudeo, V. (2026). Estimation and optimisation of profit for tomato farmers in Nashik and Pune districts, and banana farmers in Jalgaon district: With a solution of real time profit function. University of Mumbai.
66. Velayudhan, P. K., Singh, A., Jha, G. K., Kumar, P., & Thanaraj, K. I. (2021). What drives the use of organic fertilizers? Evidence from rice farmers in Indo-Gangetic Plains, India. Sustainability, 13. https://doi.org/10.3390/su13179546
67. Waste management policies for sustainable utilization of waste. (2025). Press Information Bureau. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2150212&reg=3&lang=1
68. Yadav, K., & Sircar, A. (2022). Fundamentals and developments of compressed biogas in city gas distribution network in India: A review. Petroleum Research, 7(3). https://doi.org/10.1016/j.ptlrs.2021.12.003
69. Yadava, D. K., Singh, R. K., Patel, V. B., Sharma, T. R., Singh, S. K., Pandey, S., Choudhury, P. R., et al. (2025). Climate resilient crop varieties: Mainstreaming to improve yield and moderate farmers' risk. Anthropocene Science, 4, 295–328. https://doi.org/10.1007/s44177-025-00103-0