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Operational Sustainability and Environmental Risks of ODF Plus Waste Management Systems in Rural Assam: A Circular Economy Perspective

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Abstract

The transition from Open Defecation Free (ODF) status to ODF Plus (ODF+) under the Swachh Bharat Mission-Gramin represents a significant shift in India's rural sanitation agenda from infrastructure creation toward sustainable Solid and Liquid Waste Management (SLWM). In Assam, numerous Central Processing Units (CPUs) were established across Gram Panchayats to operationalize decentralized waste management systems. However, despite substantial public investment, many of these facilities remain non-functional or severely underutilized due to technical, institutional, and financial constraints. This study critically examines the operational sustainability of ODF+ waste management systems in rural Assam and assesses their associated environmental risks within the broader framework of circular economy transition.

The study adopts a systematic desk-research methodology based entirely on secondary data collected from government reports, policy documents, environmental studies, SBM-G records, institutional assessments, and published literature. A triangulation-based analytical framework was used to evaluate infrastructure functionality, governance capacity, financial sustainability, and environmental impacts. The analysis integrates infrastructure gap assessment, spatial-environmental nexus mapping, and policy-economic comparison to identify systemic weaknesses in rural waste management systems. Findings reveal a significant disconnect between sanitation infrastructure creation and long-term operational sustainability. Most Gram Panchayats lack trained technical personnel, maintenance systems, and reliable operational financing mechanisms, resulting in idle machinery and dysfunctional waste-processing facilities. The study further identifies severe environmental externalities arising from unmanaged waste accumulation, including leachate contamination of wetlands, ponds, irrigation canals,

groundwater systems, and agricultural land. In Assam's flood-prone rural landscape, seasonal inundation intensifies the spread of pollutants, threatening fisheries, soil health, water quality, and agrarian livelihoods.

The paper argues that the current subsidy-dependent sanitation model is structurally unsustainable and incapable of ensuring long-term environmental protection or economic resilience. To address these challenges, the study proposes a phased transition toward decentralized circular economy frameworks emphasizing waste recovery, user-fee systems, women-led Self-Help Group (SHG) management models, technical skill development, market integration for compost and recyclables, and climate-resilient infrastructure planning. The study concludes that the sustainability of ODF+ systems in rural Assam depends not merely on infrastructure expansion, but on the creation of locally embedded institutional ecosystems capable of integrating technical capacity, financial viability, environmental governance, and circular economic value generation within climate-vulnerable rural regions.

Key words: decentralized, operational sustainability, circular economy, resilience,

The transition from basic sanitation to a self-sustaining circular economy represents the next frontier in India's rural development agenda. Under the Swachh Bharat Mission (Gramin) (SBM-G), the state of Assam achieved Open Defecation Free (ODF) status in 2019, marking a major milestone in rural sanitation coverage. Following this achievement, the development focus shifted toward ODF Plus (ODF+), which emphasizes the scientific management of Solid and Liquid Waste Management (SLWM) systems to ensure environmental sustainability and long-term sanitation outcomes.

To operationalize ODF+ mandates, numerous Gram Panchayats across rural Assam established Central Processing Units (CPUs) equipped with waste segregation and processing machinery. These facilities were envisioned as decentralized waste management hubs capable of processing biodegradable and non-biodegradable waste streams at the local level. However, despite substantial infrastructural investments, a significant number of these CPUs remain either non-functional or severely underutilized.

The operational paralysis of rural waste management infrastructure is primarily linked to three interrelated challenges: the acute shortage of local technical expertise, weak institutional management systems, and the absence of financially sustainable operational models. Most Gram Panchayats continue to rely heavily on irregular government grants and external financial support to sustain routine operation and maintenance activities. In many cases, machinery installed under SBM-G remains idle due to the absence of trained operators, delayed repair mechanisms, and poor revenue generation capacity.

The environmental implications of these failures are increasingly visible across rural Assam. Improperly managed solid and liquid waste often accumulates near settlements, drainage channels,

ponds, and agricultural lands. Over time, leachate generated from unmanaged waste infiltrates nearby water bodies and soil systems, contributing to contamination of shallow groundwater, irrigation canals, and cultivable land. In an agrarian state such as Assam—where fisheries, agriculture, wetlands, and floodplain ecosystems form the foundation of rural livelihoods—such contamination directly threatens ecological stability and economic productivity.

The issue is particularly significant in flood-prone regions of Assam, where seasonal inundation accelerates the spread of untreated waste into rivers, wetlands, and agricultural fields. The absence of sustainable waste management systems therefore creates a cyclical environmental burden that undermines public health, water security, and rural economic resilience.

Against this backdrop, the present study seeks to critically examine the operational and environmental dimensions of ODF+ implementation in rural Assam. The study investigates the institutional, technical, and financial gaps responsible for the underperformance of Central Processing Units while simultaneously evaluating the ecological risks associated with unmanaged waste systems. Further, the research proposes a strategic roadmap for transitioning rural Assam from subsidy-dependent sanitation infrastructure toward decentralized, financially viable circular economy frameworks capable of transforming waste into a productive resource.

1.1. Gap in Research

Despite growing national attention toward ODF Plus implementation, existing literature primarily focuses on sanitation coverage and infrastructure creation rather than the long-term operational sustainability of rural waste management systems. Limited research has systematically examined the intersection between institutional failure, subsidy dependence, environmental degradation, and circular economy transition within the context of Assam's flood-prone rural landscape. Furthermore, studies rarely connect dysfunctional sanitation infrastructure with agrarian ecological risks such as wetland contamination, fisheries decline, and soil degradation. This study attempts to address these gaps by integrating governance analysis, environmental risk assessment, and circular economy perspectives into a unified analytical framework.

1.2. Objectives of the Study

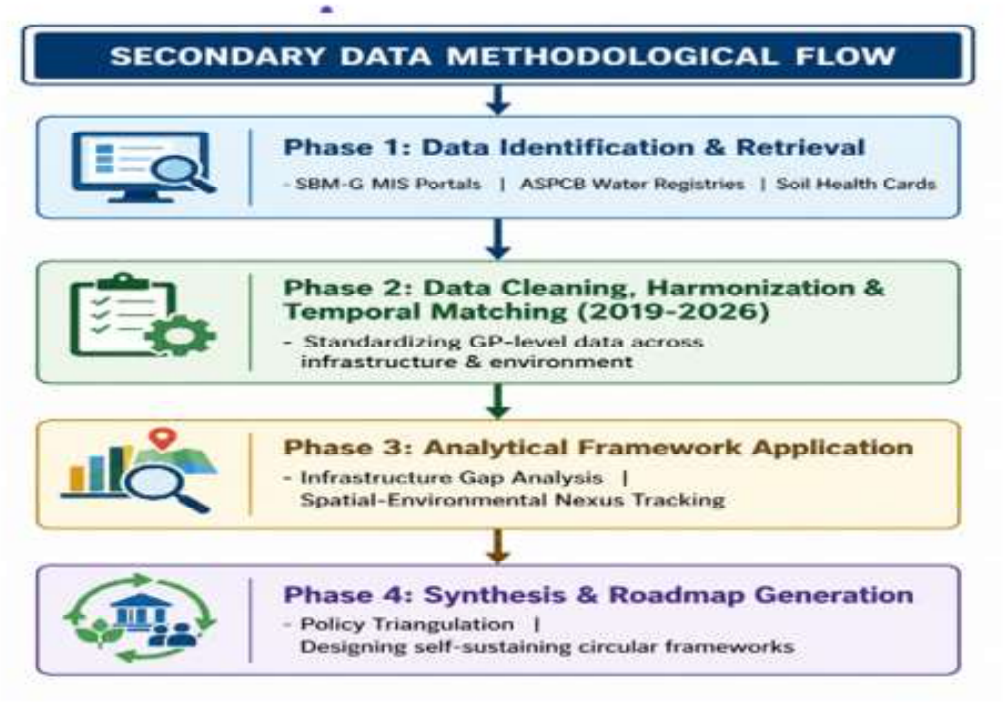
The study is guided by the following objectives:

1. To assess the operational status of Central Processing Units (CPUs) established under ODF+ initiatives in rural Assam and identify the technical, institutional, and financial factors responsible for their underutilization or non-functionality.
2. To evaluate the environmental impacts of unmanaged solid and liquid waste, particularly leachate contamination affecting ponds, irrigation canals, groundwater systems, and agricultural soil in rural Assam.
3. To examine the fiscal sustainability of existing rural waste management systems and analyze the extent of dependence on government subsidies and external financial assistance.

4. To investigate the relationship between dysfunctional waste infrastructure and ecological degradation within Assam's rural agrarian economy.
5. To formulate a strategic roadmap for transforming rural sanitation systems from subsidy-driven infrastructure models into self-sustaining circular economy frameworks based on waste recovery, resource efficiency, and localized revenue generation.

1.3. Research Methodology

This study adopts a systematic desk-research design, relying entirely on the extraction, triangulation, and synthesis of secondary data. Since the research evaluates institutional, financial, and environmental gaps across rural Assam, a multi-sectoral macro-approach is utilized. This setup links public infrastructure data with environmental quality registries without requiring new primary field samples. (Fig. 1)



1.4. Inclusion and Exclusion Criteria

To ensure data integrity and relevance, strict boundaries are set for the desk research:

- Inclusion Criteria: Data focused on rural areas (Gram Panchayats) within Assam; datasets covered the timeline from 2019 (post-ODF declaration) to the present; environmental data were linked to parameters influenced by waste (e.g., leachate indicators).
- Exclusion Criteria: Data explicitly representing urban municipal corporations (e.g., Guwahati Municipal Corporation) were excluded. Incomplete or unverified datasets from non-governmental portals omitted to preserve statistical reliability.

1.5. Data Analysis and Triangulation Framework

The study processed the secondary data using a three-stage analytical framework:

1. Infrastructure Gap Analysis: A comparative assessment matching established physical infrastructure assets against actual processing metrics. This uncovers the exact point where operational failure occurs (e.g., collection vs. segregation vs. processing).
2. Spatial-Environmental Nexus Mapping: Cross-referencing areas with high densities of non-functional CPUs against regional water and soil degradation reports. This links infrastructure failure directly to ecological damage in the rural economy.
3. Policy and Economic Triangulation: Comparing financial constraints in Assam's Gram Panchayats with successful circular economic policies used elsewhere. This analysis identifies regulatory bottlenecks and forms the basis for the final revival roadmap.

2. Review of Literature

The existing body of literature on rural sanitation in India demonstrates that achieving Open Defecation Free (ODF) status was only the first stage of a much broader sanitation transformation process. The Swachh Bharat Mission-Gramin (SBM-G) Phase I primarily focused on eliminating open defecation through toilet construction and behavioral change campaigns. This phase significantly expanded sanitation access across rural India and contributed to substantial improvements in household toilet coverage (UNICEF India, 2022). However, scholars argue that the transition to SBM-G Phase II, commonly referred to as ODF Plus, introduced a far more complex challenge by emphasizing Solid and Liquid Waste Management (SLWM) systems (NITI Aayog, 2024). Unlike toilet construction, which largely depends on household-level adoption, ODF Plus requires coordinated community-wide infrastructure, continuous technical management, institutional accountability, and long-term financial sustainability (Patel & Singh, 2024).

Researchers highlight that sustainable rural sanitation now depends not only on behavioral compliance but also on the effective management of waste generated within villages. This includes waste collection, segregation, transportation, treatment, recycling, composting, and safe disposal mechanisms (Ministry of Jal Shakti, 2024). Consequently, the focus of rural sanitation policy has gradually shifted from infrastructure creation alone toward the establishment of integrated environmental management systems capable of operating sustainably over time (NITI Aayog, 2024).

A major theme emerging from the literature is the institutional and technical weakness of decentralized waste management systems in rural areas. Several studies observe that Gram Panchayats (GPs), despite being responsible for implementing SLWM activities, often lack trained technical personnel and operational expertise (Visakhapatnam Rural Governance Studies, 2025). Waste-processing machinery such as plastic shredders, balers, composting units, and segregation systems require regular operation, repair, and maintenance, yet rural institutions frequently do not possess the human resources necessary to manage these technologies effectively (IDR, 2025).

As a result, many waste-processing facilities become partially functional or completely non-operational shortly after installation. Scholars commonly describe these infrastructures as “white elephant assets,” referring to facilities created through significant capital investment but rendered ineffective because of weak operational planning (IDR, 2025). The problem is further intensified by fragmented governance structures, where one department is responsible for infrastructure construction while another is expected to manage operation and maintenance without adequate technical or financial support (Visakhapatnam Rural Governance Studies, 2025). Delayed repairs, shortage of spare parts, and dependence on external technicians further reduce the long-term functionality of these systems.

The literature also emphasizes the absence of localized technical training ecosystems in rural regions. Rural youth and community workers are rarely provided with specialized skill development related to waste management technologies. Consequently, villages remain dependent on external agencies for technical support, which increases operational costs and delays maintenance activities (Patel & Singh, 2024). Scholars therefore advocate for decentralized capacity-building programs, technical training centers, and community-based management systems to improve the sustainability of SLWM infrastructure (NITI Aayog, 2024).

Financial sustainability represents another critical challenge identified in rural sanitation studies. Research consistently shows that while government schemes provide substantial support for initial capital expenditure (CapEx), Gram Panchayats struggle to manage recurring operational expenditure (OpEx) (IDR, 2025). Routine expenses such as labor wages, machinery maintenance, transportation, electricity, and fuel costs often exceed the financial capacity of local institutions. In many cases, sanitation systems deteriorate because there are insufficient financial provisions for long-term operation and maintenance (Visakhapatnam Rural Governance Studies, 2025).

Studies further reveal that local revenue-generation mechanisms remain weak in most rural waste management systems. User-fee collection is often poorly implemented due to limited administrative capacity and low public willingness to pay for sanitation services. Similarly, market linkages for compost, recyclable plastics, and other recovered materials remain underdeveloped, reducing the economic viability of decentralized waste systems (IDR, 2025). As a result, many rural sanitation projects continue to depend heavily on government subsidies and external financial assistance.

To overcome these structural limitations, contemporary environmental economics increasingly promotes the integration of circular economy principles into rural sanitation planning (Ellen MacArthur Foundation, 2023). Circular economy models conceptualize waste as a recoverable resource rather than merely a disposal problem. Under this framework, biodegradable waste can be converted into compost or organic fertilizer, while recyclable materials such as plastics can be aggregated, processed, and sold within secondary markets (Ellen MacArthur Foundation, 2023).

Studies from different Indian states demonstrate that decentralized recycling systems, compost production units, and waste-to-wealth initiatives can simultaneously generate local income, create rural employment opportunities, and reduce environmental pollution (NITI Aayog, 2024). Successful circular economy models are generally characterized by strong institutional coordination, technical training, community participation, and stable market connections for recovered materials (Patel & Singh, 2024). Scholars argue that rural waste management systems become sustainable only when they evolve from subsidy-dependent schemes into locally embedded economic ecosystems capable of financing routine operational costs through resource recovery and revenue generation (Ellen MacArthur Foundation, 2023).

Environmental literature strongly associates unscientific waste disposal with severe ecological and public health risks. Open dumping and poorly managed waste sites generate toxic leachate containing organic pollutants, pathogens, and hazardous substances (Patel & Singh, 2024). During rainfall, this contaminated liquid infiltrates soil and nearby water systems, degrading environmental quality. In ecologically sensitive and flood-prone regions such as Assam, the risks become significantly more severe because ponds, wetlands, irrigation canals, and floodplain ecosystems remain closely interconnected (NITI Aayog, 2024).

Research conducted in rural environments indicates that unmanaged waste disposal can increase Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Dissolved Solids (TDS) in local water bodies, thereby reducing water quality and threatening aquatic ecosystems (Patel & Singh, 2024). Fisheries are particularly vulnerable because elevated pollution levels reduce dissolved oxygen in water, affecting fish survival and productivity. The literature also highlights the impact of waste contamination on agriculture and soil health.

Polluted irrigation water and waste residues can disrupt soil nutrient composition, reduce fertility, and introduce toxic substances such as microplastics into agricultural systems (NITI Aayog, 2024). In flood-prone alluvial regions, seasonal flooding further amplifies environmental risks by spreading waste materials and contaminants across agricultural fields, wetlands, and grazing lands. Livestock systems and rural food chains therefore become increasingly exposed to long-term ecological degradation (Patel & Singh, 2024).

Overall, the literature suggests that the sustainability of ODF Plus initiatives depends on a comprehensive integration of technical capacity, institutional governance, financial viability, environmental protection, and community participation. Researchers widely agree that rural sanitation systems cannot remain effective through infrastructure creation alone. Instead, long-term success requires decentralized operational systems, skilled local institutions, circular economy-based financial mechanisms, and environmentally sustainable waste management practices capable of supporting rural development over time (UNICEF India, 2022; NITI Aayog, 2024; Ellen MacArthur Foundation, 2023).

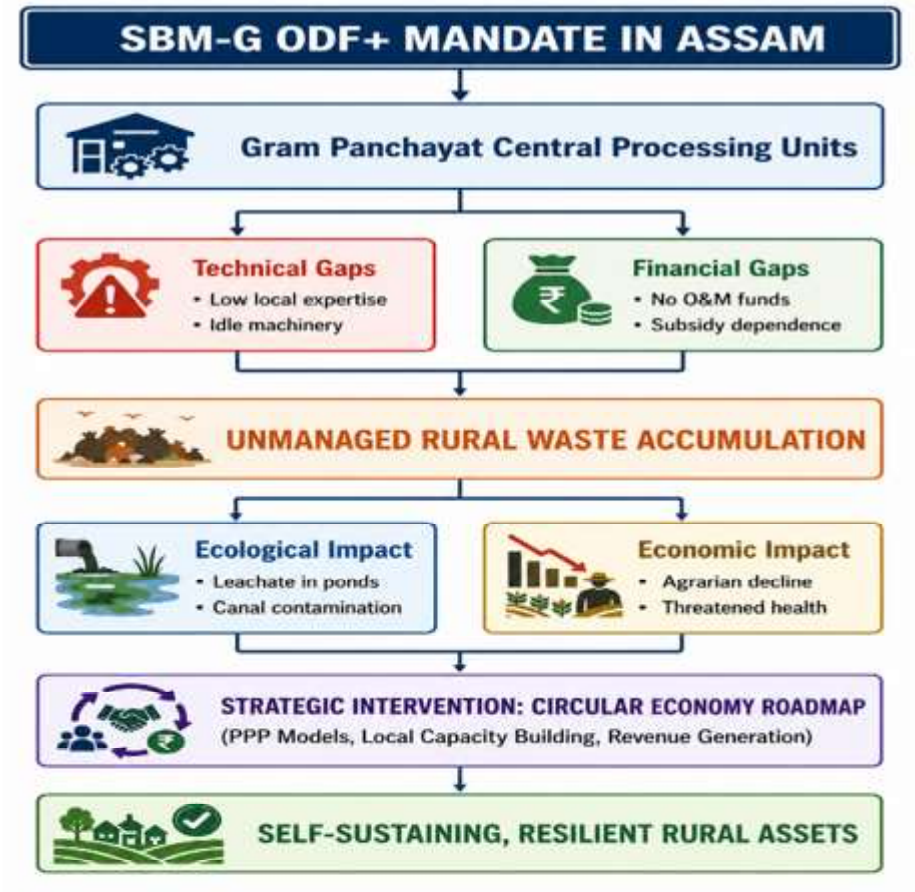
3. Conceptual Framework

The study adopts a "Systemic Failure to Circular Recovery" conceptual framework. The framework illustrates how institutional, technical, and financial deficiencies interact to produce infrastructure failure, environmental degradation, and economic vulnerability.

The framework begins with inadequate technical capacity, weak governance structures, and subsidy dependence at the Gram Panchayat level. These constraints contribute to the underutilization or non-functionality of Central Processing Units, leading to improper waste disposal and unmanaged leachate generation.

Environmental degradation emerges through contamination of water bodies, agricultural land, and rural ecosystems. The resulting ecological stress negatively affects agriculture, fisheries, rural health, and livelihood systems.

The recovery pathway proposed within the framework emphasizes technical strengthening, institutional reform, financial sustainability, community participation, and circular economy integration. Through waste recovery and decentralized revenue generation, the framework envisions the transformation of rural sanitation infrastructure into environmentally sustainable and economically resilient systems.



4. Situation Analysis

The current state of Solid and Liquid Waste Management (SLWM) in rural Assam presents a stark contrast between rapid physical infrastructure development and severe operational stagnation. This situation analysis breaks down the socio-technical, financial, and environmental conditions across the state's Gram Panchayats (GPs) following the 2019 Open Defecation Free (ODF) milestone.

4.1 The Operational Status of Central Processing Units (CPUs)

Under the Swachh Bharat Mission-Gramin (SBM-G) Phase II, hundreds of Central Processing Units (CPUs) were built across Assam's 33 districts to act as decentralized hubs for sorting and processing waste. However, administrative registries and field assessments reveal a widespread breakdown in functionality:

- Idle Physical Infrastructure: While concrete structures, material recovery facilities (MRFs), and compost pits are physically intact, a high percentage of units operate far below capacity or have been abandoned entirely.
- Mechanical Obsolescence: Technical assets such as plastic shredders, bailing machines, and organic trammels sit idle. Without routine operation, this machinery suffers from moisture damage and rust, exacerbated by Assam's humid climate.
- The SBM-G MIS Paradox: Government dashboards show high numbers of "completed assets." However, these figures reflect capital construction rather than active daily operations. The data shows a widening gap between the infrastructure built and the actual tons of waste processed per day.

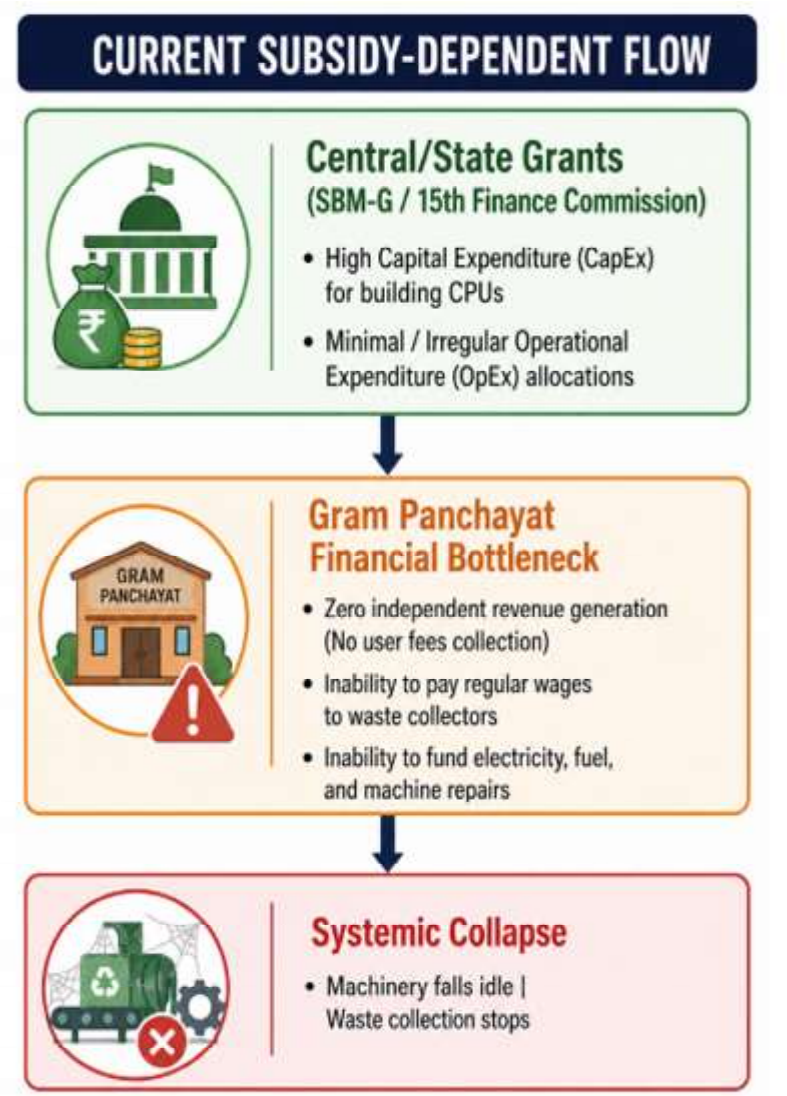
4.2 Institutional Capacity and Technical Deficits

The operational failure of these CPUs stems directly from deep institutional and technical capability gaps at the local government level:

- Absence of a Trained Workforce: Gram Panchayats do not have dedicated, technically skilled personnel to run, service, and maintain mechanical waste equipment.
- Fragmented Governance: The responsibility for rural waste is split between the Public Health Engineering Department (PHED)—which handles infrastructure construction—and the Panchayat and Rural Development (P&RD) Department, which manages day-to-day operations. This dual-agency setup creates accountability gaps, leaving no clear owner for routine operations.
- Lack of Repair Systems: When a machine breaks down, rural areas lack local supply chains for spare parts and specialized mechanics. This causes minor mechanical failures to permanently shut down entire processing units.

4.3 Financial Architecture and Subsidy Dependence

The financial model sustaining rural sanitation in Assam is structurally fragile and heavily reliant on top-down funding streams:



- The CapEx-OpEx Imbalance: While the 15th Finance Commission untied and tied grants fund initial capital costs (CapEx), they do not provide reliable, recurring money for operational costs (OpEx) like electricity, fuel, and wages.
- Weak Local Revenue: Rural Assam has almost no functioning user-fee collection systems for waste management. Culturally, households are hesitant to pay for trash removal, and local panchayats lack the administrative power to enforce collection.
- Absent Market Linkages: CPUs produce organic compost and compressed plastic, but they lack commercial links to sell these materials to Assam's agricultural sectors, tea estates, or road construction industries.

4.4 Environmental Realities and Agrarian Vulnerabilities

Because the formal CPU network is largely non-functional, rural waste collection has broken down. This creates severe, direct environmental issues for Assam's sensitive ecology:

- Leachate Contamination in Wetlands: Unmanaged waste clusters accumulate near village borders, wetlands (*beels*), and community ponds. During rains, highly toxic leachate leaks into these water bodies, driving up Biochemical Oxygen Demand (BOD) and wiping out local fish populations.
- Threats to the Agrarian Economy: Contaminated water from blocked irrigation canals flows directly into paddy fields. This alters soil nutrients, lowers crop yields, and introduces microplastics and heavy metals into the food supply.
- The Monsoonal Flood Catalyst: Assam faces heavy seasonal flooding every year. When rivers overflow, floodwaters sweep through open, unmanaged dumpsites, spreading plastic and untreated waste across thousands of hectares of fertile farmland and protected wetlands. This turns a localized waste issue into a widespread ecological hazard.

5. Conclusion & Actionable Roadmap

5.1 Bridging the Structural Disconnect: The transition from basic Open Defecation Free (ODF) status to a fully functional ODF Plus (ODF+) circular economy in rural Assam remains constrained by a critical structural disconnect between infrastructure creation and operational sustainability. While substantial investments have been made under the Swachh Bharat Mission-Gramin (SBM-G) to establish waste management infrastructure, including Central Processing Units (CPUs), insufficient attention has been given to operation and maintenance (O&M) financing, technical capacity development, and sustainable revenue generation mechanisms. Consequently, many processing facilities remain partially functional or completely idle despite significant capital expenditure.

This infrastructure-operation financing gap is no longer merely a waste management challenge; it has emerged as a significant environmental and economic concern for Assam's predominantly agrarian economy. Inefficient processing and disposal systems have resulted in the accumulation of unmanaged solid and liquid waste, generating leachate that contaminates village ponds, wetlands (beels), irrigation channels, and groundwater resources. Such contamination adversely affects fisheries, agricultural productivity, and public health. During annual monsoon floods, accumulated waste is frequently dispersed across agricultural fields and rural settlements, amplifying ecological degradation, and increasing climate-related vulnerabilities.

Addressing these challenges requires a strategic transition from an infrastructure-centric approach toward a decentralized, community-driven, and financially sustainable waste management model. Emphasis must be placed on operational efficiency, local ownership, resource recovery, circular economy principles, and climate resilience. By transforming waste into a valuable economic resource and strengthening local institutional capacity, Assam can simultaneously

improve environmental quality, protect its agricultural economy, create rural livelihoods, and achieve the long-term objectives of ODF+ sustainability.

5.2 Actionable Roadmap (2026–2030)

The following phased roadmap is designed to systematically address the operational, institutional, environmental, and financial challenges identified in this study while advancing the long-term sustainability of rural waste management systems.

Phase 1: Immediate Stabilization and Regulatory Foundation (Months 1–6)

Strategic Alignment: Objective 1 (Assessing Operational Status) and Objective 3 (Fiscal Sustainability)

Action 1: Comprehensive Technical and Asset Audit

The Public Health Engineering Department (PHED), in collaboration with the Panchayat and Rural Development (P&RD) Department, should conduct a statewide diagnostic assessment of all rural CPUs. Infrastructure and equipment should be categorized as:

- Fully Functional
- Repairable
- Obsolete or Non-Operational

The findings should inform a targeted rehabilitation and replacement plan.

Action 2: Standardized Gram Panchayat Byelaws

All Gram Panchayats should adopt uniform waste management byelaws establishing:

- Mandatory household user fees (¹ 20–¹ 50 per month)
- Commercial establishment fees (¹ 100–¹ 200 per month)
- Penalties for illegal dumping and non-compliance
- Clear provisions for fee collection and enforcement

This framework will establish a stable local revenue base for routine operation and maintenance.

Action 3: Universal Source Segregation

Implement intensive awareness and behaviour-change campaigns promoting a three-bin segregation system:

- Wet Organic Waste
- Dry Recyclable Waste
- Domestic Hazardous Waste

Segregation at source is essential to improve resource recovery efficiency and reduce contamination.

Target Indicators (By 2027):

- 100% CPU asset audit completed.
- 100% Gram Panchayats adopt waste management byelaws.
- 80% household participation in source segregation

Phase 2: Operational Handover and Capacity Building (Months 7–18)

Strategic Alignment: Objective 1 (Institutional Effectiveness) and Objective 5 (Self-Sustaining Frameworks)

Action 1: SHG-Led Operational Management through ASRLM

Formal tripartite agreements should be established among Gram Panchayats, the Assam State Rural Livelihoods Mission (ASRLM), and local Self-Help Groups (SHGs).

Under this arrangement, SHGs will:

- Manage waste collection and transportation.
- Operate processing facilities.
- Maintain records and accounts.
- Retain user-fee revenues to cover operational costs, maintenance expenses, and livelihood incentives.

This model promotes local ownership and women-led entrepreneurship.

Action 2: Development of Rural Technical Skill Ecosystems

Partnerships should be established with:

- Industrial Training Institutes (ITIs)
- Assam Agricultural University
- Polytechnic Institutions

Training modules should focus on:

- Waste processing technologies
- Machinery operation and maintenance
- Compost production and quality control
- Anaerobic digestion systems
- Resource recovery enterprises

Target Indicators (By 2028):

- 75% of CPUs managed by SHGs.
- At least one trained waste management technician per Gram Panchayat
- 85% user-fee collection efficiency

Phase 3: Value Chain Integration and Market Linkages (Months 19–36)

Strategic Alignment: Objective 4 (Agrarian Economy Protection) and Objective 5 (Waste Recovery and Revenue Generation)

Action 1: Establishment of Hub-and-Spoke Processing Networks

Develop regional waste management clusters consisting of:

- 5–7 Gram Panchayats per cluster
- Low investment “Spoke” villages performing collection and primary segregation.
- Centralized “Hub” facilities undertaking advanced processing, shredding, baling, and aggregation.

This model improves economies of scale and strengthens commercial viability.

Action 2: Standardized Compost Production and Marketing

Upgrade composting operations to comply with Fertilizer Control Order (FCO) quality standards.

Develop long-term procurement agreements with:

- Tea estates
- Farmer Producer Organizations (FPOs)
- Organic farming cooperatives
- Agricultural input distributors

Such market linkages will create predictable revenue streams while reducing dependence on chemical fertilizers.

Action 3: Plastic Resource Recovery Partnerships

Establish agreements with:

- Authorized recyclers
- Plastic manufacturers
- Road construction agencies

Recovered plastics can be utilized in road construction and industrial recycling processes.

Target Indicators (By 2029):

- 50 regional waste-processing clusters operational
- 50% of compost production sold through formal contracts.
- 70% reduction in unmanaged plastic disposal
- Significant increase in CPU-generated revenue

Phase 4: Climate Resilience and Long-Term Scaling (Months 37–60)

Strategic Alignment: Objective 2 (Environmental Impact Mitigation) and Objective 4 (Ecological Protection)

Action 1: Climate-Resilient Waste Infrastructure

Prioritize retrofitting of facilities located in highly flood-prone districts such as:

- Majuli, · Barpeta, Dhemaji, Lakhimpur,

Infrastructure improvements should include:

- Elevated processing platforms
- Reinforced boundary structures
- Covered storage bays.
- Improved drainage systems
- Leachate collection and treatment facilities

Action 2: Nature-Based Environmental Safeguards

Promote: Constructed wetlands; Vegetative buffer zones; Bio-drainage systems;

Green barriers around processing facilities

These interventions can reduce pollution, enhance flood resilience, and improve ecological health.

Action 3: Strengthening Extended Producer Responsibility (EPR)

The Assam State Pollution Control Board (ASPCB) should actively enforce national EPR regulations by requiring producers and brand owners to support: Rural collection centres; Plastic aggregation systems; Transportation and recycling networks. This approach can provide supplementary financing while improving recovery rates.

Target Indicators (By 2030):

- 100% of flood-prone CPUs climate-proofed
- Full integration of EPR-supported collection systems
- Significant reduction in waste leakage into rivers and wetlands
- Improved environmental quality indicators in rural water bodies.

5.3 Expected Strategic Outcomes by 2030

Strategic Action	Lead Agencies	Target Outcome by 2030	Expected Environmental and Economic Impact
Enforcement of Byelaws	P&RD Department, Gram Panchayats	100% rural local body coverage	User Fees and Stable operational funding and reduced dependence on government grants
SHG-Based Operational Management	ASRLM, PHED, SHG Cooperatives	75%+ CPUs managed by women-led groups	Green job creation, improved operational efficiency, and local ownership
Source Segregation and Resource Recovery	Gram Panchayats, SHGs	80% household compliance	Improved recycling and efficiency and reduced landfill burden
Hub-and-Spoke Processing Networks	ASPCB, Private Recyclers, PWD Assam	50 regional clusters operational	Increased material recovery and reduced environmental leakage
Compost Commercialization	Agriculture Dept., Tea Estates, FPOs	50% compost marketed through formal agreements	Enhanced soil health and additional revenue streams
Climate-Resilient Infrastructure Management	PHED Assam, State Disaster	100% flood-prone CPUs retrofitted ecosystem protection	Reduced flood-related waste dispersal and
EPR-Based Financing Mechanisms	ASPCB, Producers, Brand Owners	Statewide EPR implementation	Long-term financial sustainability and improved recycling performance

5.4 Final Reflection

The long-term sustainability of rural sanitation and waste management systems in Assam will depend not merely on the expansion of physical infrastructure, but on the development of decentralized institutional ecosystems that integrate financial viability, technical resilience, community participation, environmental stewardship, and circular economy principles. By strengthening local governance, empowering community institutions, creating market linkages, and building climate-resilient infrastructure, Assam can transform rural waste management from a persistent environmental challenge into a catalyst for sustainable rural development, ecological conservation, and inclusive green economic growth.

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