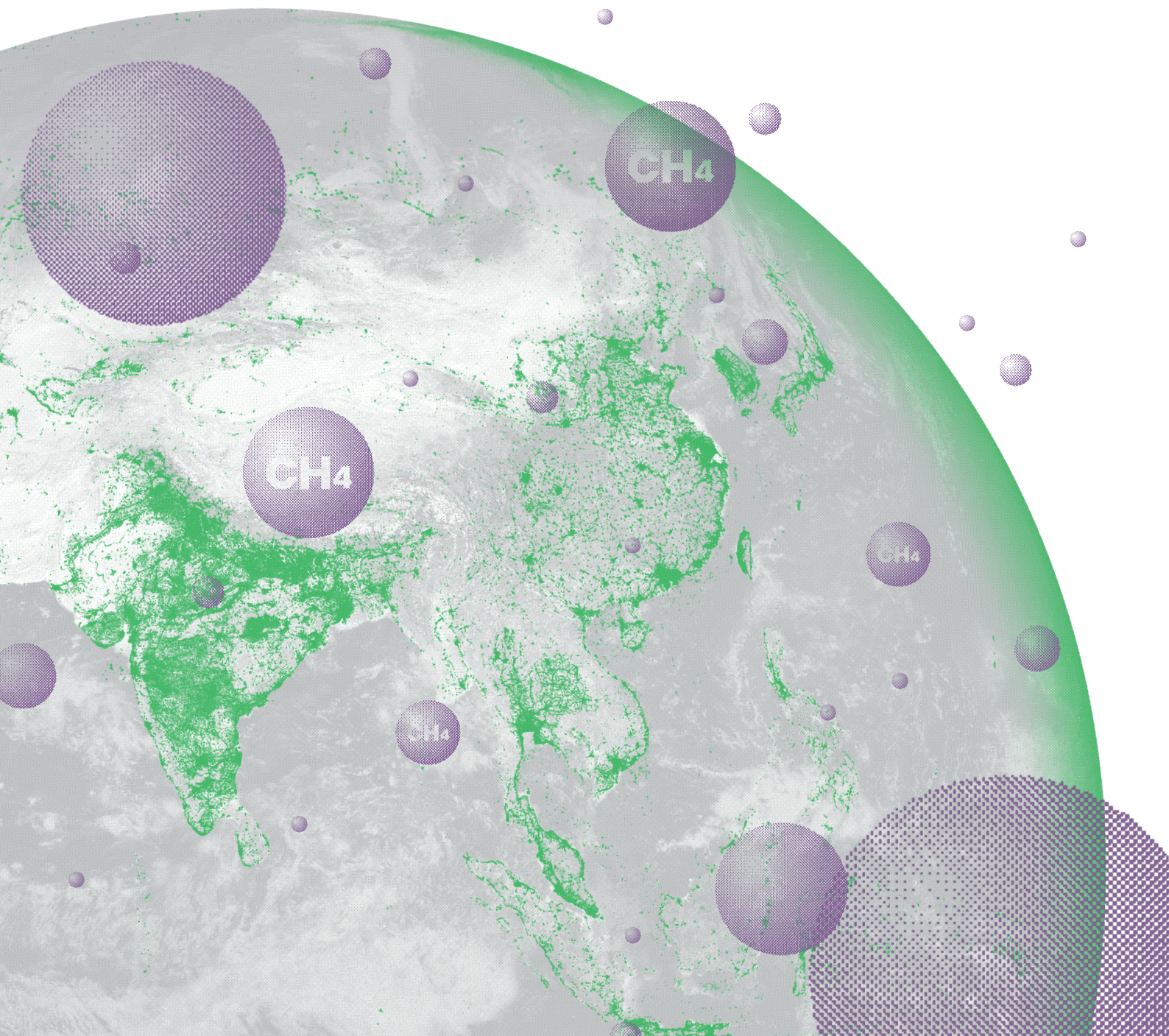


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# Waste Methane Management in Asia

Comparative Analysis and Pathways  
for Collaborative Action



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## Introduction

Methane is a potent, short-lived climate pollutant responsible for nearly 0.5°C of global temperature rise. Though it remains in the atmosphere for about 12 years, its climate impact is 86 times stronger than carbon dioxide over 20 years, making methane mitigation one of the most effective strategies for tackling climate change. [1]

The waste sector contributes around 20% of annual global anthropogenic methane emissions, and under current practices in the waste sector, emissions are projected to rise to 2.3 Gt CO<sub>2</sub>-e (2,300 Mt CO<sub>2</sub>-e) per year by 2030. However, the sector also offers significant mitigation potential (10%), with up to 1.8 Gt CO<sub>2</sub>-e (1,800 Mt CO<sub>2</sub>-e) in annual reductions by 2050, achievable at net savings if targeted technical measures are implemented early. [2] Reducing methane from waste delivers major health and economic benefits, including the prevention of about 1 million premature deaths each year and economic gains of USD 4,300 per tonne of methane. [14]

Asia is experiencing a steady rise in methane emissions driven by rapid population growth, urbanization, and increasing consumption. In 2024, the Asian region generated an estimated 684.5 Mt CO<sub>2</sub>-e of methane from the waste sector. [3] According to a 2025 Report by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the East and North-East Asia subregion<sup>1</sup> alone accounted for one-third of these emissions, reflecting its high waste generation, an urbanization rate of 81%, and expanding industrial activity. [4] Among the five regions, Asia shows the largest projected increase in waste-sector methane emissions between 2020 and 2030. [5]

Given this trajectory and the sector's significant mitigation potential in the near term, understanding how Asian countries are addressing waste methane and where challenges persist is critical. This analysis reviews waste methane management across six Asian countries - Japan, South Korea, China, India, Malaysia, and Indonesia - to identify shared outcomes of the best practices, remaining challenges and gaps, and priority areas for potential coordinated regional action. These countries were selected because they account for a sizable share of Asia's waste sector methane emissions while reflecting diverse policy approaches, technological development and waste sector challenges. It incorporates ground-level insights from the Asia Waste Methane Convening 2025, drawing directly on the experiences and priorities raised by participants from across the region.

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1 This analysis adopts the ESCAP (2016) regional classification. East and North-East Asia (ENEA) comprises China; Democratic People's Republic of Korea (DPR Korea); Hong Kong, China; Japan; Macao, China; Mongolia; and the Republic of Korea. Additional subregional groupings are described in the Annex.

## Chapter 1. Waste Methane in Asia: Emissions, Drivers, and Mitigation Pathways

### 1. Sources and Emissions Profile of Waste Methane in Asia

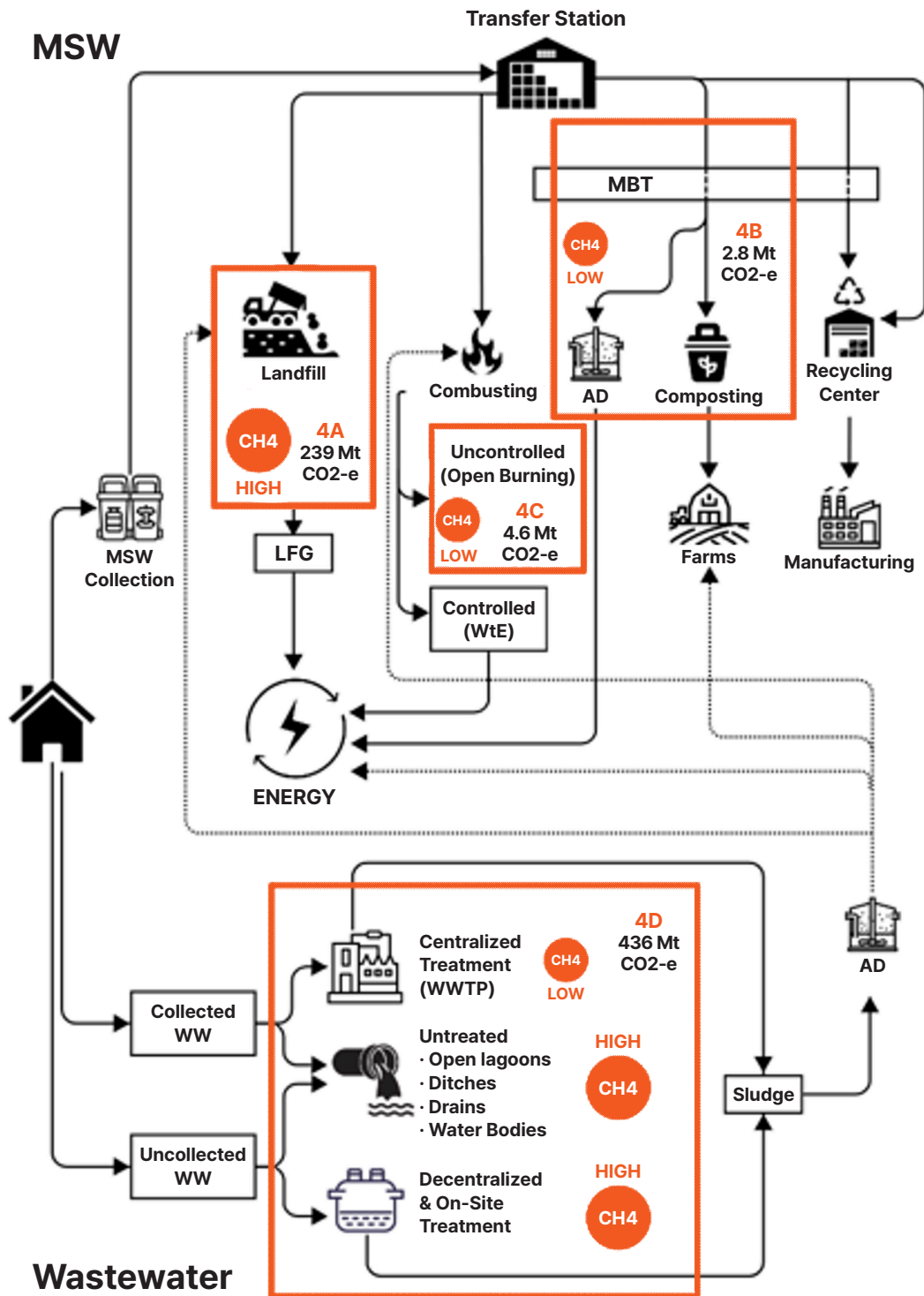
Methane from the waste sector comes primarily from two anthropogenic sources: municipal solid waste (MSW) and wastewater, each accounting for about 12% and 8% of global methane emissions respectively across regions. [5] In Asia, the opposite trend is observed: methane emissions from wastewater are larger than from MSW. Although poorly managed landfills are widely spread across the region, methane emissions from wastewater are almost twice as high as those from MSW, which signals the poor wastewater treatment management in the Asian region. [4] Other methane sources in Asia, such as incineration and open burning and biological treatment processes (composting, anaerobic digestion, Mechanical-Biological Treatment (MBT)), contribute only minor shares of methane emissions.

**Figure 1** visualizes the waste life cycle for MSW and wastewater and shows where methane is generated using the IPCC waste-sector categories (4A–4D) [15,17], with the key methane-emitting stages highlighted in red boxes. Methane emissions shown represent values for the Asian region based on EDGAR 2024 data. The diagram is read from left to right, starting with household MSW collection and wastewater generation, and following the arrows through different treatment and disposal pathways.

For MSW, the largest methane source is 4A (solid waste disposal in landfills), accounting for 239 Mt CO<sub>2</sub>-e in Asia. In landfills, methane is produced through anaerobic decomposition of organic materials such as food waste, garden waste, cardboard, and paper, particularly in unmanaged or poorly managed waste dumping sites. Smaller contributions come from 4B (biological treatment), at 2.8 Mt CO<sub>2</sub>-e, and 4C (incineration and open burning), at 4.6 Mt CO<sub>2</sub>-e, which together represent only minor shares of total waste-sector methane emissions.

For wastewater, 4D (wastewater treatment and discharge) is the dominant methane source in Asia at 436 Mt CO<sub>2</sub>-e. Emissions are highest from untreated wastewater discharged into open lagoons, drains, and water bodies, as well as from decentralized and on-site systems under anaerobic conditions. Centralized wastewater treatment plants generally show lower methane intensity, particularly where biogas is captured and utilized.

**Figure 1.** Methane Emissions Across the Life Cycle of MSW and Wastewater in Asia



Source: Author, based on IPCC (2006, 2019) and EDGAR (2024)

Note: Methane emissions shown represent values for the Asian region based on EDGAR 2024 data.

## 2. Management and Mitigation Pathways for MSW and Wastewater in Asia

### Municipal Solid Waste (MSW)

Asia generates more solid waste than any other region, producing an average of 450–800 tonnes of municipal solid waste (MSW) per day in major urban cities, and this volume continues to rise, with growth projected for at least another decade. This trend is closely linked to increases in gross national income (GNI) and is driven by urbanization, population growth, and rising consumption, particularly in China, India, and Indonesia. [7] Waste composition also varies by income level: low- and middle-income countries have waste streams dominated by high-methane-risk organic materials (around 60%), while high-income Asian economies have a lower organic share of about 38%. [8] Yet, due to limited source segregation and inadequate treatment systems, large volumes of organic-rich waste are disposed of in open dumps and unsanitary landfills, resulting in high methane emissions from MSW across Asia. [9]

According to EDGAR 2024 data, MSW generated roughly 246 Mt CO<sub>2</sub>-e in Asia, where almost the entirety of MSW methane emissions is represented with landfill disposal alone and accounted for about 239 Mt CO<sub>2</sub>-e. [3] These emissions also represent a major mitigation opportunity: studies indicate that applying existing best practices, modern technologies, and feasible strategies could cut landfill methane by 80–90% by 2030, and this abatement potential is three to six times more cost-effective than that of the wastewater sector. [4, 10, 14]

In this context, effective MSW methane mitigation follows the waste hierarchy by reducing waste generation, separating organics at the source, and diverting organic materials away from landfills. Key mitigation practices and benefits [7, 16] include:

Mitigation Practices	Key Benefits
<ul style="list-style-type: none"> <li>• Pay-As-You-Throw (PAYT) / Volume-Based Waste Fee (VBWF)</li> <li>• Composting</li> <li>• Anaerobic Digestion (AD)</li> <li>• Mechanical–Biological Treatment (MBT)</li> <li>• Waste-to-Energy (WtE) – biogas generation</li> <li>• Advanced thermal treatment</li> <li>• Landfill-gas (LFG) capture</li> </ul>	<ul style="list-style-type: none"> <li>• Improved source separation of waste and circularity</li> <li>• Bioenergy generation</li> <li>• Reduced landfill burden, leachate, and operational costs</li> <li>• Public health improvements, odor reduction, and cleaner environments</li> <li>• Nutrient recovery and improved soil health</li> <li>• Green job creation</li> </ul>

Across Asia, however, the capacity to implement these measures varies widely. High-income countries such as Japan, where about 75% of MSW is incinerated, rely on advanced waste-to-energy and sorting

systems, while many South and Southeast Asian countries still collect less than half of their waste and continue to rely on open dumping or burning of organics. China’s rapid shift from 64% landfilling to 20% in six years and emerging efforts in Central Asia to replace large dumpsites show progress, but unmanaged disposal remains common. These trends highlight the need for expanded organics diversion and broader deployment of landfill gas capture to reduce MSW methane across the region. [9]

## Wastewater

Asia produces about 40% of the world’s wastewater, yet the region - especially South Asia – shows the lowest wastewater collection rates at 31% and treatment rates at 16%. [11] Rapid urbanization of the Asian region and reliance on septic tanks, open lagoons, and basic anaerobic ponds result in large volumes of sewage and sludge decomposing without oxygen, leading to disproportionately high methane emissions. [4] In 2024, wastewater generated approximately 436 Mt CO<sub>2</sub>-e of methane emissions in Asia, making it one of the region’s largest waste-sector sources. [3]

Despite these challenges, the sector holds significant mitigation potential. Modern anaerobic treatment systems can recover biogas containing 60–70% methane, which can be used for heat, electricity, or upgraded to biomethane. [12] Fully scaled, wastewater methane reduction measures could deliver up to 671 Mt CO<sub>2</sub>-e in annual reductions by 2050, making it one of the most impactful mitigation opportunities in the region. [13]

Effective wastewater methane mitigation focuses on reducing anaerobic conditions, improving treatment efficiency, and capturing or utilizing biogas. Main wastewater methane emissions mitigation measures and benefits [18, 19] are:

Mitigation Practices	Key Benefits
<ul style="list-style-type: none"> <li>• Biogas capture in covered anaerobic reactors and lagoons</li> <li>• Anaerobic digestion (AD) of sewage and sludge with energy recovery</li> <li>• Replacement of open anaerobic ponds with secondary treatment and WWTPs (with biogas recovery and utilization)</li> <li>• Improved sludge management with controlled digestion and reduced sludge retention. [14]</li> </ul>	<ul style="list-style-type: none"> <li>• Major public health and sanitation improvements</li> <li>• Improved water quality and ecosystem protection</li> <li>• Higher treatment efficiency and reduced untreated discharge</li> <li>• Odor reduction and improved local air quality</li> <li>• Reduced sludge volume and safer sludge handling</li> <li>• Bioenergy generation</li> </ul>

Across Asia, the ability to implement these measures varies greatly. High-income economies have advanced wastewater treatment and sludge digestion systems, while many South and Southeast Asian

countries continue to depend on septic tanks, unlined lagoons, and informal discharge. These disparities highlight the need for expanded treatment infrastructure, improved sludge handling, and wider deployment of biogas recovery to reduce wastewater methane across the region.

### 3. Scope of Country Coverage

Despite shared regional trends, waste-sector methane outcomes vary widely across Asia. While the region as a whole faces rising waste generation, rapid urbanization, and increasing methane emissions from municipal solid waste and wastewater, countries differ significantly in system development levels, implementation capacity, financing conditions, and urban settlement patterns. These structural differences determine not only the scale of methane emissions, but also the feasibility, pace, and effectiveness of mitigation interventions across municipal solid waste and wastewater streams.

The following chapter examines waste methane management across six Asian countries (Japan, South Korea, China, India, Malaysia, and Indonesia), recognizing that this selection cannot fully capture the complexity and diversity of the region. Together, these countries represent a sizable share of Asia's waste sector methane emissions and reflect varied policy and implementation contexts. The focus of the analysis is to identify what is working in practice, what gaps and challenges remain, and where coordinated action could be most useful.

It is important to acknowledge several methodological limitations inherent to this study. National statistics on waste generation, methane emissions, and treatment capacities are often derived from differing baseline assumptions, classification systems, and collection intervals, which limits the degree to which direct quantitative comparisons can be drawn. Beyond data constraints, each country operates within a distinct institutional, regulatory, and socio-economic context, meaning that policy instruments or technical solutions that prove effective in one setting may not be readily transferable to another. Cultural attitudes toward waste, the structure of local governance, and the role of the informal sector further shape outcomes in ways that are difficult to capture through a uniform comparative framework. As such, the findings presented in this report should be interpreted as indicative rather than definitive, and with due recognition of the structural and contextual differences that underpin each country's waste methane management trajectory.

This country focus was also informed by the Asia Waste Methane Convening, a 2-day event held in South Korea in September 2025 wherein participants from various Asian countries discussed challenges and future collaboration opportunities. Discussions underscored that regulatory reform alone is insufficient to drive measurable emission reductions. While strengthened policy and regulatory frameworks are

essential to enable and institutionalise action at the national level, participants highlighted the need for bottom-up learning grounded in implementation experience across different national contexts. Exchanging operational lessons across diverse national and subnational contexts—particularly on landfill management, organic waste diversion, and wastewater treatment—was identified as critical to ensuring that top-down policy instruments are realistic, enforceable, and responsive to on-the-ground constraints.

## Chapter 2. Regional Landscape and Country Profiles

Chapter 2 presents a comparative analysis of waste sector methane management across six Asian countries: South Korea, Japan, China, Malaysia, Indonesia, and India. Together, these cases enable a balanced regional comparison across advanced and emerging systems, helping to identify shared challenges, effective approaches, and priority entry points for regional collaboration to accelerate methane reduction. Each country profile follows a consistent structure, beginning with a national overview of the waste and methane landscape, followed by an examination of existing waste methane reduction policies and measures, their progress, and current implementation challenges.

### 1. South Korea [SFOC]

#### Overview

##### ***High Municipal Waste Recycling***

Between 2019 and 2023, Korea generated approximately 17.5-19.5 million tonnes of waste annually, including about 5 million tonnes of food waste per year. The waste management system is characterized by a high recycling rate (86% in 2023) and low reliance on landfilling (5%) and incineration (5.6%) of MSW, supported by dense urban living in high-rise apartments that enables large-scale segregated waste collection. [SK1]

##### ***Waste Methane Dominated by Landfills***

Despite this strong performance, methane emissions from waste remain significant. In 2022, methane emissions from South Korea's waste sector totaled 12.57 Mt CO<sub>2</sub>-e, accounting for about 35% of the nation's total methane emissions (35.67 Mt CO<sub>2</sub>-e). According to the 2022 National GHG Inventory, landfills account for 11.60 Mt CO<sub>2</sub>-e (92.3%), wastewater and sewage for 0.86 Mt CO<sub>2</sub>-e (6.8%), biological treatment of solid waste for 0.11 Mt CO<sub>2</sub>-e (0.9%), and incineration and open burning for 0.0018 Mt CO<sub>2</sub>-e (0.014%). [SK4]

#### Policies and Measures

##### ***Mitigation Targets and Landfill Bans***

South Korea's waste methane reduction strategies are embedded in its Nationally Determined Contributions (NDC) and the 2023 National Methane Reduction Roadmap. The NDC targets reducing waste sector GHG emissions from 17.1 Mt CO<sub>2</sub>-e in 2018 to 9.1 Mt CO<sub>2</sub>-e by 2030, while the Methane

Roadmap aims to cut waste sector methane emissions from 8.8 Mt CO<sub>2</sub>-e in 2020 to 4.5 Mt CO<sub>2</sub>-e by 2030. Key strategies include reduction of generated waste, increased waste recycling rates, increased methane capture from landfills and biological treatment facilities, reduction of generated organic waste, and biogasification of captured methane gas from landfills.

To achieve these targets and specifically to address emissions coming from organic waste, South Korea implemented the **Wastes Control Act, Enforcement Rules and Decrees**, which banned direct landfilling of sewage sludge and food waste in 2003 and 2005, respectively. [SK9]

### ***Sludge-to-Energy and Food Waste Recycling***

Given the ban of direct landfilling of sewage sludge, Korea has started to look for other ways to utilize sewage sludge. Per the amendment of Wastes Control Act Enforcement Rule in 2009, sewage sludge was permitted to be used as auxiliary fuel in coal and combined cycle heat power plants, provided that the sludge consisted of 5% of the total fuel mix and had a lower heating value of 3,000 kcal/kg or higher. The Sudokwon Landfill site has installed sewage sludge-to-energy facilities in three phases: solidification of sludge for soil cover (ended July 2025), thermal drying of sewage sludge as auxiliary fuel for the on-site thermal power plant, and an advanced sludge-to-energy facility that generates 170 tons of fuel per day for the nation's power sector. [SK12]

Similar to the treatment of sludge, food waste is currently recycled into animal feed, fertilizer, compost and fuel for biogas production. For example, Sudokwon Landfill is also treating food waste leachate for various purposes, such as biogas production, sludge drying (used as fuel source) and power generation. [SK13]

### ***Long-Term Biogas Investment Plan***

In 2012, South Korea established long-term strategies towards sludge waste reduction, waste-to-energy and methane emissions reduction by announcing the "2030 Plan for Sludge Reduction and Biogas Production/Utilization Plan." With a total planned investment of approximately 15 trillion Korean Won (USD \$1 billion) from 2012 until 2025, funds were allocated to improving digester facilities and upgrading biogas generation infrastructure. Essentially, the long-term goal of this initiative was to utilize digester gas (CH<sub>4</sub> and CO<sub>2</sub>) generated from anaerobic digestion of sewage sludge as a source of biogas, as well as treat and overall reduce sewage sludge. [SK14]

## Progress

### ***Biogas Mandates to Scale Up Organic Waste Conversion***

Despite the allocation of funds in line with the “2030 Plan for Sludge Reduction and Biogas Production/Utilization Plan,” only about 6% of organic waste was converted to biogas. The government subsequently passed the **Act on Promotion and Production of Biogas from Organic Waste Resources (2022)**. This Act, which is applicable to local governments, livestock operations with 25,000+ pigs, and waste treatment facilities, mandates the public sector to convert 80% of organic waste to biogas by 2045, while the private sector converts the same percentage of organic waste to biogas by 2050.

The Act also includes the national government investing in pilot projects that produce biogas from animal/vegetable waste residues from the private sector. The national government has also worked with subnational governments - the Ministry of Environment announced the installation of biogasification facilities in 8 Korean municipalities. Should these projects be operational by 2030, it is expected that about 90,000 Nm<sup>3</sup>/yr of biogas could be produced from 1,660 tons/day of organic waste. Overall, the country is aiming for a production of 500 million Nm<sup>3</sup>/year of biogas in 2026, as well as greenhouse gas emissions reduction of up to 1 million tCO<sub>2</sub>-e/year. [SK10]

### ***Landfill Methane Drivers and Targeted Policies***

Organic waste remains a critical driver of landfill methane, accounting for about 27% of landfilled waste in 2022. [SK5] Although landfilled MSW has declined sharply (from about 25 Mt in 1996 to 9.8 Mt in 2023 [SK2]), existing landfills remain a major methane emissions source. Further reductions are expected following revisions of the Enforcement Rules of the **Wastes Control Act [SK3]**, which prohibits direct landfilling of household wastes in the Seoul Metropolitan region from 2026, and nationwide by 2030. These measures are driven by tightening landfill capacity, prompting the government to require incineration of household waste prior to landfilling. The **Volume-Based Waste Fee (VBWF, 1995)** further supports organic waste reduction through a pay-as-you-throw (PAYT) system for mixed waste, while recyclables are collected for free. [SK11]

## Challenges

### ***Design-Operation Gap***

Although some Korean landfills were designed as semi-aerobic to reduce methane emissions, many operate under anaerobic conditions in practice due to high leachate levels in gas pipelines and narrow pipe diameters that restrict air inflow. The 2024 National GHG Inventory assumes all landfills operate anaerobically [SK4], while some local officials continue to classify sites as semi-aerobic based on design plans rather than actual performance, revealing a significant operational knowledge gap.

### ***Unclear Standards and Resource Constraints***

Clear government standards for determining semi-aerobic operation are still lacking, and monitoring and verification of on-site conditions remain weak. In addition, limited local government budgets constrain upgrades and proper operation, as well as expansion of waste-to-energy projects, increasing dependence on central government funding.

## **2. Japan [IGES]**

### **Overview**

#### ***Waste Management Profile***

Japan's waste management system is characterized by (i) a very high reliance on controlled incineration (with increasing energy recovery), (ii) steadily expanding recycling efforts, and (iii) declining dependence on landfilling of municipal solid waste. The quantity of landfilled waste decreased substantially from approximately 109 Mt in 1990 to 3.2 Mt in 2023, while the recycling rate increased from 7.4% to 19.5%. The national "waste reduction rate" (volume reduction through recycling and treatment, including incineration) reached 99.2%. [J1]

For solid waste disposal, landfills are engineered with semi-aerobic structures promoted at 63% of municipal waste landfill sites as of 2018, which suppress anaerobic conditions and methane generation compared to conventional anaerobic sites. [J2] For food-loss prevention, Japan has advanced policies through the 2019 Act, which complements upstream methane mitigation by reducing organic waste generation. For wastewater treatment, coverage reached 93.7%, of which 81.8% is served mainly by the sewerage system with aerobic treatment, while 9.5% is treated by decentralized Johkasō systems, which are more prone to anaerobic conditions. [J3]

#### ***Methane Emissions and Waste-Sector Breakdown***

Japan's methane emissions are distributed as follows. Japan's total greenhouse gas (GHG) emissions in FY2023 were approximately 1.071 Gt CO<sub>2</sub>-eq (excluding LULUCF), of which methane (CH<sub>4</sub>) accounted for about 2.7%—equivalent to roughly 29.4 Mt CO<sub>2</sub>-eq, using the IPCC AR5 GWP100 value of 28. [J4] The agriculture sector is the largest source of methane emissions, accounting for 82%, while the waste sector contributes 11.2% of Japan's total methane emissions (3.293 Mt CO<sub>2</sub>-eq). Within the waste sector, wastewater treatment and discharge account for 1.672 Mt CO<sub>2</sub>-eq in 2023 (50.8%, a 49.1% reduction since 1990), solid waste disposal for 1.534 Mt CO<sub>2</sub>-eq in 2023 (46.6%, an 86.3% reduction since 1990), biological treatment for 0.077 Mt CO<sub>2</sub>-eq (2.3%), and waste incineration for 0.010 Mt CO<sub>2</sub>-eq (0.3%).

## Policies and Measures

Japan's waste methane reduction policies are articulated in its Nationally Determined Contributions and the Plan for Global Warming Countermeasures. A decrease of 11% and 25% compared to FY 2013 is set as the target for FY 2030 and FY2040 respectively (approximately 29.1 Mt CO<sub>2</sub>-eq by FY2030 and 25 million Mt CO<sub>2</sub>-eq by FY2040).

### ***Landfill Methane and Fukuoka Method***

A semi-aerobic landfill structure is adopted when installing a final waste disposal site. A key practice that makes semi-aerobic landfills particularly effective in Japan is the "Fukuoka Method" which introduces air through leachate and gas collection pipes. Other measures to reduce methane emissions from landfilling waste include reevaluation of the disposal method by municipalities, thorough waste sorting, and strengthening the disposal system, which will directly reduce the landfilling of organic waste, such as food waste.

### ***Circular Economy Targets***

The government promotes 3R + Renewable activities to achieve the targets set forth in the Fifth Fundamental Circular Economy Plan under the Circulation Act and the waste reduction targets set forth in the Waste Management Act. National policy targets include cutting business food loss and waste (FLW) by 60% and household FLW by 50% by 2030 (vs. FY2000). [J7]

### ***Methane Recovery and Utilization from Wastewater***

For wastewater treatment, the government promotes methane recovery and utilization from sewage sludge through anaerobic digestion. Methane-rich digestion gas from sewage sludge is used for power generation, vehicle fuel, and city gas. Sludge is also dried or carbonized to produce solid fuels that serve as a coal substitute in thermal power plants. [J9]

In addition to the above policies and measures, there are various mechanisms in place to promote organic waste diversion, food loss and waste reduction, as well as resource circulation. These include initiatives aimed to encourage consumer behavior change. [J10] Also, many facilities boost recycling in the Tokyo area and reduce fossil fuel use by converting food waste into methane-based power. [J11]

## Progress

### ***Food Sector***

Business-related food waste had already achieved the national halving target by FY2022—down from about 5.7 million tons in FY2000 to roughly 2.7 million tons—prompting the government to set a more ambitious 60% reduction target in 2025. [J10]

### ***Solid Waste and Wastewater***

In solid-waste management, the total final disposal volume fell by over 80% between FY2000 and FY2021. [J12]

Wastewater treatment is carried out at more than 2,000 wastewater treatment plants (WWTPs), of which only approximately 300 large or medium WWTPs are equipped with anaerobic digesters. [J13] As a result, around 70% of sewage sludge is incinerated by municipalities primarily for volume reduction rather than for energy recovery.

While anaerobic digestion is limited for domestic wastewater treatment, its application is gradually increasing in certain industries with high organic wastewater loads, such as food processing, breweries, pulp and paper production, and livestock processing.

### ***Landfill Methane***

In particular, Japan has achieved substantial reductions in landfill methane through the semi-aerobic “Fukuoka Method.” Field experience and CDM documentation indicate this design can cut landfill GHG emissions by roughly 20–50% compared with unmanaged or conventional anaerobic sites.

## Challenges

### ***Incineration-Driven Declines and Limited Organic Diversion***

Japan’s solid waste methane emissions have already declined by 86% since 1990, largely because landfilled MSW dropped from 109 Mt (1990) to 3.2 Mt (2023) along with the development of incinerators. This high reliance on incineration reduces the perceived need for organic waste diversion. Sorting of food waste at household level is not as rigorously adopted as recycling while methanization plants have been developed to generate energy from organic waste from industries.

### ***Domestic Wastewater and Remaining Gaps***

Domestic wastewater is now Japan’s largest methane source within the waste sector (~50.8% of waste CH<sub>4</sub>). Johkasō systems in rural areas are more prone to anaerobic conditions, but upgrading or replacing

them requires high household-level or municipal expenditure. In addition, biogas utilization markets are still limited, especially for injection into gas grids or for vehicle fuel outside major metropolitan areas.

### 3. China [HD Institute]

#### Overview

##### ***Municipal Wastewater Growth***

Over the past decade, China has experienced continuous growth in municipal wastewater generation, rising from 46.66 billion m<sup>3</sup> in 2015 to 68.56 billion m<sup>3</sup> in 2024. [CN1] This increase has been met with a sustained expansion of treatment infrastructure, averaging 6% annual growth in capacity since 2011. As of 2024, cities have constructed 3,057 wastewater treatment plants, achieving a municipal wastewater treatment rate of 99%. [CN1]

##### ***Landfill Decline and Incineration Rise in Solid Waste Disposal***

In the municipal solid waste sector, collection volumes have fluctuated slightly between 2019 and 2024, stabilizing at approximately 235.1 to 259.6 million tons annually. [CN1] China's waste management profile is characterized by a high harmless disposal rate, which has remained near 100% since 2020. Most notably, there has been a dramatic structural shift away from landfills - decreasing from 63.7% of disposal in 2015 to just 5% in 2024 - while incineration rates have surged from 34.3% to 84.6%. This transition away from landfilling has significant implications for reducing methane generation from municipal solid waste.

#### Policies and Measures

China's approach to methane control has evolved from general references in broader climate documents to a dedicated, high-level national action plan.

China's methane policy has transitioned from a secondary industrial concern to a central pillar of its national climate strategy. Initially, frameworks like the 2007 National Plan and various Five-Year Plans treated methane largely as a byproduct of industrial safety and energy conservation rather than a standalone climate goal. This shifted significantly following the 2020 "Dual Carbon" announcement, which elevated methane control to a strategic priority and led to the establishment of comprehensive monitoring systems. The Implementation Opinion on Promoting Synergistic Pollution and Carbon Reduction in Wastewater Treatment (December 2023) [CN12] calls for reducing methane emissions by improving sewer pipeline management and enhancing sludge resource utilization. The evolution

culminated in the landmark 2023 Methane Emission Control Action Plan, the nation's first top-level design dedicated to methane, which implemented a "1+N" policy framework with specific qualitative targets for waste management and resource utilization. This national directive has since catalyzed a series of localized action plans across various provinces and cities, marking a new era of dedicated, multi-level governance for non-CO<sub>2</sub> emissions. Directives in 2024 and 2025 mandated sewer pipeline expansion and rehabilitation to curb fugitive emissions from the wastewater sector. [CN13, 14]

Throughout this timeline, China's waste management strategy has shifted from a focus on "sanitary disposal" to "resource utilization" and "co-benefit from synergistic pollution and carbon reduction".

### **Source Reduction and Zero-Landfill**

Simultaneously, strict waste classification policies are being enforced to divert organic waste from landfill since the 2017 Implementation Plan of Municipal Solid Waste Separation [CN15], which required 46 key cities to implement mandatory waste separation. The Opinion on Accelerating the Construction of a Waste Recycling System (February 2024) [CN16] and the Zero-Waste City Initiative [CN17, 18, 19] have aggressively promoted incineration over landfilling, including the goal of reaching "zero landfill" for primary MSW in qualified cities. [CN20]

In sum, China's waste sector methane policy has matured from a secondary consideration of sanitation management to a core strategy for climate mitigation.

## **Progress**

### **Infrastructure Shift and Declining Waste-Sector Methane**

China's shift in waste treatment characterized by a rapid infrastructure transition toward incineration for solid waste and centralized treatment for wastewater has had a marked impact on methane emissions. According to the national greenhouse gas emissions inventory, China's methane emissions have experienced a sharp decrease, falling from 1.69 billion ton CO<sub>2</sub>-e (2018 baseline) to 0.60 billion ton CO<sub>2</sub>-e (2020 baseline) as a result of various emissions reduction efforts. From 2018 to 2020, methane emissions from the waste sector specifically saw a substantial decline, dropping from 195 million ton CO<sub>2</sub>-e to 73.8 million ton CO<sub>2</sub>-e, with landfilling contributing 68.5% and wastewater contributing 30.9% to this total. [CN2]

### **Solid Waste**

In the solid waste sector, incineration accounted for 62.1% of treatment by 2020, while sanitary landfilling dropped to 33.1%. The ratio of solid waste continued to decline, reaching just 5% by 2024. [CN1] This reduction is driven by the implementation of national "zero-landfilling" policies and strategies focused

on waste classification (specifically diverting organics) and landfill gas capture, which are expected to continuously reduce methane emissions from the sector.

### **Wastewater**

In the wastewater sector, methane is primarily generated within the sewer collection system, sludge handling units, and anaerobic treatment zone. Centralized treatment has proven effective in controlling fugitive emissions. Over the past decade, Chinese policies have encouraged the recovery of methane from sludge anaerobic digestion for energy use, while reducing emissions from wastewater collection systems is emerging as a new area of policy focus.

### **Challenges**

China has made significant strides in the past decade - driven by the mandatory waste separation, Zero-landfill initiative, Zero-Waste City initiative, and the expansion of anaerobic digestion (AD) infrastructure - sustaining and deepening these reductions requires addressing several critical bottlenecks including the following.

#### ***Treatment Capacity Gap and Administrative Fragmentation***

While China has achieved notable progress through waste separation and infrastructure expansion, several structural and technical hurdles remain for deep methane reduction. A primary challenge is the “front-end” and “back-end” mismatch, where organic waste collection often outpaces the construction of specialized disposal facilities. This capacity gap is compounded by administrative fragmentation, as siloed government bureaus for water and sanitation create coordination barriers for investors. These silos often delay integrated projects, such as the co-digestion of sludge and kitchen waste, which are essential for maximizing methane capture and resource recovery.

#### ***Data Uncertainty and Immature MRV Systems Mitigation Trade-offs and Finance Barriers***

Furthermore, the sector faces significant data gaps and financial constraints. Current emission inventories often rely on theoretical estimates rather than site-specific measurements, highlighting a need for more robust Monitoring, Reporting, and Verification (MRV) systems to pinpoint actual leakages in landfills and sewer networks. Simultaneously, technical trade-offs—such as the high costs of advanced capture technology and the complex climate impact of incinerating aged waste—present economic risks. Bridging these gaps will likely require the integration of green financing and carbon trading mechanisms to make private investment in methane mitigation more viable.

## 4. Malaysia [Forever Sabah]

### Overview

#### ***POME and Landfills Drive Methane Emissions***

The waste sector accounts for two of the three largest methane-emitting sub-sectors in Malaysia: methane from palm oil mill effluent (POME)<sup>2</sup>, which is the liquid waste produced from several stages in the process of converting solid biomass into certified palm oil and produces 511 kt CH<sub>4</sub>/year (or 32% of Malaysia's total methane emissions), and methane from solid waste (landfills) at 245 kt CH<sub>4</sub>/year (15% of total methane emissions) in 2021. [MY1]

#### ***Solid Waste and Unsanitary Landfills***

Driven by rapid urbanization and industrialization, Malaysia's solid waste generation is projected to reach 15.4 million tons by 2025. [MY2] Landfilling remains the dominant disposal method (69%, may not include illegal dumping), yet over 80% of the country's 137 sites are classified as unsanitary open dumps.

Malaysia's waste composition is shifting: while food waste remains the primary component (35–50%), plastic (13–20%) and paper (8–19%) volumes are surging. However, infrastructure and public awareness have not kept pace, leaving the national source separation rate at less than 1%.

Consequently, landfills account for 75% of the waste sector's methane emissions (excluding POME). While new policy discussions explore life cycle efficiency and a potential transition toward incineration to move away from indiscriminate landfilling, these strategies are still under evaluation for their greenhouse gas impacts. Current efforts face the significant challenge of upgrading aging infrastructure while simultaneously addressing high organic waste generation.

### Progress

#### ***POME as the Dominant Source***

Methane emissions from Malaysia's waste sector are 23.2 Mt CO<sub>2</sub>-e. (calculated using AR5 GWP100 of 28) or 52% of Malaysia's total methane emissions. A breakdown of major 2021 methane emissions sources from the waste sector from Malaysia's 2024 First Biennial Transparency Report (BTR1) is as follows. [MY8] POME wastewater (5D2) is the dominant source at 14.3 Mt CO<sub>2</sub>-e/year (61.6% of waste-

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2 POME is the by-product of several stages of cleaning and opening palm fruits and pressing the oils and sits in on-site retention ponds (lagoons) or tanks where it undergoes anaerobic processes and releases methane.

sector emissions), followed by landfill disposal (5A) at 6.85 Mt CO<sub>2</sub>-e/yr (29.5%), domestic wastewater (5D1) at 1.9 Mt CO<sub>2</sub>-e/yr (8.2%), and rubber industrial wastewater (5D2) at 0.08 Mt CO<sub>2</sub>-e/yr (0.4%).

### ***Landfill Growth and POME Decline Amidst Data Uncertainty***

Limited and poor quality of data make trend analysis difficult and unreliable. According to national emissions data, GHG emissions from waste (primarily methane) increased by 28% from 2005-2019. POME was the largest source (57%) of waste methane emissions but its average annual growth rate during this time period was 0.55%, while landfill emissions grew at 4.8% annually. [MY9] Landfill methane emissions continue to increase in a strong correlation with Malaysia's population growth. [MY10] Federal government GHG calculations show that POME methane emissions have plateaued and started to decline from 2019-2021, driven partly by Malaysian Palm Oil Board (MPOB) requirements for installation of methane capture facilities at mills taking effect in 2019, but the trend is uncertain as other data sources show a continuous increase in emissions from POME. [MY11] Another potential methane source from palm oil waste that has not been quantified is emissions from improper disposal of empty fruit bunches (EFB), which a study in Thailand showed to produce comparable methane emissions to POME. [MY12] With these caveats, Malaysia's BTR1 shows a 8% decrease in waste sector methane from 2019 to 2021.

Based on current mitigation activities (including increased recycling rates and methane capture from POME), the BTR1 projects that waste-sector methane emissions will decrease from 23.4 Mt CO<sub>2</sub>-e in 2021 to 21.3 Mt CO<sub>2</sub>-e in 2030 but will remain very high.

## **Policies and Measures**

### ***NDC and Pledges Lack Methane-Specific Targets***

Malaysia's third nationally determined contribution (NDC 3.0) sets a target to unconditionally reduce its economy-wide GHG emissions by 15-30 Mt CO<sub>2</sub>-e, below Malaysia's peak emissions (expected to occur between 2029-2034) by 2035. [MY13] Efforts to scale up methane capture from solid waste sites and POME are mentioned as demonstrating alignment with the first Global Stocktake's call to reduce methane emissions by 2030, but there are no methane or waste-sector GHG targets. Malaysia is also a signatory to the Global Methane Pledge and the COP29 Declaration on Reducing Methane from Organic Waste, but there is no methane policy, national target, or action plan for the waste sector or any other sectors. The National Climate Change Policy (NCCP) 2.0 (2024), which serves as the basis for drafting of the impending national Climate Change Act, includes two key actions (no plans or financing yet) related to waste and methane: it calls to enhance circular economy and sustainable waste management, including through Extended Producer Responsibility (EPR), user-pay and polluter-pay principles, and industry self-

regulation (ST2S1KA15), and to strengthen measures to reduce methane from O&G production, waste, and agricultural sectors (ST2S1KA17). [MY14]

### ***Fragmented Policy Framework***

The 2005 National Strategic Plan for Solid Waste Management does not mention methane or other GHG issue, focusing instead on cleanliness while advancing two main strategies: federalization (i.e., taking back responsibility and control from states and local municipalities, who had largely failed to implement under the previous policy) and driving privatization (in the belief that this would increase implementation rates). [MY15] Act 672, Malaysia's Solid Waste and Public Cleansing Management Act (2007) and primary waste policy (implemented since 2011 designed to advance the above strategy) leaves it to states to choose to follow Act 672 or enact their own policies. Malaysia's Borneo States (Sarawak and Sabah) and the island state of Penang have declined to come under the act seeing it as an infringement of state sovereignty. Recent initiatives, such as the Circular Economy Blueprint for Solid Waste (2025–2035), the Malaysia Plastics Sustainability Roadmap (2021–2030), and the National Cleanliness Policy still rely upon this legislation (and the antiquated Environmental Policy Act, 1974) limiting their ability to drive important goals such as the 4Rs and Extended Producer Responsibility, failing to address methane, and still not applying across the country due to federal-state conflict.

## **Challenges**

### ***System-wide Challenges***

Core challenges in Malaysia include a set of interrelated constraints: limited data and understanding of methane in waste management, contributing to sparse policies; weak traction of central policies over existing practices and private-sector outsourced activities (especially in the Borneo states); limited monitoring and enforcement capacity; limited financial and technical capacity to develop urban waste alternatives; and palm-oil industrial waste-to-energy technologies that are well-known but cannot compete on cost with subsidized fossil-fuel generation, particularly where significant grid expansion is necessary to reach mills.

### ***Data Gaps***

These overarching constraints are compounded by data gaps at the operational level. For instance, incomplete data on food waste management and lack of proper gas monitoring at most landfills or mills create uncertainty in total emissions estimates, emissions trends, and poor understanding of spatial variability among landfills.

### **Infrastructure**

A key cross-cutting issue is infrastructure. There is insufficient infrastructure for recycling and composting, while private sector business models are often not financially viable in Sabah and other states. While policies envision a shift toward a waste-as-a-resource approach, insufficient infrastructure, collection and preparation systems hinder expansion of waste-to-energy (WtE) and fertilizer applications, which also require monitoring and quality control systems to meet environmental standards. [MY16] POME methane capture provides another example. Uptake of POME methane capture has been slow because many mills are remote from transmission lines and face grid interconnection hurdles. Projects also struggle to compete with subsidized fossil electricity, secure financing, and rebuild trust after earlier UN CDM and federal FiT setbacks, even though the sector remains interested in waste-to-energy.

## **5. Indonesia [WRI Indonesia]**

### **Overview**

#### ***Industrial Wastewater Leads Emission Profile***

According to Indonesia's national GHG inventory, methane emissions from the waste sector reached 5,818.21 Gg CH<sub>4</sub> in 2022. [IDN1] Emissions originate from six sources: solid waste disposal sites, open burning, composting, domestic wastewater, industrial wastewater, and industrial solid waste. Industrial wastewater is the largest contributor, accounting for 2,826.39 Gg CH<sub>4</sub>, or around 49% of total waste sector methane emissions. Solid waste disposal sites follow as the second largest source, contributing 1,869.07 Gg CH<sub>4</sub>, or about 32%. This emissions profile reflects both the high organic content of waste and the predominance of anaerobic treatment and disposal practices across sectors.

#### ***Solid Waste Disposal***

Indonesia generated 56.63 million tonnes of solid waste per year [IDN2], with per capita generation ranging from 0.14 to 0.83 kg/day. [IDN3] Only 39.01% waste is managed properly, while 21.85% waste is still dumped in landfills using open dumping methods, and the other 39.14% is released into the environment through open burning, illegal dumping, or disposal into water bodies. [IDN2] Waste collection remains largely mixed and unsegregated, and food waste dominates the waste stream, accounting for around 41% of total municipal solid waste. [IDN4] Given the high share of organic waste and the continued reliance on mixed disposal, solid waste disposal sites remain a major source of methane emissions.

Methane emissions from landfills present a critical and evident problem, manifesting as serious safety hazards such as landslides and fires. In 2005, the Leuwigajah landslide disaster caused 143 fatalities

when methane buildup contributed to a landfill failure. [IDN5] More recently, in 2023, about 38 landfills across Indonesia experienced fires, with methane accumulation and hot weather identified as key contributing factors. [IDN6] Landfill fires continue to occur yearly, underscoring the persistent and multifaceted risks associated with landfill methane emissions.

### **Wastewater**

Wastewater management is similarly characterized by limited centralized infrastructure. Only around 1% of households are connected to a centralized sewerage system, with most households relying on on-site sanitation systems such as septic tanks, many of which operate under anaerobic or poorly managed conditions. [IDN7] In addition, untreated domestic wastewater is frequently discharged into water bodies, creating localized anaerobic environments and complicating environmental monitoring. [IDN7] Industrial wastewater, particularly from high-organic sectors (e.g., food processing, agro-industry, and palm oil), contributes additional organic loading that can lead to methane generation during treatment or discharge. However, comprehensive data on methane capture and utilization in industrial wastewater treatment plants (WWTPs) remains limited.

## **Policies and Measures**

### **National Framework**

Indonesia's waste and wastewater management framework is governed by a combination of national and subnational regulations. While these policies do not explicitly target methane, many mandated practices influence methane generation and mitigation. Solid waste policies reinforce waste reduction, sanitary landfill standards, and waste diversion, including waste-to-energy initiatives. Meanwhile, wastewater regulations aim to strengthen domestic sanitation systems, expand low-emission infrastructure, and require industrial facilities to conduct wastewater treatment and monitoring.

One specific policy that explicitly links waste and emission is the Minister of Environment and Forestry Decree No. 842 of 2024, which sets long-term targets of zero waste by 2040 and zero emissions by 2050. To reach the targets, the decree listed measures such as landfill mining starting in 2025, a ban on open burning by 2030, full adoption of 3R (reduce, reuse, recycle) and circular economy approaches, restrictions on new landfills after 2030, and the gradual phase out of landfills through waste-to-energy (WtE) development and expanded recycling. [IDN8]

The development of WtE is further emphasized by the issuance of Presidential Regulation No. 109 of 2025. The main points of this regulation include: expanding the WtE target to all regions (that meet the regulatory requirements), because previously, regulation only focused on accelerating the development of WtE power plants in 12 priority locations; emphasizing the role of Danantara, Indonesia's sovereign

wealth fund, in this WtE development. Danantara’s role includes investment support and the selection of business entities that will develop and manage WtE facilities. [IDN9]

### **International Commitments**

Indonesia has signed the Global Methane Pledge at COP26. While country does not yet have a dedicated national methane action plan, key climate policy documents, including the Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) and the recently submitted Second Nationally Determined Contribution (SNDC), emphasize methane reduction, utilization, and prevention in the waste sector. [IDN10] [IDN11] Mitigation measures mentioned in the SNDC are as follows (for the two largest methane contributors from the waste sector):

Domestic Solid Waste	Industrial Wastewater
<ul style="list-style-type: none"> <li>• Rehabilitation of open dumpsite into sanitary landfill equipped with LFG recovery</li> <li>• Composting and 3R</li> <li>• Implementation of WtE power plants, solid recovered fuels (SRF), and refuse derived fuels (RDF)</li> <li>• Implementation of municipal waste management</li> <li>• Landfill mining</li> </ul>	<ul style="list-style-type: none"> <li>• WWTP biogas recovery</li> <li>• WWTP sludge removal/energy recovery or material utilization</li> <li>• Utilization of empty fruit bunch (EFB)</li> </ul>

## **Progress**

### **Waste Banks**

As of 2025, Indonesia recorded 14,890 registered waste banks nationwide, supporting community-level waste separation and material recovery. [IDN4] Waste banks have been shown to contribute to around 10% of the national recycling efforts. [IDN12] However, these impacts remain geographically limited and have not yet translated into widespread household-level segregation nationwide.

### **Collection Systems**

Collection systems in urban areas are well established. In around 73 sampled cities, approximately 89.9% of waste reported to municipal systems was collected and managed, indicating relatively strong service provision in selected urban contexts. [IDN13]

### **Waste to Energy**

While methane capture and utilisation varies across landfills, some facilities have implemented LFG systems. A notable example to start with is the Manggar Landfill in Balikpapan City, where captured LFG is utilised for cooking purposes, providing energy to around 380 nearby households. [IDN14]

However, other WtE projects received mixed results, such as the Putri Cempo WtE power plant in Surakarta. Ever since its operation in early 2024, it has received backlash due to several reasons, such as the inadequate wastewater treatment that polluted the nearby rivers and fly ashes that are exposed to local communities, eventually disrupting public health. [IDN15]

## Challenges

### ***Weak Enforcement, Fragmented Governance and Finance Gaps***

Despite a relatively comprehensive regulatory framework, methane-specific requirements remain limited and weakly enforced. Overlapping and fragmented responsibilities for waste management across ministries and levels of government lead to coordination challenges. Municipal budgets are constrained, limited investments in waste infrastructure, landfill gas systems, and advanced wastewater treatment, while access to climate and blended finance remains limited at the local level.

### ***Limited Capacity and Markets***

Technical capacity is also a key constraint. Many cities lack trained personnel for landfill operations, landfill gas recovery, composting, and advanced wastewater treatment. Data gaps persist due to inconsistent reporting, incomplete facility coverage, and limited local capacity for monitoring and verification. Although methodological upgrades to higher tier inventory are underway, these improvements are not yet fully institutionalized nationwide. Additional barriers include weak markets for compost, biogas, and recycled materials, low public participation in waste segregation, continued open burning, and limited awareness of methane and air quality impacts.

## 6. India [EPIC India]

### Overview

#### ***Rapid Waste Growth and Treatment Gaps***

Indian cities currently generate 55 million tons of MSW annually, a number that is projected to reach 165 million tons by 2030 and 435 million tons by 2050. Almost half all generated MSW is biodegradable. [IN1] 46% of the generated waste is either landfilled or left untreated. [IN2] India's urban sewage generation is estimated at 72,368 megalitres per day (MLD), but 72% of it is untreated sewage. [IN3] India's primary focus in the waste sector is to provide service delivery for a rapidly urbanizing population at large scales.

### ***Unengineered Dumpsites and Informal Collection***

India's waste management sector is characterized by high levels of landfilling (mostly un-engineered dumpsites), high levels of informality in the waste chain especially in collection, poor rates of segregation and large volumes. Major cities often have decades-old legacy waste in their dumpsites being reduced through biomining, and certain ULBs have made rapid progress and can reliably treat most of their waste.

### ***Waste Methane Offers Immediate Action Potential***

The largest contributor to India's methane emissions is agriculture, primarily through enteric fermentation and rice cultivation. Waste-based methane, however, is immediately actionable as it aligns with broader objectives of improving urban services and potential energy utilization.

The breakdown of annual waste sector methane emissions (from the 2020 GHG National Inventory submitted to the UNFCCC) is as follows: 4D2 Industrial Wastewater at 21 Mt CO<sub>2</sub>-e, 4A Managed Waste Disposal on Land at 19 Mt CO<sub>2</sub>-e, and 4D1 Domestic and Commercial Wastewater, CH<sub>4</sub> - 16 Mt CO<sub>2</sub>-e. [IN4]

## **Policies & Measures**

India has made policies for both MSW and waste water management, along with complementary policies for incentivizing the uptake of methane from organic sources. These policies do not come with methane-reduction targets, but they come with waste-reduction and gas-usage targets. The policies are formulated at the national level, while execution sits largely with ULBs. These policies are rules and guidelines, often with financial incentives. ULBs are given much flexibility in deciding on implementation pathways whose targets are then monitored, although often with little verification.

### ***Solid Waste Management Rules***

The main MSW policy is the Solid Waste Management Rules, which are periodically updated - the current version is the Solid Waste Management Rules, 2026, notified by the Ministry of Environment, Forest and Climate Change (MoEF&CC) on January 28, 2026, superseding the 2016 framework and coming into force on April 1, 2026. These rules are extensive and provide set targets for the ULBs, and duties for the monitoring agencies and large-scale waste generators, including mandatory four-stream segregation and Extended Bulk Waste Generator Responsibility (EBWGR). [IN5] ULBs are also currently financially supported and incentivized through the Swachh Bharat Mission scheme (Clean India Mission, currently in 2nd phase) for better waste management, under which treatment capacity being developed includes 30,700 tons per day (TPD) of compost plants, 15,100 TPD of biomethanation plants, 45,200 TPD of MRF-cum-RDF plants, and 9,700 TPD of waste-to-electricity plants. [IN6] The scheme has much more robust

data collection, though the Rules' monitoring provisions remain weaker, and enforcement continues to improve as institutional capacity and data systems mature.

### ***Circular Economy Framework***

India's national waste management policies actively recognize waste-based methane as a potential circular economy resource and revenue opportunity. The Draft Liquid Waste Management Rules, 2024 (notified by MoEF&CC, October 7, 2024) mandate environmentally sound management, treatment, and reuse of wastewater and sludge, introducing an Extended User Responsibility (EUR) framework with reuse targets of 20% by 2027–28, rising to 50% by 2030–31. Co-digestion of MSW and wastewater continues to be explicitly recommended for biogas recovery in sewage treatment plants (STPs) larger than 10 MLD. AMRUT 2.0 provides rapid urban infrastructure development focusing on water management, with sewer expansion and sewage treatment plants (STPs) / faecal sewage treatment plants (FSTPs) as key components. In October 2024, MoHUA launched the Jal Hi Amrit (Water is Nectar) scheme (INR 13 billion budget) to incentivize states and ULBs to improve STP performance and generate 10,000 MLD of recyclable water for reuse. [IN7]

### ***NDCs Lack Methane Targets***

India does not have methane as an explicit target in its NDCs. India's commitments include 47% reduction in emissions intensity from 2005 levels to 2030, which will cover sector-agnostic methane, and net-zero by 2070 without clarifying the scope of the gases. Both MSW management and wastewater management goals are structured as service-delivery goals, not as climate mitigation strategies. [IN8]

### ***Monitoring***

Data and monitoring around waste-based methane is entirely based on bottom-up inventories. The activity data for these inventories has high uncertainties and may not accurately reflect methane emissions. There have been some policy pushes towards on-ground monitoring, but that is not feasible with financial and capacity constraints. [IN4]

## **Progress**

### ***Solid Waste: Significant Gains in Collection and Processing Under SBM-U***

Under Swachh Bharat Mission - Urban 2.0 (SBM-U 2.0), 100% door-to-door waste collection has been achieved in 97% of urban wards, and source segregation is being practised across 85% of wards nationally. [IN9] As reported by States and union territories on the Swachhatam portal, total MSW generation in urban areas stands at 1,66,096 TPD, of which 1,33,164 TPD is processed, representing a rise in waste processing capacity from 16% in 2014 to 80.17% today, through the setting up of material

recovery facilities, composting plants, construction and demolition (C&D) waste plants, bio-methanation plants, and waste-to-energy facilities.

### ***Legacy Dumpsite Remediation***

SBM-U 2.0 includes a targeted programme to remediate all legacy dumpsites, freeing up land locked under 250 million tonnes of legacy waste. As of March 2026, out of 2474 dumpsites, 48% had been remediated based on the initial targets. With fresh waste still incoming in the largest dumpsites, 209 of those have been a part of an acceleration program since November 2025 to go on until September 2026. These dumpsites held 123 million tonnes of waste, of which 60% is yet to be remediated. [IN10]

### ***Wastewater Infrastructure: Capacity Expansion Through AMRUT***

Under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) (Phase 1), 890 sewerage and septage management projects worth ₹34,505 crore (3.6 billion USD) have been grounded, creating 4,447 MLD of sewage treatment capacity, of which 1,437 MLD has been developed for recycling and reuse. [IN11] Under AMRUT 2.0, 592 sewerage and septage projects worth ₹67,607.67 crore (6.4 billion USD) have been approved, covering 6,739 MLD of sewage treatment capacity (new or augmented), of which 2,093 MLD is earmarked for recycling and reuse. [IN12] Of the 313 STPs initiated under AMRUT with a total capacity of 6,232 MLD, 214 STPs with a capacity of 4,174 MLD have been completed, with approximately 18,000 km of sewerage network laid.

### ***Treated Wastewater Reuse***

Multiple national policies actively promote reuse: the National Mission for Clean Ganga framework targets 50% reuse of treated wastewater by 2025 in states with operational STPs and 100% by 2050, while AMRUT 2.0 mandates cities to meet 20% of urban water demand and 40% of industrial water demand at the state level through recycled water. [IN13]

## **Challenges**

Key obstacles to advancing India's waste methane sector can be found across diverse policy areas, including technology, infrastructure, operations, governance, finance, and data.

### ***Infrastructure and Operations***

Both solid waste and wastewater systems need system-wide improvements. Solid waste systems lack robust infrastructure for segregation, transport, processing, and engineered disposal [IN1], largely owing to the mismatch with waste characteristics. [IN14] In wastewater, ~72% of urban sewage remains untreated. [IN15] STPs frequently rely on anaerobic systems, with only a small fraction having functional digesters, and most septic tanks being poorly maintained, leading to uncontrolled decomposition.

[IN16] These infrastructure gaps also contribute to ongoing operational issues. Solid waste operations remain fragmented, with weak integration of informal workers, poorly coordinated collection-processing contracts, and inadequate O&M across the chain. Wastewater operations suffer from intermittent STP functioning due to high energy requirements and persistent O&M gaps that reduce treatment reliability and gas capture. [IN1] [IN15]

### ***Governance and Coordination***

ULBs depend on outdated procurement systems that prioritize low-cost bidding over quality and lack the staff and technical capacity to adopt innovative technologies or plan integrated systems. [IN17] In wastewater, responsibilities are split among multiple agencies, creating gaps in planning, O&M, financing, and reporting. Methane mitigation is not included in India's NDCs and rarely appears in state climate plans, reinforcing institutional silos.

### ***Finance and Markets***

Finance and market realities further limit scale-up. Solid waste systems face low user willingness to pay and limited ULB fiscal space, restricting necessary investments. [IN1] Wastewater systems recover only 20-30% of O&M costs (15th Finance Commission trend), and high energy expenses reduce STP operating hours. [IN18] Markets for compost, RDF, biogas/city gas, and other end-products in solid waste remain underdeveloped, particularly in Tier 2-3 cities where economies of scale are limited. [IN19] Wastewater systems similarly lack reliable markets for biogas and biomethane, treated wastewater reuse, or sludge-derived products. [IN15]

### ***Data and Accounting***

Solid waste data is largely based on population-derived assumptions, with limited chain-wide monitoring and estimates primarily derived from landfill activity. [IN20] Wastewater systems lack measurement for methane at STPs, FSTPs, lagoons, and septic systems. The Indian Government's Central Pollution Control Board (CPCB) monitoring focuses on water quality parameters, and national inventories rely on IPCC defaults, leaving major gaps such as unreported emissions from septage and septic tanks. [IN15]

## Chapter 3. Comparative Analysis

### 1. Comparative Evaluation Across Six Countries

The comparative assessment presented in this chapter is based on a traffic-light grading system developed through expert judgment by country specialists, as shown in the below table. The grading reflects qualitative evaluation informed by the country analyses in Chapter 2. It assesses implementation depth, institutional embedding, and observable outcomes within each national context. The full Comparative Framework tables, which formed the analytical foundation for each specialist's assessment, are included in the Appendix.

Best Practice Category (Example)	Practice (Example)	South Korea	Japan	China	Malaysia	Indonesia	India
Waste Segregation & Collection	Household source separation	●	● (Food waste: ●)	●	●	●	●
	Door-to-door collection	●	●	N/A	●	●	●
	Integration of informal workers / cooperatives	N/A	N/A	●	●	●	●
Landfill Management	Sanitary landfill development	●	●	●	●	●	●
	Semi-aerobic landfill	●	●	N/A	●	●	●
Waste Processing and Recovery	Recycling	●	●	●	●	●	●
	Composting	●	●	●	●	●	●
	Incineration with energy recovery	●	●	●	●	●	●
	LFG (landfill gas) capture	●	●	●	●	●	●
	Biogas generation	●	●	●	●	●	●
Wastewater	Wastewater Treatment	●	●	●	●	●	●
	Sludge Digestion	●	●	●	●	●	●
	Methane Capture	●	●	●	●	●	●
	Biogas generation	●	●	●	●	●	●

● **Well established**

The practice is widely implemented at scale, supported by strong policy and institutional frameworks, and demonstrates consistent, measurable, and effective outcomes.

● **Emerging**

The practice is partially implemented or in early stages of scaling, often through pilot projects or limited regional rollouts. While policy support or investment may exist, effectiveness remains uneven, and key challenges persist (e.g., financing, institutional capacity, enforcement).

● **Major gap**

The practice is largely absent or ineffective, with weak or missing regulation, limited infrastructure, or major implementation failures. This represents a significant barrier to methane mitigation due to governance, financing, technical, or social constraints.

**(N/A) Not applicable**

The practice is not relevant given the country's waste management system structure, level of infrastructure development, or policy context.

As shown above, waste methane management reflects structural diversity rather than a shared trajectory across six countries. Demographic pressures, fiscal space, administrative design, and infrastructure legacies differ markedly. Some systems prioritize engineered disposal and incineration. Others rely on decentralized approaches, community engagement, or industrial methane capture. These configurations shape both the sources of methane and the feasible pathways for mitigation.

A structured comparative analysis can be drawn across five principal dimensions: waste segregation and collection; landfill management; waste processing and recovery; wastewater treatment; and cross-cutting themes.

### Waste Segregation and Collection

South Korea, Japan, China	Malaysia, Indonesia, India
<ul style="list-style-type: none"> <li>Household source separation is integrated into broader waste management frameworks</li> <li>Collection systems are structured and municipality-led</li> <li>The main issue is how consistently it is maintained in practice</li> <li>Country-specific constraints remain</li> </ul>	<ul style="list-style-type: none"> <li>Source separation exists, but implementation is uneven</li> <li>Public participation, enforcement, and collection systems vary widely</li> <li>Community-based or city-level initiatives play an important role</li> <li>The main challenge is expanding these practices more consistently across the system</li> </ul>

Household source separation functions as the primary upstream control across all six countries. Where separation is institutionally reinforced through municipal oversight and synchronized collection systems, diversion of organics becomes predictable. Where separation remains partial, landfill methane risk persists regardless of downstream infrastructure.

South Korea and Japan institutionalize separation through municipally managed systems with stable regulatory frameworks and routine collection. This alignment supports high diversion rates and relatively controlled organic waste streams. In Korea, metropolitan landfill restrictions have introduced capacity pressures that require continual system recalibration. In Japan, locally differentiated sorting rules allow adaptation to regional processing capacity, though classification complexity can challenge consistency across jurisdictions.

China illustrates large-scale policy mobilization. Mandatory separation policies have been introduced across hundreds of cities, creating structural shifts in urban waste flows. Operational coherence across cities, however, depends on harmonized classification systems and collection integrity.

Malaysia, Indonesia, and India illustrate different ways in which segregation policies face implementation limits. In Malaysia, a national mandate for source separation exists, but uptake remains low due to weak enforcement and limited public participation. In Indonesia, segregation operates mainly through community-based waste banks and intermediate facilities, which achieve diversion in specific areas but have not translated into widespread household-level separation. India shows clear variation across cities: some municipalities have built effective segregation systems through sustained monitoring and citizen engagement, while many others struggle with fragmented systems and weak incentive alignment.

Collection systems affect whether separated waste streams remain distinct in practice. South Korea's framework emphasizes collection arrangements that support low contamination in separated food waste

streams, while Japan's framework describes municipality-led collection routines organized by waste type and schedule. China's framework describes a structured collection and transfer sequence linked to categorized downstream facilities but also flags a key failure point: separated waste can be re-mixed during collection when dedicated vehicles or compatible transfer infrastructure are insufficient. Indonesia shows uneven collection coverage across geography. While there is a relatively strong collection performance in urban contexts, nationwide coverage, especially in rural regions, remains incomplete due to underfunding and infrastructure constraints.

Comparatively, waste segregation and collection effectiveness depends on three observable factors reflected in the framework: behavioral uptake, enforcement consistency, and the integrity of separated streams during collection. Where participation is high and separated waste remains distinct through the collection stage, diversion outcomes are stronger. Where enforcement is weak or waste streams are re-mixed during collection, performance remains uneven.

### Landfill Management

Engineered landfill systems (South Korea, Japan)	Landfill modernization (China)	Selected sanitary facilities (Malaysia)	Open dumping or legacy dumpsites (Indonesia, India)
<ul style="list-style-type: none"> <li>• Semi-aerobic design</li> <li>• Variation lies in site-level performance and practical constraints such as land availability, costs, availability of on-site experts</li> </ul>	<ul style="list-style-type: none"> <li>• Older disposal sites are being upgraded into sanitary landfills</li> <li>• Sanitary standards are part of broader landfill modernization efforts</li> </ul>	<ul style="list-style-type: none"> <li>• Sanitary landfill facilities exist at selected sites</li> <li>• Broader expansion remains shaped by infrastructure and technical constraints</li> </ul>	<ul style="list-style-type: none"> <li>• Sanitary coverage remains limited relative to total disposal facilities</li> <li>• Legacy dumpsites shape landfill profiles</li> <li>• Integrated waste management systems are being explored in multiple landfill sites (e.g., India)</li> </ul>

Sanitary landfill development and semi-aerobic landfill application reveal different structural starting points across the six countries.

China reports active upgrading of older disposal sites into sanitary landfills with environmental control measures. Sanitary standards form a central part of landfill modernization efforts. South Korea and Japan also apply engineered landfill approaches. In South Korea, semi-aerobic landfill design is established, though site-level performance does not always align with intended semi-aerobic functioning. Japan reports widespread use of controlled landfills across municipalities, often incorporating semi-aerobic

design to reduce leachate and gas buildup, while also noting constraints linked to land availability and construction costs.

Indonesia presents a lower proportion of sanitary landfill sites relative to total disposal facilities, with open dumping and controlled landfills still present in the system. India's landfill profile is shaped by accumulated legacy dumpsites, where remediation efforts are ongoing. Malaysia reports high-standard sanitary landfill facilities at selected sites, including engineered liner systems, though broader implementation faces infrastructure and technical constraints.

Comparatively, sanitary landfill development differs in both coverage and operational consistency. Semi-aerobic design is present in multiple countries, but performance and scale vary. The distinction lies in how extensively engineered standards are deployed across sites and how consistently those designs function in practice.

### ***Waste Processing and Recovery***

Waste recycling systems in South Korea, Japan, and China are organized through structured municipal frameworks. In Malaysia, Indonesia, and India, recycling operates with greater variation across jurisdictions, and in several cases is supported by community-based or informal recovery networks.

Composting is system-embedded in South Korea and present in China, Indonesia, and India at varying scales. In Japan and Malaysia, composting plays a more limited role within overall processing configurations.

Landfill gas (LFG) capture appears in China and South Korea through multiple recovery projects with energy utilization components. Malaysia and Indonesia report site-level LFG initiatives. Although LFG capture is rated as limited in both Japan and India, the underlying drivers differ. In Japan, the limited deployment reflects the low methane generation potential of landfills, as the majority of organic waste is diverted to incineration rather than disposed of in landfills.

Biogas generation from organic waste is reported in China and South Korea and appears in selected city-level applications in India. Malaysia and Indonesia also report biogas initiatives at specific facilities.

Comparatively, the difference lies in how recycling, composting, LFG capture, and biogas generation are positioned within each national waste system. In some contexts, these pathways are implemented across municipalities; in others, they operate through selected facilities or city-level initiatives.

### ***Wastewater Treatment***

Wastewater methane management differs across the six countries in terms of treatment coverage, sludge digestion practices, and the extent to which methane capture is integrated into treatment infrastructure.

South Korea incorporates sludge digestion within wastewater treatment operations, linking methane capture to centralized utility infrastructure. China similarly reports a centralized treatment.

In both Japan and Indonesia, domestic wastewater management relies on decentralized systems. For instance, in Japan, where domestic wastewater represents the largest methane source within the waste sector, rural areas depend heavily on johkasō systems, which are more prone to anaerobic conditions, and upgrading or replacing these systems requires substantial household or municipal expenditure.

Malaysia and Indonesia show methane capture particularly in industrial wastewater streams, most notably palm oil mill effluent systems. In these contexts, methane mitigation is associated with regulated effluent treatment and facility-level biogas recovery.

India presents variation across cities. Biogas recovery from sludge and wastewater treatment is reported in certain urban utilities, while overall treatment coverage and methane capture vary across municipalities.

Comparatively, wastewater methane outcomes are shaped by two structural conditions: the extent to which domestic wastewater is connected to centralized treatment infrastructure, and the degree to which industrial effluent streams are effectively managed.

### ***Cross-Cutting Themes***

Several themes recur across the comparison.

Institutional coordination affects stability. Where waste, wastewater, and climate authorities operate under aligned mandates, methane mitigation measures are more likely to be sustained over time. Fragmented responsibilities complicate scaling even when technical options are available.

Financing structures influence implementation pathways. Sanitary landfills, LFG capture systems, and anaerobic digesters require predictable funding and long-term operational support. Municipal fiscal constraints appear across diverse contexts, shaping the pace and scale of infrastructure deployment.

Operational discipline and monitoring capacity determine durability. Infrastructure installation alone does not secure emission reduction. Sustained maintenance, transparent reporting, and performance monitoring convert policy intent into measurable methane mitigation.

### ***From Comparative Gaps to Cooperation Priorities***

Rather than treating all gaps identified in the comparison as equally difficult or equally urgent, the framework also points to a smaller set of practices that may be understood as regional low-hanging fruit. They still require financing, administrative capacity, and sustained implementation. They are, however, comparatively actionable because they are already well established in three of the six countries assessed. In particular, household source separation, sanitary landfill development, and recycling stand out in this respect. South Korea, Japan, and China each demonstrate that these practices can be institutionalized at scale through different governance models, while Malaysia, Indonesia, and India continue to show either partial uptake or clear implementation gaps.

For that reason, these three practices should be treated as priority areas for regional cooperation. Household source separation offers the most immediate upstream methane benefit because it reduces the flow of organics into mixed disposal streams before downstream treatment becomes more technically demanding. Sanitary landfill development remains a priority because it addresses persistent disposal realities in systems where open dumping or poorly controlled landfilling continues to generate avoidable emissions. Recycling, while not a methane measure in a narrow technical sense in every case, functions as a foundational diversion strategy that reduces pressure on disposal systems and supports broader material recovery. Taken together, these areas offer the clearest opportunity to raise the regional baseline in the near to medium term. A practical cooperation agenda could therefore focus on policy transfer, municipal technical exchange, operational standards, and targeted infrastructure support in these three areas, using existing experience as an intra-regional reference point.

## **2. Opportunities for Collaboration**

The comparative analysis in Section 3.1 demonstrates that waste methane mitigation across Asia is shaped by various factors including institutional alignment, financing structures, and operational capacity, as well as showcases how different countries are faring on waste methane mitigation.

The absence of a universally applicable waste policy/solution makes it challenging for international collaboration. In particular, a primary challenge lies in the “transferability” of solutions: strategies that are effective in one country may not translate to a different country. Nevertheless, each country exhibits practices, insights and experiences that could inform others under similar conditions. Collaboration

should be structured around mutual learning, adaptive replication, capacity-building and context-sensitive scaling.

Opportunities for collaboration on waste methane span across different levels and stakeholders. Meaningful progress requires coordinated engagement across national, subnational, and community levels, as waste methane mitigation cannot be addressed through a single policy instrument or by any one actor alone. Rather, it demands a layered approach that connects government institutions, local communities, technical experts, and financing bodies toward shared mitigation goals. The following sections outline three principal areas where collaborative efforts can be most impactful: strengthening national-level implementation and governance; building awareness and facilitating knowledge exchange; and deploying targeted technical assistance, capacity-building, and pilot projects.

## 1) National-level Implementation

### ***Inter-governmental Learning Platforms***

Effective methane mitigation relies on robust regulatory frameworks and institutional coordination. To move past current fragmentation, governments could collaborate on initiating structured policy dialogues or learning platforms that align solid waste, wastewater and climate governance. These methods can clarify institutional mandates, regulatory scope, and cross-sector responsibilities - which leads up to the establishment of national-level policies on waste methane mitigation.

### ***Development of National Waste Methane Roadmaps***

Establishment of a National Waste Methane Roadmap is a vital first step to align national policies and regulations. By fostering stakeholder collaboration, the roadmap could deliver prioritized interventions, timelines and viable financing options. Formulation of a clear roadmap provides the blueprint for implementation of methane mitigation. Effective methane mitigation implementation could also ensure the integration of these measures into the country's National Determined Contributions (NDCs). This could further solidify countries' commitments to lowering overall greenhouse gas emissions.

Robust Monitoring, Reporting and Verification (MRV) frameworks are important to ensure integrity of waste methane mitigation - with potential collaboration opportunities including the development of Tier 2 or higher emission factors, as well as monitoring systems that align with national greenhouse gas reporting standards.

However, it is also important to ensure that national government-level policies translate into actionable results in the subnational, city and local levels. Achieving this requires collaboration between government and non-government stakeholders, as well as amongst non-government stakeholders.

## 2) Awareness-building and Knowledge Sharing

Waste issues are innately driven by local contexts. Therefore, community engagement remains essential, particularly in contexts where source separation and informal sector participation on waste management shape outcomes.

### ***Awareness-building Platforms***

While this Comparative Analysis considers each country's situation on landfilling and waste processing/recovery, one of the most effective waste methane mitigation measures is to reduce the amount of waste generated, which requires a behavioral change on waste generation. Potential collaboration includes devising a system and platform to encourage waste prevention, as well as waste segregation and separation.

### ***Knowledge-sharing Platforms***

Waste issues are deeply embedded in local contexts. In particular, there are cases in which local community members are actively involved to address waste issues, via platforms such as waste banks, neighborhood composting groups and coalitions. Utilizing local knowledge is essential to understanding where the challenges lie, as well as provide context on the behavioral nuances of the region or evaluate economic incentives when considering solutions for waste mitigation.

Knowledge-sharing platforms could provide a starting point on effective waste governance, especially if there is involvement between citizens and local governments. Therefore, for effective collaboration, it would be ideal to ensure that local-led initiatives are well-connected with national waste policies, as well as connecting local-based organizations with other funders and organizations engaging in best practices or with government officials.

## 3) Technical Assistance, Capacity-building, Pilot Projects

Pilot projects serve as the primary basis for evaluating the effectiveness of methane mitigation strategies. To move from theory to practice, successful collaboration requires the integration of technical assistance and capacity-building programs that address the practical aspects of implementation. These collaborative efforts require a strategic blend of technical expertise and targeted financing.

### ***Optimizing Funding Initiatives (e.g., Private Finance/ODA)***

To best optimize waste methane reduction implementation, one method is to use funding initiatives such as Blended Private Finance and Official Development Assistance (ODA) projects. These projects fund the implementation of best practices/technologies, pilot projects and capacity-building initiatives that are

catered to local contexts. For effective collaboration opportunities, funding projects could be packaged into investment bundles (e.g., diverting organic waste + composting + landfill upgrades) to address multiple waste streams at a time, or via blended finance, wherein grants are combined with concessional loans.

### ***Utilization of Carbon Markets***

With the rules, guidelines and methodologies for the Article 6 carbon markets from the Paris Agreements becoming more clear, there are opportunities for collaboration for various stakeholders to engage in waste methane mitigation initiatives. Since there is a return on investment in the form of carbon credits, carbon markets could be a different economic instrument to introduce and fund technical assistance, capacity building and pilot projects.

### ***Peer-to-peer Learning***

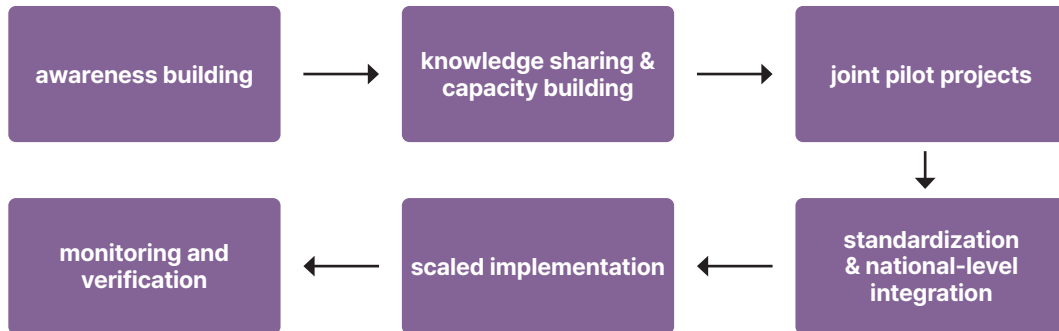
Peer-to-peer learning amongst countries that have similar waste profiles could be effective, since the gaps between countries are not as drastic. Referencing the comparative table at Chapter 3.1, it is more challenging for an organization from a “green light” country to relay best practices and effective pilot projects to a “red light” country on a workshop setting since the differences in contexts are very large. There are less gaps and challenges in designing capacity-building programs for countries that have similar contexts and situations.

## **Pathway for Regional Cooperation**

While the three collaborative areas outlined above represent important entry points, a persistent challenge in practice is not simply a lack of awareness of the problems, but rather the complexity of knowing where to begin. Waste methane mitigation is uniquely difficult to coordinate because it suffers from two overlapping forms of fragmentation. Vertical fragmentation refers to the institutional disconnect between national policy mandates and subnational implementation realities. In many countries, waste facility operations are legally mandated to municipal authorities, yet national climate commitments are negotiated and tracked at the central government level, creating a structural gap between policy design and on-the-ground execution. Horizontal fragmentation, on the other hand, reflects the inherent complexity of the waste methane sector itself, which spans the entire waste management chain from source segregation and collection through to waste processing and recovery, landfill management, and wastewater treatment. When these two dimensions of fragmentation intersect, both domestic and regional action become significantly more difficult to initiate and sustain.

For this reason, regional cooperation should not be pursued in an ad hoc manner, but rather advanced through a structured, stepwise pathway. The proposed pathway proceeds as follows: awareness

building among civil society; knowledge sharing and technical capacity building among public servants and practitioners; joint pilot projects at the city and subnational level supported by targeted financing; standardization and national-level policy integration; scaled implementation; and robust monitoring and verification. Each step builds on the foundation of the previous, and progression through the pathway requires deliberate effort and enabling conditions at each stage.



Assessed at the regional level, Asia as a whole, despite considerable variation across individual countries, remains concentrated in the early stages of this pathway, broadly at the awareness-building phase. Civil society engagement on waste issues has grown, and knowledge-sharing initiatives have begun to emerge, but these have yet to systematically translate into operational pilot projects, coherent national policies, or scaled implementation. The imperative, therefore, is to advance deliberately to the next stage.

### ***Awareness Building led by Civil Society***

The first step, awareness building, is primarily driven by civil society actors. Locally embedded systems such as India's informal waste worker networks and Indonesia's community waste banks illustrate the contextual realities within which awareness building must be situated. Embracing and Integrating diverse stakeholders ensures that the cooperation pathway is inclusive of those most directly affected by waste management outcomes.

### ***Knowledge Sharing and Capacity Building via Peer-to-Peer Platforms***

Building on this foundation, the second step involves knowledge sharing and technical capacity building, targeted at public servants and practitioners. Performance gaps in waste methane mitigation most commonly emerge at the operational rather than the design stage. Structured exchange platforms at both subnational and national level can enable peer-to-peer transfer of operational knowledge on practices such as semi-aerobic landfill operation, landfill gas recovery, composting and organic waste stabilization, and sludge digestion, in ways that formal policy dialogue cannot substitute.

### ***Joint Pilot Projects with Financing***

The third step involves joint pilot projects at the city and subnational level, where financing becomes the critical enabling condition. Capital-intensive infrastructure such as sanitary landfills, anaerobic digesters, and wastewater treatment facilities requires sustained and innovative funding arrangements, including blended finance models that combine climate funds with infrastructure grants, public-private partnerships for landfill gas projects, and expansion of methane capture from agro-industrial effluents such as palm oil mill waste.

### ***Standardization and National Policy Integration: Basic Rule-Setting***

Successful pilot projects then provide the evidence base for the fourth step: standardization and national-level policy integration. Before proven approaches can be codified into regulatory frameworks, however, governments must first establish and agree on basic rule-setting foundations, including minimum standards for waste facility operations, clear institutional mandates, and baseline regulatory requirements that create the enabling conditions for consistent implementation. Building on this groundwork, more advanced policy integration can follow, wherein proven approaches are aligned with national greenhouse gas reporting commitments and incorporated into broader climate governance frameworks.

### ***Monitoring and Verification as Cross-cutting Priority***

The final step, monitoring and verification, is not merely a technical formality but a foundational requirement that underpins the integrity of the entire pathway. As highlighted across multiple countries examined in this report, a critical and recurring gap is the absence of reliable measurement data, consistent reporting standards, and institutionalized verification mechanisms. Without robust monitoring systems, it becomes difficult to assess whether interventions are delivering actual emissions reductions, to attract continued financing, or to meet national greenhouse gas reporting obligations. Strengthening monitoring and verification capacity is therefore both an endpoint of the pathway and a cross-cutting priority that must be addressed at every stage.

## Conclusion

Methane mitigation in Asia's waste sector is increasingly urgent and presents substantial mitigation potential. Across the region, rapid urbanization, population growth, industrial expansion, and changing consumption patterns are driving sustained increases in waste generation and associated methane emissions. At the same time, the sector contains multiple technically available mitigation pathways that can deliver near-term emissions reductions when supported by coherent governance, adequate financing, and operational capacity.

This report has examined waste methane management across six countries: South Korea, Japan, China, Malaysia, Indonesia, and India. The comparative assessment demonstrates that waste methane outcomes are shaped by institutional design, fiscal space, infrastructure maturity, regulatory coherence, and the distribution of responsibilities across national and subnational authorities.

Methane is generated primarily in landfills and wastewater systems, yet it is also shaped by upstream decisions across the waste management chain, from segregation and collection to processing and recovery. This structural characteristic contributes to the complexity of waste methane mitigation. The sector spans multiple stages, each governed by distinct policies, institutions, and operational practices. At the same time, overarching policies are articulated at the higher national level, while methane outcomes depend on how systems and facilities perform in practice, including at the subnational level. When these structural features intersect, translating policy ambition into measurable reductions becomes challenging.

For this reason, regional cooperation should proceed in a structured and deliberate manner. Awareness-building and community engagement provide a foundation for behavioral change. Knowledge-sharing and technical exchange support improvements in operational practice. Pilot projects at city and subnational levels can generate practical evidence under specific institutional and financial conditions. Standardization and integration into national frameworks allow successful approaches to be replicated. Scaled implementation depends on predictable financing, institutional alignment, and strengthened monitoring, reporting, and verification systems.

The comparative analysis demonstrates that mitigation practices are already present in different forms across the six countries. The central challenge is not the absence of technical options, but the alignment of governance systems, financing structures, and operational capacity so that these options can be implemented consistently and at scale. Structured collaboration, grounded in implementation experience and supported by robust monitoring, offers a credible pathway for advancing waste methane mitigation across Asia.

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## Appendix

Country	Practice/Policy Area	Effective Implementation (Observed Outcomes)	Limitations (Implementation Gaps)
South Korea	Waste Segregation / Source Separation	<ul style="list-style-type: none"> <li>- Strong behavioral change (Based on 2023 data [SK1]):               <ul style="list-style-type: none"> <li>-86% national recycling rate enables high diversion of organics and reduced landfill methane generation.</li> <li>-99% of separately collected food waste is recycled.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- With the ban on direct landfilling of household waste from the metropolitan region at the Sudokwon landfill, Seoul metropolitan governments are facing challenges in segregating this waste.</li> <li>- Some household waste goes to regional waste disposal facilities, causing capacity constraints.</li> </ul>
	Collection Systems	<ul style="list-style-type: none"> <li>- Incentivizing source separation and waste reduction through Volume-Based Waste Fee (VBWF).</li> <li>- High density housing enables standardized bins and frequent waste collection.</li> <li>- Food waste streams exhibit low contamination.</li> </ul>	
	Landfill Management		<ul style="list-style-type: none"> <li>- Design-operation mismatch: Many landfills are designed as semi-aerobic but operate under anaerobic conditions in practice.</li> <li>- Unclear standards: Government Definitions and performance Criteria for "semi-aerobic" operations remain unclear.</li> <li>- Budget constraints: Insufficient provincial funding limits proper operation, maintenance and upgrades.</li> </ul>
	Waste-to-Energy	<ul style="list-style-type: none"> <li>- Landfill gas capture with ~50 MW power generation at Sudokwon Landfill.</li> <li>- Mandatory biogas production from organic waste in public and private sectors (based on Biogas Act, passed in 2022).</li> </ul>	<ul style="list-style-type: none"> <li>- Low economic viability: Smaller regional landfills generate insufficient recoverable gas to justify investment.</li> <li>- Finance barriers: Subnational governments face challenges in funding waste-to-energy initiatives.</li> </ul>
Japan	Waste Segregation / Source Separation	<ul style="list-style-type: none"> <li>- Each municipality establishes its own rules under the Waste Management and Public Cleansing Law, including local regulations and penalties.</li> <li>- Violations are typically addressed through warning stickers, public awareness efforts and in-person guidance.</li> </ul>	<ul style="list-style-type: none"> <li>- Due to regional differences in waste processing and recycling capabilities, nationwide standardization is challenging.</li> <li>- New materials continue to emerge, but local rules often fail to keep up.</li> <li>- While some municipalities have enacted ordinances with penalties, actual enforcement is rare.</li> <li>- Complex sorting: Japan's uniquely detailed sorting system is hard to understand, especially for foreign residents and visitors.</li> </ul>
	Collection systems	<ul style="list-style-type: none"> <li>- General waste collection is primarily managed by local municipalities. Collection is usually done at designated points (curbside collection), on designated days and times, by type of waste (e.g., burnable, recyclable, PET).</li> <li>- Private companies may also be contracted by businesses or apartment complexes, especially for commercial or industrial waste (more flexible than general waste collection).</li> </ul>	<ul style="list-style-type: none"> <li>- No significant issue exists as the collection is controlled by the municipality.</li> </ul>
	Landfill Management	<ul style="list-style-type: none"> <li>- Controlled landfills are the most common and widely used across municipalities for non-burnable waste and incineration residues (ash). [J15]</li> <li>- Semi-aerobic design is often used to reduce leachate and gas buildup.</li> </ul>	<ul style="list-style-type: none"> <li>- Limited land availability</li> <li>- High cost of landfill construction and maintenance</li> </ul>
	Waste-to-Energy	<ul style="list-style-type: none"> <li>- Over 70% of municipal solid waste is incinerated. Since the 1960s, Japan has adopted incineration as its primary method of urban waste disposal.</li> <li>- Japan established strict structural and maintenance standards for plant construction. Over time, significant technological advancements, such as dioxin reduction, acid gas removal, and ash recycling, have enhanced both environmental and energy performance.</li> </ul>	<ul style="list-style-type: none"> <li>- With declining population and reduced incineration volumes due to 3R (Reduce, Reuse, Recycle) and resource circular efforts, oversizing facilities may lead to lower operating rates and energy recovery, resulting in inefficiencies.</li> <li>- Optimizing facility size during renewal, along with extending facility lifespan, can reduce total costs and contribute to decarbonization. [J16]</li> </ul>

Country	Practice/Policy Area	Effective Implementation (Observed Outcomes)	Limitations (Implementation Gaps)
<b>China</b>	Waste Segregation / Source Separation	<ul style="list-style-type: none"> <li>- The 2017 Implementation Plan of Municipal Solid Waste Separation (issued by the National Development and Reform Commission and Ministry of Housing and Urban-Rural Development) marked a transformative milestone in China's waste management, requiring 46 pilot cities to implement a mandatory separation scheme. By 2024, waste separation systems have been established in more than 90% of cities at the prefectural level and above (totaling 333). [CN24]</li> <li>- For instance, following the July 2019 mandatory MSW separation ordinance, Shanghai achieved a significant reduction in organic waste (around 35% of total MSW) sent to landfills. [CN26]</li> </ul>	<ul style="list-style-type: none"> <li>- Terminology and categories vary significantly between cities, e.g., while Shanghai uses a four-group system (Recyclable, Hazardous, Dry, and Wet/Organic), Beijing uses a similar four-category approach but employs different terms (Kitchen/Organic, Recyclable, Hazardous and Others). Inconsistencies in how items are defined create public confusion.</li> <li>- For example, a food shell is classified as "Dry Waste" in Shanghai but as "Other Waste" in Beijing. This lack of standardization makes accurate separation difficult for residents traveling between cities. Separating mixed-material items remains a physical challenge.</li> <li>- Removing plastic packaging or non-organic containers from kitchen waste is labor-intensive and often leads to contamination.</li> <li>- There remains a gap in public willingness and long-term waste-separation habits, and some organic waste still remains mixed in landfills. [CN25]</li> </ul>
	Collection Systems	<ul style="list-style-type: none"> <li>- Waste collection is primarily managed by local municipalities in China and follows a structured sequence - from designated community drop-off points to neighborhood garbage transfer stations and then to specialized disposal facilities. Following categorized downstream processing, organic (wet) waste is normally transferred to AD facilities for biogas production or aerobic composting plants.</li> <li>- Recyclables are directed to integrated sorting centers for material recovery and secondary market use.</li> <li>- Dry/other waste is transported to incineration plants or sanitary landfills.</li> <li>- Hazardous waste is directed to specialized hazardous waste treatment centers.</li> </ul>	<ul style="list-style-type: none"> <li>- Collection and transfer capacities are not fully synchronized with the volume of separated waste in some cities. A critical point of failure occurs when separated waste is re-mixed during the collection process (often due to a shortage of dedicated vehicles), undermining public trust and destroying the economic value of recyclables.</li> <li>- Many older transfer stations were designed for mixed waste and lack the specialized equipment needed to handle high volumes of separated wet waste effectively.</li> </ul>
	Landfill Management	<ul style="list-style-type: none"> <li>- Since 2010, China has aggressively upgraded sites into "sanitary landfills" equipped with advanced environmental controls. Following the Zero Waste City Initiative, Zero Landfill Initiative and waste-to-energy initiative, the recent focus has shifted from constructing new landfills to the rigorous management of existing ones. A significant milestone is the expansion of landfill gas capture and utilization.</li> <li>- By 2024, more than 260 Landfill Gas Capture and Utilization projects were operational nationwide. These projects prioritize the conversion of methane into electricity or heat. While comprehensive national data on the total carbon offset is still emerging, these initiatives align with China's Methane Emissions Control Action Plan, effectively turning a climate liability into a renewable energy resource.</li> </ul>	<ul style="list-style-type: none"> <li>- Chinese MSW normally has a high moisture content and generates excessive leachate, which is significantly more expensive and technically difficult to treat than in many Western countries. [CN27]</li> <li>- Secondary pollution from old sites: many old landfills (non-sanitary) were not equipped with proper base liners and continue to leak pollutants and emit fugitive methane. Land scarcity and overcapacity: in many major cities, landfills have reached capacity years ahead of schedule, and finding new sites is very costly and difficult.</li> <li>- The shift in waste strategy from landfills to incineration has led to rapid growth and overcapacity in incinerators, leaving some landfills underutilized.</li> </ul>
	Waste-to-Energy	<ul style="list-style-type: none"> <li>- China has prioritized Waste-to-Energy (WtE) pathways - specifically municipal solid waste (MSW) incineration and organic waste-to-biomethane - in its waste management.</li> <li>- Following the Zero Landfill policy and WtE initiative, MSW incineration capacity has grown exponentially. In 2019, the volume of incinerated MSW exceeded landfill disposal for the first time. By 2024, more than 80% of MSW was incinerated, while landfilling plummeted to just 5%. [CN1]</li> <li>- Recent efforts of excavating aged landfill waste to burn in incinerators have further mitigated legacy methane generation, reclaiming valuable land and addressing historical pollution sources.</li> <li>- In the wastewater sector, China has successfully piloted the co-digestion of wastewater sludge and food waste in some cities. These projects capture biomethane for use as compressed natural gas for vehicles (e.g., Xiangyang, Jingmen), onsite power generation (e.g., Beijing), or injection into municipal biogas grids (e.g., Ningbo), turning sludge into a high-value energy carrier.</li> </ul>	<ul style="list-style-type: none"> <li>- While the WtE infrastructure is expanding, several administrative and technical hurdles persist:</li> <li>- Co-digesting urban organic waste (e.g., kitchen waste) with wastewater treatment plant (WWTP) sludge often faces regulatory gridlock because food waste and WWTP sludge are managed by different departments in many cities.</li> <li>- Excavated aged waste moved from landfills to incinerators has low calorific value and may require auxiliary fuel to burn, causing additional CO<sub>2</sub> emissions.</li> <li>- Many biomethane projects rely heavily on government subsidies. Without a mature financial support system, the high operational costs of WtE (e.g. co-digestion) projects can be difficult to sustain for cities.</li> </ul>

Country	Practice/Policy Area	Effective Implementation (Observed Outcomes)	Limitations (Implementation Gaps)
<b>Malaysia</b>	Waste Segregation / Source Separation	<ul style="list-style-type: none"> <li>- Solid Waste and Public Cleansing Management Act 2007 (Act 267) mandates separation at source (SAS) by 2015: However, SAS rate is still very low (0.2% of waste in 2023).</li> </ul>	<ul style="list-style-type: none"> <li>- Low societal awareness, low motivation and incentives, lack of enforcement, many local governments have yet to set up SAS programs and collection: SAS is not yet ingrained in Malaysia's culture.</li> </ul>
	Collection Systems	<ul style="list-style-type: none"> <li>- Via Act 672 and 2015 SAS mandate, sorting and processing infrastructure increased: national recycling rate increased from 15% in 2015 to 38% in 2024 (target: 40% in 2025).</li> <li>- Paper recycling mitigated 4.7 Mt CO<sub>2</sub>-e in 2019 (all GHGs) according to government calculations.</li> </ul>	<ul style="list-style-type: none"> <li>- While 7 of 13 states and 2 of 3 federal territories have adopted Act 672 and SAS, there is a lack of participation and insufficient federal-state coordination, low motivation by individuals to participate, insufficient recycling infrastructure: organics comprise ~35% of commingled solid waste.</li> </ul>
	Landfill Management	<ul style="list-style-type: none"> <li>- Bukit Tagar Enviro Park (BTEP) sanitary landfill in Selangor is a Level IV landfill with composite bottom liner system, leachate and landfill gas collection and treatment systems including SCADA system: Improved leachate treatment (2,200 m<sup>3</sup>/day).</li> <li>- On-site aeration systems in Sunway City and Sime Darby Convention Center managed by the private sector: processing capacity of 0.3-1 ton of waste/day.</li> </ul>	<ul style="list-style-type: none"> <li>- Insufficient infrastructure, lack of technical knowledge</li> </ul>
	Waste-to-Energy	<ul style="list-style-type: none"> <li>- Public-private composting demonstration program with the support of Kitakyushu City (Japan) and KITA in Cameron Highlands: converts 2 tons of food waste/day to compost to distribute to farmers.</li> <li>- Food waste-to-biogas-and-compost facility (dry anaerobic digester) installed in 2022 by Ampang Jaya Municipal Council (AJMC) is the first in the country: processes 0.5 tons waste/day.</li> <li>- Dry anaerobic digestion plant operated by Petaling Jaya City Council: processes 0.5-1 ton of food waste/day.</li> <li>- BTEP Waste-to-Energy project: 12 MW capacity and generated highest certified emission credit reductions of any landfill project in Southeast Asia under UNFCCC CDM (2.7 Mt CO<sub>2</sub>-e).</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of composting facilities, lack of technical knowledge</li> </ul> <p>Malaysia's Agricultural Research Institute (MARDI) is analyzing results for commercial viability:</p> <ul style="list-style-type: none"> <li>- First pilots (AJMC digester) are undergoing assessment by the Local Government Development Ministry and SWCorp to assess potential for replication.</li> <li>- High capital costs and limited financial support from federal to municipal governments: there are concerns of whether Waste-to-Energy plants can treat solid waste with high moisture content.</li> </ul>

Country	Practice/Policy Area	Effective Implementation (Observed Outcomes)	Limitations (Implementation Gaps)
<b>Indonesia</b>	Waste Segregation / Source Separation	<ul style="list-style-type: none"> <li>- Localized implementation exists through waste banks and TPS3R (Reduce-Reuse-Recycle Waste Management Sites), enabling segregation of recyclables and organics in selected communities.</li> </ul>	<ul style="list-style-type: none"> <li>- Household-level waste segregation remains limited, with most waste still mixed at collection. Actual recycling rates are low at ~7% of total waste. [IDN16]</li> <li>- Many 3R facilities face challenges, such as: limited human resources, inadequate funding, low community engagement in source segregation, and infrastructure constraints. [IDN17]</li> </ul>
	Collection Systems	<ul style="list-style-type: none"> <li>- In urban areas, formal collection services cover a significant share of generated waste.</li> <li>- In around 73 sampled cities, approximately 89.9% of waste reported to municipal systems was collected and managed, indicating relatively strong service provision in selected urban contexts. [IDN13]</li> </ul>	<ul style="list-style-type: none"> <li>- Actual waste collection coverage is incomplete nationwide, with average municipal collection service covering only ~50% of total municipal area. This is largely due to: insufficient waste collection vehicles, collection points, and transportation infrastructure. This stems from underfunding and lack of operational resources for waste management activities at the local level. [IDN12]</li> <li>- Geographic disparity due to uneven infrastructure development and limited municipal budgets, which prioritize higher-density urban areas and leave vast rural regions with little to no formal collection service. [IDN18]</li> </ul>
	Landfill Management	<ul style="list-style-type: none"> <li>- A small share of disposal sites are classified as sanitary landfills, at ~5.3%. [IDN19] A few examples demonstrate better operational performance, such as Balikpapan City's landfill, which applies sanitary landfill practices, complemented by landfill gas facilities.</li> </ul>	<p>Majority of landfills operate as open dump sites (~43.1%) and controlled landfills (~41.6%) [IDN19], due to:</p> <ul style="list-style-type: none"> <li>- Insufficient infrastructure and capacity: local governments lack the technical facilities, engineered landfill liners, leachate systems, and trained personnel needed to operate sanitary landfills. [IDN20]</li> <li>- Overcapacity and growth pressures: many landfills approach or exceed designed capacity due to rapid urban waste increases without sufficient expansion of engineered infrastructure. [IDN21]</li> </ul>
	Waste-to-Energy	<p>Updated data regarding existing WtE (electricity generated, etc.) in Indonesia is limited. However, there are some examples with updated data from several WtE facilities:</p> <ul style="list-style-type: none"> <li>- Balikpapan landfill: landfill gas captured and utilized for cooking and heating, supplying energy for ~380 nearby households.</li> <li>- Surabaya landfill: landfill gas is utilized to generate electricity (~2 MW), complemented by a gasification facility that produces ~9 MW of electricity; electricity generated is sold to the State Electricity Company.</li> <li>- CO<sub>2</sub>-e reduced nationally: Landfill gas recovery - 18.7 kt CO<sub>2</sub>-e; Utilization of WtE powerplants, Refuse-derived fuel (RDF), and Solid Refuse Fuel (SRF) - 103.5 kt CO<sub>2</sub>-e [IDN22]</li> </ul>	<p>At several landfills, the following are observed [IDN23]:</p> <ul style="list-style-type: none"> <li>- Lack of infrastructure to monitor the LFG performance</li> <li>- Lack of maintenance</li> <li>- High investment cost without proper financial scheme</li> <li>- Insufficient capacity among local stakeholders</li> <li>- No support from the local community</li> </ul>

Country	Practice/Policy Area	Effective Implementation (Observed Outcomes)	Limitations (Implementation Gaps)
<b>India</b>	Waste Segregation / Source Separation	<ul style="list-style-type: none"> <li>- Robust monitoring and citizen engagement create successful waste segregation systems, such as in Indore and Alapuzzha.</li> <li>- This was achieved through Top-down push from the urban local bodies, holistic design of the collection system, and multi-decade effort toward citizen engagement. [IN21]</li> </ul>	<ul style="list-style-type: none"> <li>- The majority of cities still have ineffective segregation due to fragmented collection systems, high levels of informality, lack of citizen awareness, lack of enforcement.</li> </ul>
	Collection Systems		<ul style="list-style-type: none"> <li>- Incentive misalignment between citizens, waste collectors, enforcement officials and landfill/disposal operators leads to coordination challenges. [IN22]</li> </ul>
	Landfill Management		<ul style="list-style-type: none"> <li>- India has a major challenge with legacy waste accumulated in dumpsites. Only 61% has been remediated so far, with most landfills still seeing fresh daily waste coming in. Lack of markets for the remediated waste, technological and capacity constraints make progress difficult, especially on large dumpsites.</li> </ul>
	Waste-to-Energy	<ul style="list-style-type: none"> <li>- Places that have been successful in ensuring a steady stream of segregated waste have also managed to utilise it for BioCNG. There have been smaller plants with concentrated organic waste, such as in agricultural markets. [IN23]</li> <li>- Nagpur treats municipal wastewater and supplies tertiary treated effluent to a power plant, reusing over 90% of the city's wastewater for industrial cooling and reducing freshwater abstraction. [IN27]</li> <li>- Large sewage treatment plants with operational anaerobic digesters and power units (e.g., documented biogas-from-sewage plants in India) show that sludge biogas can offset a portion of plant electricity demand and cut emissions. [IN29]</li> </ul>	<ul style="list-style-type: none"> <li>- The most common waste-to-energy approach has been through incineration. These incinerators may reduce methane, but at the cost of high pollution emissions. Larger cities often have the scale to operate these plants at the right capacity, but face resistance from citizens when expanding. These are attractive for constrained urban local bodies with high volumes of daily waste but little underlying infrastructure to ensure quality feedstock.</li> <li>- Nationally, only about 28-30% of urban wastewater is treated and an even smaller share is reused due to limited tertiary capacity, weak offtake agreements, and poor pricing incentives. [IN28]</li> <li>- Most sewage treatment plants lack digesters or underutilise them; biogas is frequently flared or not captured because of O&amp;M gaps, lack of utilization mandates, and weak financial incentives for energy recovery. [IN30]</li> </ul>
	Wastewater Treatment	<ul style="list-style-type: none"> <li>- Chandigarh's near-universal sewerage and surplus STP capacity enable treatment of almost all municipal wastewater. [IN25]</li> <li>- High-income apartments Bengaluru and Chennai utilise treated greywater for landscaping and flushing [IN24], while Delhi Jal Board and other big cities supply treated wastewater for horticulture, irrigation and other industrial uses. [IN26]</li> <li>- Gujarat's 2018 Reuse of Treated Wastewater policy targets 70% reuse by 2025 and 100% by 2030, catalyzing investments in conveyance infrastructure and industrial reuse arrangements. [IN31]</li> </ul>	<ul style="list-style-type: none"> <li>- Most households discharge mixed wastewater with no source separation, and many Tier I/II cities lack full sewerage coverage, meaning only a fraction of sewage reaches sewage treatment plants; costly retrofitting limits on-site reuse and nutrient recovery to niche developments.</li> <li>- Although reuse policies exist, uneven state-level implementation, limited urban local body capacity, unclear tariffs, and weak monitoring mean treated effluent is still often discharged to drains or rivers instead of being reused.</li> </ul>