WHITEPAPER ON CARBON FINANCE FOR MUNICIPAL SOLID WASTE MANAGEMENT IN DEVELOPING COUNTRIES: OPPORTUNITIES, LIMITATIONS, AND RECOMMENDATIONS

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Catalytic Finance Foundation

Catalytic Finance Foundation (Catalytic) is a non-profit organisation with the mission to accelerate the design and deployment of catalytic finance solutions for sustainable infrastructure and businesses, increasing synergies between the public and private sectors. We identify and develop robust project pipelines and deploy technical assistance to support projects to become more investible and impactful. Catalytic seeks to ensure positive social and environmental outcomes in addition to financial returns for impact investors, applying strict environmental and social safeguarding measures and credible methodologies for the measurement and evaluation of positive impacts. Its Catalytic Cities programme designs and aims to set up blended-finance solutions to scale up and speed up the deployment of finance to help cities reach their climate goals.

IKI

The International Climate Initiative (IKI) is an important part of the German government's international climate finance commitment. The IKI is implemented by the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close cooperation with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Federal Foreign Office (AA). The initiative was founded in 2008 and aims at enabling and promoting climate and biodiversity projects in developing, emerging, and transition countries.

GIZ

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is a federal enterprise with worldwide operations. It supports the German Government in the field of international cooperation for sustainable development and is an implementing organisation of IKI. Through its work GIZ assists people and societies in shaping their own future and improving living conditions.

Global Methane Hub

The Global Methane Hub (GMH) funds and convenes partners who work at the international, national, and local level to make sure all actors are working together toward the shared goal of curbing methane pollution in the most efficient way possible. The GMH funds and convenes organizations that are reducing methane on the ground in the best way for their communities, serve as a central hub for information about methane mitigation, and advocate for free data sharing.

Rocky Mountain Institute

The Rocky Mountain Institute (RMI) is an independent, nonpartisan, nonprofit that transforms global energy systems through market-driven solutions to secure a clean, prosperous, zero-carbon future for all. RMI works in the world's most critical geographies and engages businesses, policymakers, communities, and non-governmental organizations to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030.

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ACRONYMS

ACEF	African Circular Economy Facility
ACR	American Carbon Reserve
ADB	Asian Development Bank
AfDB	African Development Bank
BORDA	Bremen Overseas Research and Development Association
CAPEX	Capital Expenditure
CAR	Climate Action Reserve
CCP	Core Carbon Principles
CDM	Clean Development Mechanism
CBI	Climate Bonds Initiative
CNG	Compressed Natural Gas
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSR	Corporate Social Responsibility
DFI	Development Finance Institute
EDF	Environmental Defense Fund
EPR	Extended Producer Responsibility
ETS	Emission Trading System
EU	European Union
FMCG	Frequently Moving Consumer Goods
GCC	Global Carbon Council
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GS	Gold Standard
GS4GG	Gold Standard for Global Goals

ACRONYMS

HCA	Host Country Approval
ICAO	International Civil Aviation Organization
ICVCM	Integrity Council for Voluntary Carbon Market
IPCC	Intergovernmental Panel on Climate Change
ITMO	Internationally Transferred Mitigation Outcome
JI	Joint Implementation
KfW	Kreditanstalt für Wiederaufbau
LDC	Least Developed Country
LFG	Landfill Gas
LLDC	Landlocked Least Developed Country
LoA	Letter of Authorization
MDB	Multi-lateral Development Bank
MSW	Municipal Solid Waste
MRV	Monitoring, Reporting and Verification
MW	Mega Watt
NDC	Nationally Determined Contribution
ODA	Overseas Development Assistance
OPEX	Operational Expenditure
PPP	Public-Private Partnership
RBF	Result based Financing
SAF	Sustainable Aviation Fuel
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
SWOT	Strengths, Weaknesses, Opportunities and Threats
TPD	Tonnes Per Day
UMDF	Urban and Municipal Development Fund
UNEP	United Nations Environment Program
USD	United States Dollar
VCM	Voluntary Carbon Market
VCS	Verified Carbon Standard
VVB	Validation and Verification Body

EXECUTIVE SUMMARY

Municipal solid waste (MSW) is often poorly managed in developing countries[1] due in part to insufficient government budget and limited institutional capacity. While international development finance provides some financial and technical support, the amount of funding has been marginal and does not usually cover the cost of operation. As a result, weak source segregation, limited collection, and inadequate treatment lead to widespread dumping, high methane emissions, and poor environmental and health outcomes. These challenges lead to mixed waste arriving at processing facilities, landfills and dumpsites, resulting in significant methane emissions - approximately 20%[2] of global anthropogenic methane - and contributing to air, water, and land pollution.

Methane is a potent greenhouse gas (GHG), with a global warming potential 84 times greater than CO_2 over a 20-year period, and 28 times more over the first 100 years[3]. Yet it remains relatively short-lived in the atmosphere, making its mitigation one of the most effective near-term climate actions. Reducing methane emissions from the waste sector is increasingly recognized as a priority, as reflected in the Global Methane Pledge, signed by over 150 countries to reduce overall emissions by 30% by 2030. Still, MSW remains underserved by climate finance.

Most funding for MSW projects continues to target capital expenditures (CAPEX) [4], while operational expenditures (OPEX) [5] – which can consist of up to 70% of project financing[6] and is critical for long-term project viability – are largely unsupported. Robust business models in MSW have different sources of revenue typically consisting of user fees[7] , sale of energy recovered from waste, and sales of recycled and recovered products. However, revenue is often insufficient in developing countries where almost all costs of MSW are covered by national or local municipal budgets, sometimes accounting for up to 19% of their total budget[8]. In this context, carbon finance, a form of results-based financing (RBF), seems to offer a promising mechanism to partially close the OPEX gap by monetizing verified emission reductions.

MSW projects generate emissionreduction-based carbon credits, which have to date received lower pricing and market attention than emission removal-based credits. Historically, MSW projects have historically received support from carbon finance, particularly under the Clean Development Mechanism (CDM) of the Kyoto Protocol. More recently, interest has resurged, with annual issuance of MSW carbon credits increasing from approximately 5 million in 2016 to over 23 million in 2024[9]. Moreover, new opportunities are emerging under Articles 6.2 and 6.4 of the Paris Agreement, with pilot transactions already showing carbon credit prices

1. This paper uses the term 'developing countries' to refer to all Official Development Assistance eligible countries, as set out by the Development Assistance Committee of the OECD.
2. IPCC (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. (https://www.ipcc.ch/report/ar6/wg1/)
3. Climate Change 2014 Synthesis Report, Intergovernmental Panel on Climate Change 2014, (https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf). The Nationally Determined Contributions frequently make commitments in terms of GWP-100-based CO2 equivalent emissions at 2030.
4. Capital expenditure (CAPEX) supports the building of new infrastructure, and the purchase of equipment can be partially addressed through grants, loans, or equity.
5. Operational expenditure (OPEX) comprises of costs such as energy and utility costs, labor costs, servicing for equipment, among others, relies on a regular flow of revenues for financial viability.
6. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank. (https://openknowledge.worldbank.org/handle/10986/30317)
7. Commonly called a gate fee, paid per tonne of waste treated
8. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank. (https://openknowledge.worldbank.org/handle/10986/30317)
9. Voluntary Carbon Market Dashboard, Climate Focus (https://app.powerbi.com/view?r=eyJrIjoiMTQwMTBkZWEtOWVmZS00Y2I1LWE1OTktMDQ1MzFjMjU2MzVjIiwidCI6IjUzYTRjNzZkLWI2MjUtNGFhNi1hMTAzLWQ0M2MyYzIxYTMxMiIsImMiOjI9)

ranging from USD 10 to over USD 40 per tonne—potentially sufficient to support key waste treatment technologies in developing countries.This paper outlines the process for MSW projects to tap into carbon markets.

While carbon finance can strengthen MSW project economics, attract private investment, and contribute meaningfully to both climate mitigation and sustainable development, challenges within the existing mechanisms remain as barriers to accessing carbon finance:

- International markets provide liquidity and technological access for waste projects but face high costs, complexity, and limited accessibility for smaller players in developing countries. Moreover, some countries restrict or forbid the export of MSW-related carbon credits, prioritizing them for domestic use under their Nationally Determined Contributions (NDCs).
- Domestic markets offer local alignment and support for smaller firms, yet they struggle with limited scale and inconsistent standards. In addition, while compliance markets are emerging in some developing countries, these remain largely concentrated in developed countries.
- Voluntary carbon markets present flexible growth opportunities for waste management but require improvements in market scale, pricing, and credibility to boost reliability and adoption.

Given the challenges within the existing carbon mechanisms, carbon finance alone cannot resolve systemic inefficiencies in the waste sector and must be complemented with additional financial and technical support to projects. For instance, a performance-based mechanism which supports projects' operational phase upon the reduction of methane emissions at a price which is aligned with methane's GHG impact. This should be embedded within a broader enabling environment that includes supportive policies, clear regulatory frameworks, and adequate institutional and technical capacity for implementation.

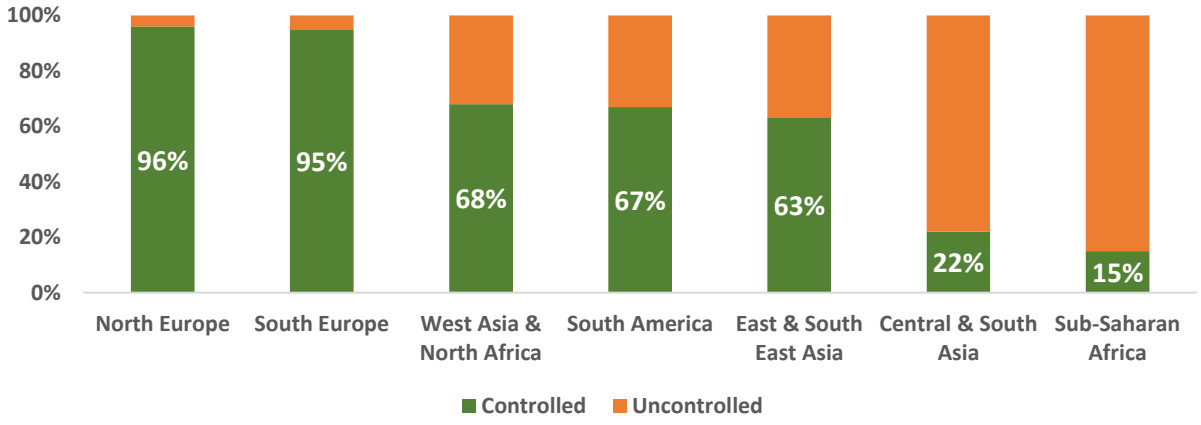
1. MUNICIPAL SOLID WASTE IN DEVELOPING COUNTRIES

Urbanization has proven to have a positive correlation with economic growth if managed effectively. However, growing cities might grapple severely with negative externalities such as the generation of solid waste[10], if not managed well. According to UNEP[11], cities around the world produced ~2.1 billion tonnes of solid waste in 2020, and it is set to increase to 3.8 billion tonnes by 2050. Lack of collection and improper processing and disposal of municipal solid waste (MSW) can cause air and water pollution, spread diseases, congest water bodies, compromise aesthetics of the city and block urban drainage systems. Moreover, if left untreated or improperly treated, organic waste would decompose in oxygen-deprived environments – such as landfills, dumpsites, and composting plants - to release methane which is 84 times more potent than carbon dioxide (CO2) over a 20-year period and 28 times more potent over a 100-year period[12], contributing significantly to global warming[13]. According to estimates, the unsustainable disposal of MSW contributes to 5% of global greenhouse gas emissions (GHG) [14] , with an estimated release of 1.6 billion tonnes of CO2eq[15] .

Currently, cities in developed countries generate approximately 60% of MSW[16] . However, with rising incomes and population growth, urban centers in developing countries will see most of the solid waste generation in the future. Importantly, waste composition differs by income level with food and green waste accounting for about 56% of total waste in developing countries[17] . As shown in Figure 1, many cities in many developing countries are grappling with a significant waste processing gap mostly due to inefficient collection and processing systems, inadequate infrastructure, limited fiscal and financial capacity, and weak governance frameworks. Collection rates are particularly low – averaging around 48% in cities and 26% outside urban areas[18] . The uncollected waste often decomposes in oxygen-deprived environments, releasing methane – a potent GHG. As a result, solid waste is responsible for about 10% of global anthropogenic methane emissions . Addressing this issue in developing countries is therefore critical for reducing methane emissions[19] and for advancing broader Sustainable Development Goals (SDGs), including health, environmental sustainability, and urban resilience.

10. MSW includes a gamut of waste generated by households, institutions and commercial establishments and consists of organic waste (kitchen waste, hotel waste, rotten vegetables and fruits) to plastic waste (plastic bags, wrappers) to glass, thermo-cols etc.
11. Global Waste Management Outlook, UNEP (2024), (https://openknowledge.worldbank.org/bitstreams/df788c58-3c21-52a2-a224-1445f0a1850b/download)
12. Forster, P., Storelvmo T., Armour K., Collins, W., Dufresne, J.-L (et.al), The physical science basis. Contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change (2024)
13. In line with established international standards, this analysis employs the 100-year Global Warming Potential (GWP) metric, as recommended by the Intergovernmental Panel on Climate Change (IPCC). The 100-year GWP provides a balanced approach, accounting for the diverse atmospheric lifespans and warming potentials of GHG, thereby supporting long-term climate policy consistency and comparability in emissions reporting. While the 20-year GWP can provide critical insights—especially for short-lived climate pollutants like methane, which exerts significant warming effects over shorter timeframes—the 100-year GWP ensures a stable metric for evaluating sustained climate impacts across policy, investment, and regulatory frameworks.
14. Hausfather, Zeke, Analysis: Global CO2 Emissions Set to Rise 2% in 2017 after Three-Year 'Plateau' (2017), CarbonBrief, (https://www.carbonbrief.org/analysis-global-co2-emissions-set-to-rise-2-percent-in-2017-following-three-year-plateau/)
15. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank. (https://openknowledge.worldbank.org/handle/10986/30317)
16. The World has a Waste Problem. Here' how to fix it, International Finance Corporation (2024), (https://www.ifc.org/en/blogs/2024/the-world-has-a-waste-problem)
17. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank. (https://openknowledge.worldbank.org/handle/10986/30317)
18. Ibid
19. WasteMAP (Data & Methodology | WasteMAP)

Figure 1: Waste Processing Gap: Developing vs. Developed Countries[20]



(Note: "Controlled" means collected, and then either recycled, recovered or disposed of in a controlled landfill; and "Uncontrolled" means not collected and so by necessity dumped or burned in the open[21] , or collected and dumped on unmanaged dumpsites)

Despite the recognition of the importance of proper MSW management by cities and the international development sector, the financing of MSW systems remains a significant challenge. The flows of climate and development finance towards the waste management sector have increased in the last decade and have been mainly provided by non-governmental organizations (NGOs), OECD donor countries, multilateral organizations (MDBs) and development financing institutions (DFIs). This support has focused on supporting cities on project design, policy advisory, financing the CAPEX of waste infrastructure, and providing feasibility and impact studies.

However, a critical financing gap remains largely overlooked: the long-term operation of waste management infrastructure post-construction. Many facilities cease functioning within a few years due to insufficient operational revenue and limited long-term technical capacity. Ensuring consistent operations over the infrastructure's intended lifespan is essential—not only to maintain service delivery but also to enhance the bankability of projects for CAPEX financing. This operational funding shortfall is typically driven by low user fee recovery, inadequate revenues from the sale of recyclables, weak incentives for efficient performance, and persistent technical challenges in facility management[22].

While a multifaceted approach is required to address these challenges, this whitepaper focuses specifically on the potential of carbon finance - as a form of result-based financing (RBF) - to help bridge the operational funding gap in MSW management facilities in developing countries.

1.1 CHALLENGES PARTICULAR TO THE MSW SECTOR

The MSW sector in developing countries faces a myriad of systemic challenges that span the entire value chain—from waste generation to final disposal. These challenges stem from structural inefficiencies, behavioral patterns, and financing gaps, exacerbating environmental and health hazards. Below is a summary of the main challenges along the value chain.

20. AGS Carbon Analysis of Global Waste Management Outlook, UNEP (2024), (https://openknowledge.worldbank.org/bitstreams/df788c58-3c21-52a2-a224-1445f0a1850b/download)
21. ibid
22. Stakeholder interviews

1. Poor Segregation at Source

The fundamental challenge lies in ineffective waste segregation at source (households, institutions, and businesses) [23]. MSW consists of various waste types—organic, recyclable, and non-recyclable—each requiring distinct processing pathways. However, poor segregation leads to mixed waste arriving at treatment facilities, which reduces efficiency of waste processing technologies, drives up operational costs due to contamination, and compromises the quality and market value of recovered products. The root causes of this include lack of appropriate collection system designed in alignment with source segregation methods for separated waste, low public awareness, lack of incentives for behavioral change, and insufficient monitoring and enforcement mechanisms.

2. Inefficient Collection and Transportation

Collection and transportation infrastructure remains inadequate, particularly in urban areas. Local governments often lack the technical and financial capacity to ensure seamless operations. This can lead to limited waste collection coverage, especially in informal settlements, lack of intermediary stations between short and long-distance destinations, and waste ending up in undesired destinations such as dumpsites or overburdened landfills. This inefficiency worsens environmental pollution along the transportation routes between waste sources and destinations.

3. Over-Reliance on Landfills and Dumpsites

Landfills, the traditional method of waste disposal, are increasingly unsustainable due to the lack of incentives for the recovery of reusable and recyclable waste materials, land scarcity, rising land costs, public opposition [24] that restrict new landfill development, and limited budget making it difficult for municipalities to expand or modernize existing landfills. In places where there is insufficient funding from local governments to finance properly engineered landfills, dumpsites and unmanaged landfills are typically used to dispose of waste. These sites create an enormous amount of health and environmental risks, including from open burning of waste to the emission of GHG and leachate into the open environment.

4. Lack and Sub-optimal Performance of Waste Treatment Facilities

In general, local governments struggle to secure funding for building any waste treatment facilities which typically serve the purpose of sorting and recovering waste materials that can be then recycled (in the case of physical materials) and recovered (in the case of energy), before sending the unusable residual waste to final disposal sites (landfills or dumpsites). When these facilities are built, they often face significant operational hurdles, such as machinery breakdowns due to lack of operational competency leading to increased operational costs; sole or heavy reliance on revenues from recovered outputs (e.g., compost or biogas) which face price volatilities and limited policy framework for uptake. As a result, many treatment facilities remain underutilized or shut down.

5. Financial Constraints

MSW management is capital and labor-intensive, requiring funding for both CAPEX and OPEX. While some financial support exists to cover the initial CAPEX, the operational cost gap remains acute predominantly because of limited cost-recovery from low gate fees, weak revenue streams, and lack of regulatory incentives.

23. Stakeholder interviews
24. AGS Carbon Interaction with Independent Consultant, Media reports

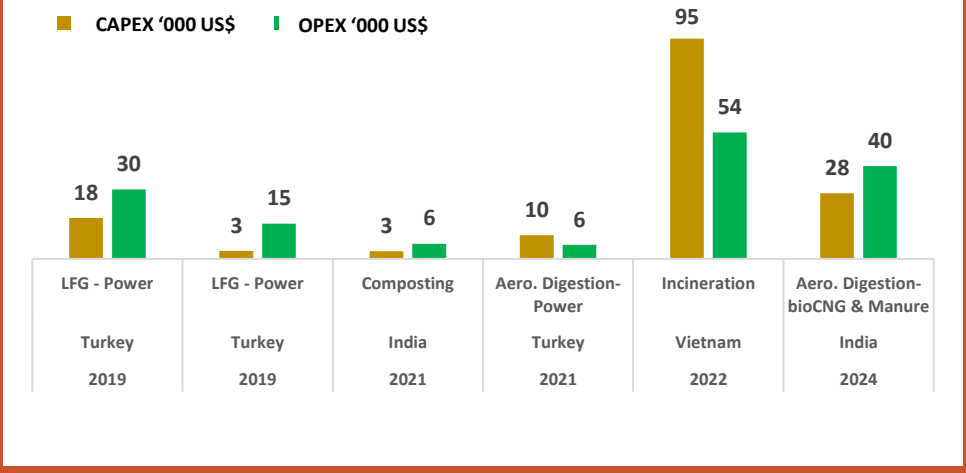
BOX 1 : OPEX AND CAPEX

The construction and operation of a waste treatment facility require the financing of CAPEX and OPEX respectively.

CAPEX supports the building of new infrastructure, and the purchase of equipment. It is normally incurred as a one-off expense at the start of a project and is typically financed from municipal or national government budget, bank loans (including MDBs), private equity, grants, or combination of these.

OPEX comprises of costs such as energy and utility costs, labor costs, servicing for equipment, among others. Unlike other infrastructure projects, these operating costs represent about 70% of MSW project total cost including collection, transportation, treatment and disposal. Costs per ton of waste range from USD 100 per tonne in developed countries to USD 5-50 per tonne in developing countries (World Bank, 2020). Similarly, cost recovery for waste services differs drastically across income levels as it relies on a regular flow of revenues (See section 1.2).
Figure 2 illustrates that projects' operating expenses typically surpass their upfront costs across the lifecycle, with waste to energy plants as an exception. These projects are registered under the CDM, Gold Standard, VERRA registries and cover significant diversity of technologies and geographies. Appendix I also provides a detailed breakdown of CAPEX and OPEX for several projects registered under carbon crediting standards.

Figure 2: CAPEX and OPEX
Cost Comparison per MSW Plant Capacity basis



(Note: AGS Carbon analysis based on registered carbon projects presented in **Appendix** I, OPEX is computed in nominal terms over 8 years period. The costs are computed on per TPD basis for illustration)

Carbon Finance and the Funding Gap for Municipal Solid Waste Management in Developing Countries: Opportunities and Limitations

1.2 CURRENT FUNDING SOURCES IN THE MSW SECTOR

The MSW sector in developing countries faces significant financial challenges, particularly in securing funding for the OPEX. While the CAPEX for infrastructure and initial investment is sometimes secured, covering ongoing operational costs remains a critical hurdle. The following section outlines existing funding sources and key opportunities to bridge this gap. Globally, municipal governments contribute approximately 50% of capital investments in waste services, with an additional 20% provided through subsidies from national or provincial governments[25]. The remaining financing is supplied by private sector actors. These investments span integrated waste management systems—from collection to processing and disposal—as well as support for sustainable practices and stand-alone facilities such as recycling centers, landfill gas recovery, and waste-to-energy plants.

1. Public Financing:

- Municipal Budgets and Taxes: Local governments typically fund MSW operations through municipal taxes and user fees. However, revenues often fall short due to low fee recovery and insufficient enforcement. Municipal governments in developing countries spend up to 19% of their budgets in MSW[26] .
- Government Subsidies: National and provincial governments may provide CAPEX support but rarely finance ongoing OPEX, limiting the long-term viability of MSW projects. Land - a major portion of upfront project costs – is often leased by local municipal bodies[27] .

2. Private Sector Financing:

Private investments in MSW management projects face significant revenue risks due to low-cost recovery as well as the small investment ticket sizes of many projects[28]. As a result, private investment in this sector is dominated by investments in waste-to-energy projects that offer more predictable returns. Public-Private-Partnerships (PPPs) can mitigate investment risk and improve financing, but their effectiveness depends on robust regulatory frameworks and incentives — many of which are absent or underdeveloped in emerging markets.

3. Public International Financial Institutions:

MDBs, DFIs, and international organizations[29] play a crucial role by providing capital, loans, grants, and technical support to MSW projects. Technical assistance typically takes the form of capacity building and policy support to governments and local bodies[30]. Relevant examples include:

- World Bank: Over USD 4.7 billion committed to 340+ MSW projects since 2000, supporting infrastructure financing and technical assistance[31] .

25. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank. https://openknowledge.worldbank.org/handle/10986/30317
26. ibid
27. AGS Carbon Interaction with Industry Consultant
28. CPI (2023), Landscape of methane abatement finance. https://www.climatepolicyinitiative.org/publication/landscape-of-methane-abatement-finance-2023/
29. Including the World Bank, the Green Climate Fund (GCF), Kreditanstalt für Wiederaufbau (KfW) Bank, the European Investment Bank (EIB), the Inter-American Development Bank (IDB), the Japanese International Cooperation Agency (JICA) United Nations Environment Programme (UNEP), Global Environment Facility (GEF), and the African Development Bank (AfDB)
30. Institutions including but not limited to the World Bank, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ and KfW Bank are proactive in this space
31. Solid Waste Management, World Bank, (2022), (https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management#:~:text=Objectives%20that%20guide%20the%20Bank's,%2C%20trucks%2C%20and%20transfer%20stations.)

- **KfW Bank**: Supported MSW projects in Serbia and Indonesia with EUR 200M and EUR 75M respectively[32]. In Indonesia, it funded landfill development and operations in Jambi and Sidoarjo, with EUR 7.6 million dedicated to sustainable operations and community engagement. [33]

- **AfDB:** Through initiatives such as the Urban and Municipal Development Fund (UMDF) and the African Circular Economy Facility (ACEF), AfDB supports climate-resilient waste infrastructure and circular economy models.

See Appendix II for a list of key international funding and technical cooperation agencies active in the sector.

4. Bonds:

Bonds are an attractive way to finance projects by leveraging capital markets. Investors purchase bonds to provide the upfront capital required to implement infrastructure projects. In return, issuers—typically corporates or government entities—pay periodic interest ("coupon payments") semi-annually or annually over the life of the bond, which often ranges from 10 to 15 years. At the end of the bond term, investors are repaid the original principal.

Green and sustainability-linked bonds are being used with growing frequency by corporates and governments to finance climate infrastructure, including MSW projects. The CBI has a taxonomy setting the standards and criteria clarifying which MSW technologies qualify as green. According to the Climate Bonds Initiative (CBI), cumulative global issuance of green and municipal bonds for the MSW sector reached approximately USD 119 billion by the end of 2023. Financial and non-financial corporates have contributed close to a third of allocations in the MSW sector, and local governments (particularly in the US) are also active[34]. However, this issuance is heavily concentrated in developed economies, which account for roughly 70% of the market share. This trend is largely attributable to the higher creditworthiness of issuers in these regions and the presence of strong, revenue-generating assets—factors that reduce investor exposure to repayment risks.

The two most common types of bonds used for MSW financing are:

- **Corporate Bonds**: Bonds issued by financial and non-financial corporates, including domestic and development banks, and waste management companies.

  Example: Renewi (UK) is an example of a corporate issuing green bonds (and loans). Their first green bond launched in 2015 and financed projects related to waste recycling into usable products; treating contaminated water and soil; treating organic waste by converting it into energy or fertilizer; and reducing emissions from transporting waste. Two further green bonds and one green loan totaling USD864m have been issued since[35].

- **Municipal Bonds:** Bonds issued generally by local governments or their agencies to finance public infrastructure projects. These bonds allow municipalities to raise funds directly from the capital markets. The decision of the investors to invest in municipal bonds is often dictated by the purpose for which the bonds are being issued and the credit rating of the municipality.

32. https://balkangreenenergynews.com/kfw-provides-eur-11-million-for-two-regional-landfills-in-serbian-cities/
33. https://www.kfw.de/stories/environment/nature-conservation/solid-waste-management-indonesia/
34. Climate Bonds Initiative (2020). Financing waste management, resource efficiency and circular economy in the green bond market. (markets_waste_resource_efficiency_briefing_2020.pdf)
35. ibid

- **Example**: Ahmedabad Municipal Corporation (AMC) in India issued green municipal bonds in 2017, raising ₹200 crore (~ USD 30 million) to fund sustainable projects, including MSW[36]. A significant portion was allocated to developing a waste-to-energy (WTE) plant with a capacity of 1,000 tonne per day (TPD), reducing landfill use, and generating clean electricity. The bond was certified by the CBI, ensuring funds were used sustainably, with monitoring and reporting mechanisms in place. This initiative enhanced waste collection, segregation, and recycling, contributing to reduced GHG emissions and improved waste disposal systems.

5. Revenues:

• User Fee or Gate Fee: Municipalities typically charge user fees to waste generators—such as households, businesses, and institutions—to recover the cost of waste collection and treatment. These fees may be fixed or linked to the volume of waste generated. In the absence of dedicated user fee systems, municipalities often rely on general tax revenues to finance waste management services. Gate fees are charged by the operators of waste treatment facilities to municipalities or third-party waste producers for each tonne of waste received. These fees are intended to cover treatment and disposal costs. However, in developing countries, revenue from user and gate fees is frequently insufficient to meet the OPEX of waste management facilities, resulting in funding gaps and service interruptions.

• Product Sales: marketable products that can be generated by a waste management plant often include recyclables such as plastics, metal, glass, and paper, energy such as biogas, biomethane, electricity, heat and re-processed bio-products such as compost and fertilizer. Revenues from the sale of these products are often unreliable due to weak market demand, price fluctuations, and lack of regulation.

• Result-Based Revenues:

- Carbon Credits: Established mechanism that enables MSW projects to monetize verified GHG emission reductions—particularly methane mitigation. Revenues can be generated through the compliance, voluntary, or international carbon markets, which serve as important tools for closing the operational funding gap.

- Plastic Credits: A relatively nascent mechanism designed to incentivize plastic waste collection and recycling. However, the market remains limited in scale and stability due to its reliance on voluntary corporate commitments. Moreover, plastic credits currently offer narrow environmental benefits, lacking integration with broader waste streams such as organic waste, which are major sources of methane emissions.

2. RESULT-BASED FINANCING: AN OVERVIEW

In recent years, MSW projects in developing regions have adopted diverse funding mechanisms to enhance financial viability. One such tool is Result-Based Financing (RBF) which makes payments only after predefined measurable outcomes - such as methane emission reductions - are achieved and independently verified. As such, it incentivizes performance while providing a revenue source. Unlike traditional financing, RBF ensures a more efficient use of resources, as payments occur only after independently verified results.
Moreover, while the outcomes under RBF mechanisms are clearly defined, the choice of methods or strategies to achieve them is typically left to the implementing entity. This flexibility encourages innovation and allows for adaptation to local conditions. Crucially, the performance risk — i.e., the risk of not achieving the agreed outcomes, and thus of generating non-performing assets — is shifted from the financier to the implementer.
Although RBF instruments vary in structure and scope, they offer a promising pathway for aligning sustainability objectives with financial markets. By linking payments to verified results, RBF mechanisms can enhance the

36. Ahmedabad-Green-Municipal-Bond-Case-Study-2.pdf

financial viability of MSW projects, particularly in developing contexts. This section outlines the conceptual framework of RBF, with a focus on two emerging applications: plastic credits and carbon credits.

2.1 PLASTIC CREDITS

Plastic credits are a market-based mechanism. Organizations or companies that reduce, recycle, or otherwise mitigate plastic waste can earn plastic credits. These credits can then be sold to entities seeking to offset their plastic usage. One plastic credit represents one tonne of plastic collected or recycled in a processing facility. By turning waste reduction into a monetizable asset, plastic credits encourage investment in urban waste management systems. Plastic credits are relatively a new phenomenon , with active participation from large corporates like Coca Cola and Amazon[38].

How it Works

• Generation of Credits: Plastic credits are earned when organizations collect and recycle plastic waste beyond a specified baseline. Project eligibility depends on the geographical location of the project and the penetration level of recycling and collection. In urban settings, this could mean enhanced recycling programs or partnerships with local waste pickers to collect plastics from landfills. Projects need to demonstrate additionality[39] and can be deemed ineligible where collection or recycling are systematically enforced with rates above 20%.

• Certification: Third-party organizations verify the plastic waste collected, recycled, or eliminated from the environment. Certification bodies like VERRA or the Plastic Credit Exchange provide standards and oversight for issuing plastic credits.

• Trading: Companies that are unable to reduce their plastic footprint directly can purchase these credits to offset their environmental impact. Buyers include corporations in industries in retail, packaging, and consumer goods, seeking to fulfil sustainability goals or regulatory requirements. This creates a financial incentive for MSW projects seeking to expand plastic recovery operations.

Limitations

• Price Volatility: Prices vary significantly and depend on the buyer and other factors such as crude oil prices[40]. Based on literature review, credits are priced in a range between USD 50-800 per tonne of plastic removed[41] and USD 500 based on marketplace sources[42].

• Weak demand: Despite the lucrative premium, plastic credit programmes are voluntary with no committed offtake of credits. They are normally bilateral initiatives where developers experience an intermittent flow of capital, based on investors' priorities[43].

• Impact: The market for plastic credit remains nascent. Only 15 plastic credit projects were registered under Verra's Plastic Credit Program between 2022 and 2024, mostly located in Africa, Asia and Europe. This is significantly lower than the registration of 40 MSW projects with emission reduction targets over

37. As of 6th May 2025, there are 24 projects registered under VERRA' Plastic Waste Reduction Program (https://registry.verra.org/app/search/PWRP/Registered)
38. AGS Carbon interview with ISWA
39. Additionality is a core principle of any carbon and plastic mechanism. A project is said to be additional, if its implementation would not have happened without support of carbon credits. If the project was already feasible, there would be no requirement of carbon or plastic credit revenue.
40. AGS Carbon interaction with ISWA
41. Gold Standard of Plastic Credit (https://plascred.com/plastic-carbon-credit/)
42. Plastic Credits White Paper, Eunomia (2024), (https://www.fauna-flora.org/wp-content/uploads/2024/05/2024MAY29_Eunomia-Plastic-Credits-White-Paper-v4.0.pdf)
43. AGS Carbon Interaction with ISWA

the same period under Verra[44]. A potential explanation for this is investors' preference for projects that reduce methane emission reductions, contributing to climate change mitigation[45].

Overall, despite their potential to drive recycling and plastic waste management, plastic credits remain a less popular choice of RBF due to their voluntary nature, lack of committed credit offtake, price volatility, and impact potential.

2.2 CARBON CREDITS

Carbon credits provide a comparatively more proven pathway for leveraging finance to incentivize GHG emission reductions from MSW projects. One carbon credit represents one tonne of carbon dioxide equivalent ($CO_2eq.$) emission reduced or removed. By generating tradable carbon credits, they enable MSW projects to monetize verified emission reductions, particularly from methane, aligning environmental and financial outcomes. When organic waste[46] decomposes in oxygen-deprived environments, such as landfills and dumpsites, it releases methane. It is estimated that a ton of landfilled organic waste produces a minimum of one tonne CO_2e[47] . The reduced methane emission from waste collection and processing, upon verification by third-party body, can be equated to CO_2 equivalent and then translated into carbon credits.

For some companies, it is challenging to reduce carbon emissions from their operations due to high costs, weak oversight of supply chains or lack of incentives and/or regulations to drive emission reduction. Instead, they can buy carbon credits generated from projects, including MSW, to meet their emission reduction targets (offsetting). The additional revenue for the projects generating and selling carbon credits could improve the financial viability of the project, making operation more financially sustainable.

The three case studies below demonstrate how MSW projects deploying different types of technology have incorporated revenue from carbon credits:

- Reliance Composting Project (South Africa - VERRA): An organic waste composting facility with a capital outlay of USD 3.4 million. Operational costs remain minimal due to the streamlined composting process, making it a replicable solution. Supported by a mix of local government subsidies and private capital, this project significantly relied on carbon credits – with increased ROI from 0.1% and 2.5% to 2.5% and 5.6% in 2015 and 2016 respectively. This additional revenue helped cover operational expenses, demonstrating how carbon finance can be instrumental in maintaining small scale MSW projects.

- Vega-Hereko Istanbul Waste-to-Energy Project (Türkiye – VERRA): Landfill gas (LFG) project commissioned in 2019, with a capital investment of USD 21 million and annual operational expenditure of USD 4.5 million. This project follows a public-private partnership model, integrating government incentives with private investment while drawing approximately 10% of its revenue from carbon credits.

- Gianyar Waste Recovery Project (Indonesia - CDM): Mixed waste recovery model with aerobic composting, commissioned in 2023. Its comparatively low CAPEX (i.e. USD 800,000), paired with minimal operational expenses, aligns well with the waste recovery needs of mid-sized urban centres. Funded primarily through international development grants with local government support, carbon revenues helped this project become viable by increasing yearly profit margin. VERRA Registry (VCS ID 1817)

44. The other project activities include waste to electricity generation, manure management. However, for comparison with plastic credit projects only waste handling and disposal projects are considered.
45. AGS Carbon Interaction with Klik Foundation
46. Organic waste includes food waste and green waste
47. DBFZ Report Nr. 47: WasteGui - Guideline for organic waste treatment in East Africa

Collectively, these projects shed light on the opportunities and barriers of carbon financing in MSW projects dependent on project size, technology, funding structure, and geography[48]. These opportunities and limitations under existing mechanisms are further explored in Chapter 3 and 4.

3. CARBON MARKETS: MECHANISMS

Carbon markets can be classified based on the buying motivation of the credit purchaser. Broadly, buyers are either driven by compliance obligations, as mandated by law or regulation, or by voluntary commitments to meet corporate sustainability goals. In addition to this motivational classification, carbon markets can also be described based on their geographic framework. The following section will delve into existing International, Compliance, and Voluntary Mechanisms.

3.1 INTERNATIONAL MARKETS

Countries which are parties to the UNFCCC reduce their emissions by buying carbon credits from projects implemented in other countries to meet their NDCs. The Kyoto Protocol, which entered into force in 2005, was the first international treaty to set legally binding GHG emission reduction targets for industrialized countries (Annex I countries). The Protocol introduced three market-based mechanisms: Joint Implementation (JI), the Clean Development Mechanism (CDM), and International Emissions Trading (IET).

Since 2021, the Kyoto Protocol was superseded by the Paris Agreement with Article 6 becoming a crucial component of the global framework that allows countries to collaborate on achieving their national climate goals upon receiving host country approval. Article 6.4 established a new market-based mechanism, similar to the CDM (See **Box 2**) under the Kyoto Protocol but operating under stricter rules to ensure sustainable development and additionality. Article 6.2 allows countries to trade emission reductions on a bilateral basis in the form of Internationally Transferred Mitigation Outcomes (ITMOS). The Joint Credit Mechanism (JCM) from Japan is an example of such bilateral mechanism. Other countries with active agreements with developing countries include Switzerland and South Korea. At present, for Article 6.2 and 6.4 mechanisms, countries are working out a process to address the issue of double counting and making corresponding adjustments[49] of carbon credits generated from these projects for meeting their NDCs. **Table 1** below shows a comparison between these mechanisms.

BOX 2: THE CLEAN DEVELOPMENT MECHANISM (CDM)

The CDM is one of the three market-based mechanisms established under the Kyoto Protocol to assist countries in meeting their GHG emission reduction targets. It enabled industrialized countries (Annex I Parties) to invest in emission reduction projects in developing countries (non-Annex I Parties) and receive Certified Emission Reduction (CER) credits - each equivalent to one tonne of CO_2 - which can be applied toward their own emission reduction commitments. It officially became operational in 2001, and it saw rapid growth between 2005 and 2012, driven by the first Kyoto Protocol commitment period. CDM projects continued to be registered and issued credits under its existing framework until its complete phase out in 2021 with the shift to the Paris Agreement's framework. **CDM projects seeking to transition to Article 6.4 must request to transition before end-2025.** Until Article 6.4 methodologies are published, CDM projects can still transition using existing CDM methodologies. If developers prefer to use the new Article 6.4.

48. A more detailed analysis of similar projects registered under different registries can be found in Appendix-VII
49. When one country sells ITMOs to another, corresponding adjustments are made to both countries' emission inventories to ensure emission reductions are not double-counted and ensuring integrity.

Table 1: Comparison of Joint Implementation, Clean Development Mechanism, and Articles 6.4 and 6.2

	Joint Implementation (JI)	Clean Development Mechanism (CDM)	Article 6.4	Article 6.2
Legal Basis	Kyoto Protocol (Article 6)	Kyoto Protocol (Article 12)	Paris Agreement (Article 6.4)	Paris Agreement (Article 6.2)
Eligible Host Countries	Annex I countries (industrialized)	Non-Annex I countries (developing)	Any country	Any country
Eligible Investor Countries	Annex I countries	Annex I countries	Any country	Any country
Credit Type Issued	Emission Reduction Units (ERUs)	Certified Emission Reductions (CERs)	Article 6.4 emission reductions (name pending finalization)	Internationally Transferred Mitigation Outcomes (ITMOs)
Oversight Body	Host country (Track 1) or JI Supervisory Committee (Track 2)	CDM Executive Board	Article 6.4 Supervisory Body	Bilateral agreement between participating Parties; transparency under UNFCCC
Verification Process	Track 1: domestic; Track 2: independent verification	Independent Designated Operational Entity (DOE)	Independent verification; modalities under development	Defined by bilateral agreements; subject to reporting and review
Use of Credits	Toward Kyoto targets (Annex I only)	Toward Kyoto targets and potentially first NDCs	Toward NDCs or other mitigation claims	Toward NDCs or other authorized uses (e.g. CORSIA)
Transition to Paris Agreement	Discontinued; not transitioned	Eligible projects can transition to Article 6.4	Active mechanism expected by 2026	Operational since 2021; use subject to agreed guidance

3.2 COMPLIANCE MARKETS

Compliance markets are regulated systems where entities are mandated by law or regulation to meet established emission reduction targets, typically at a national or regional level. They are established by countries and/or regions to help meet their own NDC.

Countries and/or regions set targets for their industries and corporations for emission reductions within their jurisdictions. Companies which reduce emissions below their allocation can sell their surplus allowances. Companies that exceed their allowance are mandated to buy these credits. This system is also called 'Cap and Trade' emission trading system and is characteristic of compliance markets as there is a mandatory "cap" on emissions allowed.

The price on CO2 is set by a market-mechanism based on the demand on emissions allowances available in relation to the emissions "supplied" by companies and industry. The sustainability and cost efficiency of the system requires that the cap targets are enforced - e.g. through monitoring and reporting - and decline over time to keep reductions attractive and generate effective carbon prices. Such Emission Trading Systems (ETS) are characteristic of domestic and regional markets. Participants are often heavy industries as well as some small to medium enterprises, such as from the hospitality sector.

The compliance mechanisms operational at domestic, provincial, and/or regional level are concentrated mainly in developed countries such as Australia, Canada, some states in the USA and in the European Union.[50] Examples include the European Union Emissions Trading System (EU-ETS), California Cap-and-Trade Program, New Zealand' ETS. China and Korea also have well developed ETS. In 2024, 36 emissions trading systems were implemented globally, with a further 22 under development or consideration, as highlighted in the ICAP Status Report 2024. Compliance markets in countries such as Brazil, India and Türkiye are emerging but are yet to be operationalized in full-scale. [51]

Since the focus of the whitepaper is on the MSW sector in developing countries, the paper does not explore compliance markets in detail. Chapter 4 delves further into the opportunities and limitations of carbon financing for MSW projects in developing countries within the international and the voluntary market mechanisms.

BOX 3: SECTORAL MARKETS

The sectoral compliance market plays a pivotal role, setting mandatory emission reduction targets for sectors such as aviation, energy, and manufacturing. Participants require a letter of approval from the host country to allow the use of carbon credits for meeting the companies' own emission reduction targets and to avoid double counting of credits towards NDCs. Participants in this market must adhere to these targets by reducing their carbon footprint or purchasing credits from projects that offset emissions. Compliance is enforced through regular audits and there are penalties for non-compliance, fostering a gradual transition towards more sustainable practices within the industry.

An example is a scheme by the aviation sector called Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), under which operators offset emissions by cancelling "CORSIA Eligible Emissions Units". Projects must meet strict criteria for additionality, permanence, and robust monitoring. Pricing depends on the market rates for eligible carbon credits. In 2024, prices for future contract rose to above USD 20 per tonne and modeling by MSCI Carbon Markets suggests that credits could see prices in the USD 27-91 range by 2035

3.3 VOLUNTARY MARKETS

Voluntary carbon markets (VCMs) operate outside regulatory frameworks are thus complementary to compliance schemes. They allow participants to purchase and trade voluntary carbon credits in an open market. Since it is voluntary, there is no cap on the amount of emissions allowed or on how many emission reductions a stakeholder may trade. VCMs predominantly include companies but also involve not-for-profit organizations, sub-national governments, and individuals. In the voluntary market, buyers often are technology firms, consumer goods companies, food and beverage corporations, and oil and gas companies, who want to offset their own emissions through buying carbon credits.

50. State and Trend of Carbon Pricing 2024, The Word Bank Group (2024), (https://www.worldbank.org/en/news/press-release/2024/05/21/global-carbon-pricing-revenues-top-a-record-100-billion)
51. State and Trends of Carbon Pricing, World Bank (2024), (https://openknowledge.worldbank.org/server/api/core/bitstreams/253e6cdd-9631-4db2-8cc5-1d013956de15/content

There is no government mandate or formal regulatory oversight governing the operation of voluntary carbon markets. Instead, standard-setting bodies such as Verra and Gold Standard act as de facto supervisory entities by developing methodologies and ensuring the environmental integrity of credits issued under their frameworks. **The comparison table** below illustrates key features of both registries. Moreover, in 2021, the voluntary carbon market landscape evolved with the creation of the **Integrity Council for the Voluntary Carbon Market (ICVCM)** [52] - a quasi-regulatory body established to define and uphold core principles for high-integrity carbon credits across the voluntary market.

VERRA vs. Gold Standard: Market Segmentation in Carbon Credit Categories

Aspects	VERRA VCS	Gold Standard
Focus	**Emission reductions**	Emission reductions with added emphasis on SDGs and Safeguarding Principles
Market Volume	822 million retired Credits (71% share)	211 million retired Credits (18% share)
Geographical Scope	2,472 registered projects in 105 countries	1,367 registered projects in 77 countries
Market Recognition	**Widely recognized**	Premium recognition for sustainable impacts
Name of Credits (1t CO2e)	Verified Carbon Units (VCUs)	Verified Emission Reductions (VERs)
Sustainable Development	Secondary focus on co-benefits	Primary focus on SDG contributions

(Note: VERRA and GS registries accessed on 01/06/2025)

3.4 REGISTRATION PROCESS

Carbon credit mechanisms follow a structured process designed to assess project eligibility, ensure environmental credibility, and enable the issuance of high-integrity credits linked to verified emission reductions. However, a significant knowledge gap persists among project developers, municipal authorities, and technology providers regarding how to effectively leverage carbon finance for MSW project financing. Importantly, carbon finance can often be accessed at relatively low marginal cost[53] , depending on the project type and the crediting mechanism used.

Projects must first be registered under a selected registry—whether under a voluntary standard or an international mechanism—before undergoing **validation and verification by an independent third party**. This process ensures alignment with the registry's principles and eligibility criteria and confirms that the appropriate **methodology** for calculating emission reductions has been applied. Once validated, the project is authorized to monitor its operations and request the issuance of carbon credits. Appendixes III and IV outline the key

52. The ICVCM serves as an independent governance body focusing on quality and transparency in the voluntary carbon market. It aims to ensure that carbon credits meet high environmental and social integrity criteria, enhancing market credibility. Their Core Carbon Principles provide a benchmark to distinguish credible carbon credits, facilitating informed investments and reducing greenwashing risks.
53. Cost refers to registry fees, cost of auditing, monitoring, and the cost of carbon consultants.

milestones for project registration across different registries, including the required frequency of monitoring, which varies depending on the waste management technology employed.

Currently, there are more than a dozen approved methodologies under voluntary standards (see Appendix IV) that quantify emission reductions from a range of solid waste management interventions. These include landfill gas capture, landfill diversion, composting, anaerobic digestion, recycling, and waste-to-energy technologies. Article 6.2 of the Paris Agreement does not provide a centralized procedure for project registration or credit issuance. Instead, it allows participating countries to bilaterally agree on which registry to use for issuing ITMOs. In contrast, the list of approved methodologies under Article 6.4 is still under development, with finalization expected by the end of 2025.

Appendix IV provides a detailed explanation of the end-to-end project cycle for carbon credit generation across key mechanisms, including VERRA, Gold Standard, and the emerging frameworks under Article 6.2 and 6.4 of the Paris Agreement. These frameworks outline the rules, principles, and operating procedures that guide project developers in implementing eligible activities and quantifying emission reductions.

3.5 KEY TERMINOLOGY

In the process of issuing carbon credits for project financing, there are important principles to bear in mind.

- Additionality: A project is said to be additional if its implementation would not have happened without the support of carbon finance. Projects in all registries must prove through rigorous analysis that the project is not financially viable without carbon credits, and must identify and address potential technical, financial and institutional barriers. By meeting the additionality criterion, projects ensure that carbon finance supports truly transformational initiatives that drive emission reductions. Projects should not attempt to generate carbon credits if the activities would have occurred regardless of carbon finance, as this undermines trust in carbon markets and poses reputational risks. Such projects have a high risk of failing verificationb and/or failing to find buyers. Beyond financial viability, the absence of legal frameworks and/or weak implementation can also serve as a ground for seeking carbon finance.

- Start date of the project often dictates the eligibility of the project to register itself in any of the mechanisms. The start date also dictates at what stage stakeholder consultation should be conducted to take feedback or input from the identified stakeholders. Under Gold Standard and Article 6.4, the start date refers to the first date of committing expenditures to the project (First work order date/First Invoice date) whereas under VERRA it implies the date of commissioning (i.e. start of operations) of the project.

- Prior consideration: Project developers must demonstrate that carbon revenues were a necessary factor in the decision to undertake the project. For Article 6.4 projects, notification of prior consideration must be submitted to the UNFCCC Secretariat within 6 months of the project start date.

- Documentation: Project developers are normally required to share the following information at the outset: Project location, Technology employed, Inputs from stakeholders, Estimated carbon credit generation, Contribution to SDGs. This information is published on the registry's website to seek feedback from the public and undergoes independent verification by auditors. The assessments ensure project applicability and suggest corrective actions if necessary. Developers often engage carbon consultants to complete documentation using prescribed templates.

- Stakeholder Consultation: Often a mandatory and critical part of the carbon credit certification process. Consultations are two-way exchanges with involved actors to ensure stakeholders can provide feedback

or raise concerns. Under VERRA, this process is strictly two-way to ensure stakeholders can provide feedback or raise concerns for project developers to incorporate such feedback. Overall, consultations are conducted on two levels:

O Initial Consultation: Held at or near the start of the project with the objectives to inform stakeholders about the project design, implementation, and its environmental and social benefits, potential risks, and explain carbon credits and related contractual arrangements.

O Continuous Consultation: Ongoing throughout the project lifecycle with the purpose of monitoring stakeholder experiences and addressing emerging issues, maintaining accessible communication channels tailored to local contexts, encouraging stakeholders to share project improvement suggestions via a formal grievance redressal procedure, provide regular updates to stakeholders (including changes in project operations, ownership details of carbon credits, and result monitoring and achievement.

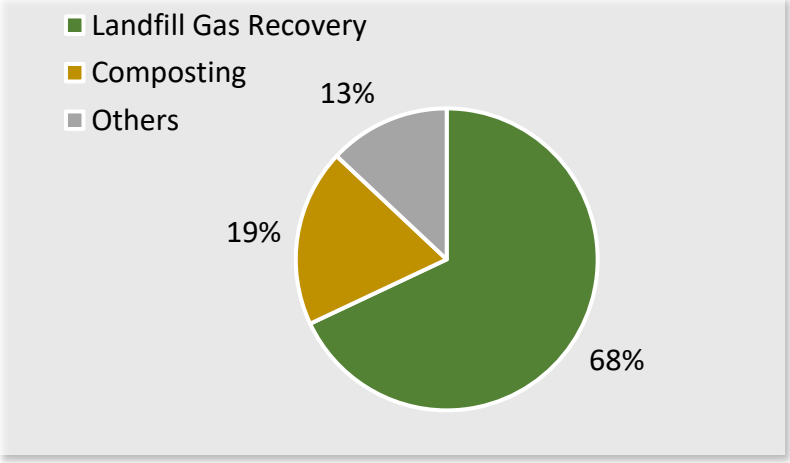
4. CARBON MARKETS AND MUNICIPAL SOLID WASTE

Carbon markets have historically played a significant role in financing MSW projects, particularly under the CDM from 2006 to 2012. The CDM demonstrated how structured carbon finance could drive sustainable waste management solutions while achieving climate mitigation goals and provided valuable lessons for future global carbon trading systems, such as Article 6.2 and 6.4 mechanisms. The CDM allowed so called Annex I Parties (developed countries) to conduct anti-global warming projects in non-Annex I Parties (developing countries).

4.1 CARBON CREDITS PROJECT DISTRIBUTION

Analysis across **the voluntary and international registries**[54] (Figure 4) **reveals that 68% of the MSW registered projects cover methane gas extraction from landfills, followed by another 19% from composting plants**. The remaining 13% include projects utilizing advanced techniques, such as controlled combustion and controlled pyrolysis for methane avoidance, and plasma technology for waste-to-energy generation. These also involve aerobic digestion of solid waste and electricity generation from waste through incineration, among other methods.

Figure 4: Carbon Credit issuance by MSW technology

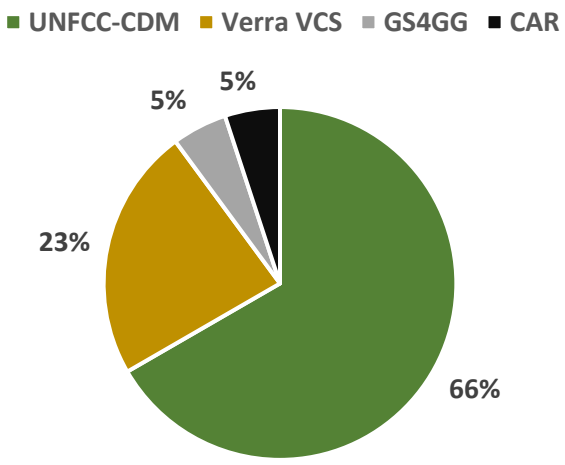


This chart represents figures expressed according to the number of registered projects under registries: UNFCCC-CDM, VERRA VCS, Gold Standard GS4GG, CAR, ACR and GCC as on 07/11/2024.

54. The mechanisms considered for this analysis include UNFCCC-CDM, VERRA-VCS, Gold Standard, and Climate Action Reserve (CAR)

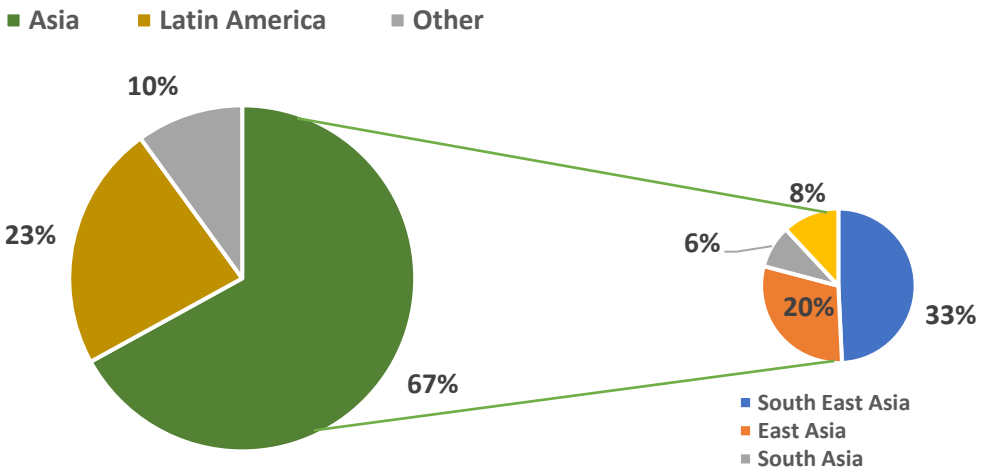
Moreover, as shown in **Figure 5**, international mechanisms make up two two-thirds of the MSW project issuance. The largest proportion comes from UNFCCC-CDM, followed by VERRA-VCS and other voluntary registries. The CDM projects under the MSW sector were registered prior to 2016, while the projects in the other three mechanisms were registered between 2015 and 2023.

Figure 5: MSW project issuance by mechanism (international and voluntary)



In terms of geographical distribution, approximately 70% of carbon projects are in Asian countries, followed by 23% in Latin America. A further breakdown reveals that South-East Asia hosts one-third of the projects while China, South Korea, and Japan together account for one-fifth of the total projects.

Figure 6: Asia Hosts the Majority of MSW Carbon Projects



4.2 HISTORICAL TRENDS

Historically, the MSW sector has witnessed low and high tides of carbon markets. The period under retrospect has been divided into two phases of 2006-2012 and 2012-2020.

- 2006-2012: Driven by the Kyoto Protocol, compliance markets under the CDM spurred investment in MSW projects. Carbon credit prices averaged **USD 15**, attracting significant private and public investments.
- Post-2012: Prices dropped **below USD 5** reflecting an oversupply of credits, and the phase-out of the CDM. This volatility reduced investor confidence.

Between 2006 and 2012, there was significant interest in MSW projects and the overall carbon market. Businesses were eager to reduce their carbon footprints, coinciding with the operational phase of the Kyoto Protocol, which facilitated the CDM. During this period, three mechanisms were active: the CDM, the Joint Implementation (JI), and the **EU Emission Trading System** (EU-ETS) which was launched in 2005 and operates in trading phases. The system is now in its fourth trading phase (2021-2030). Due to stringent emission caps under EU-ETS, the 2006-2012 period experienced increased trading volumes and favourable carbon credit pricing.

The global carbon market expanded rapidly during 2006-2012, driven by heightened demand for offsets in both international and voluntary markets. The weighted average price for carbon credits traded at around **USD 15**, with some projects achieving prices exceeding USD 20. Between 2005 and 2008, voluntary mechanisms accounted for a marginal market share of only 1% to 2%. However, their price trends were competitive with compliance markets, primarily because these mechanisms included community-level projects (such as cookstoves) that emphasized the achievement of other SDGs, thereby attracting a price premium. **Transaction volumes during this time were relatively low, ranging from 10,000 to 20,000 credits, and buyers were predominantly corporations seeking to fulfil their corporate social responsibility mandates, NGOs, and, to a lesser extent, investors looking to resell the credits**.

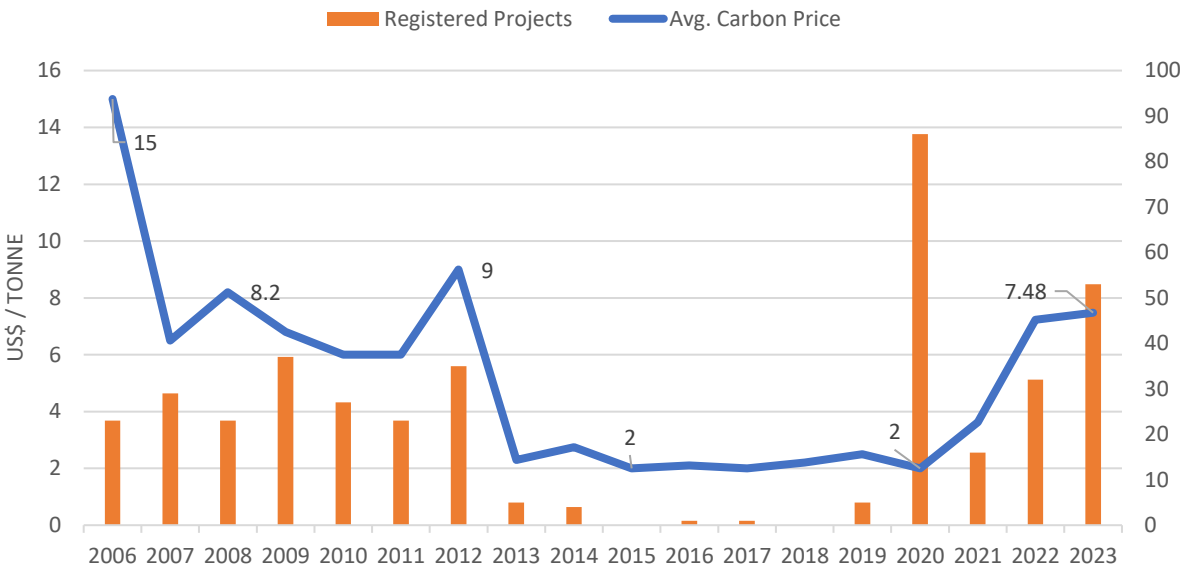
Carbon markets suffered a setback in 2008 due to the global financial crisis. As a result, the weighted average price in the voluntary market fell below USD 10 until 2010, before stabilizing through 2012, partly due to growing popularity of CDM and the introduction of new methodologies for the MSW sector. Prices were more stable in compliance markets during this period, particularly from 2008 to 2012, driven by strong demand in the EU-ETS.

Table 3: Carbon Credit Price Comparison for MSW Projects Between International and Voluntary Markets

Period	International Market (USD /tonne)	Voluntary Market (USD/tonne)
2005-2008	6 – 13	5 – 7
2009-2012	6 – 9	3 - 6
2013-2016	0.25 - 0.75	3 - 7
2017-2020	0.25 - 0.50	4 - 8
2021-2024	10-20	3 -10

Figure 7 U-Shaped Recovery of MSW Carbon Pricing

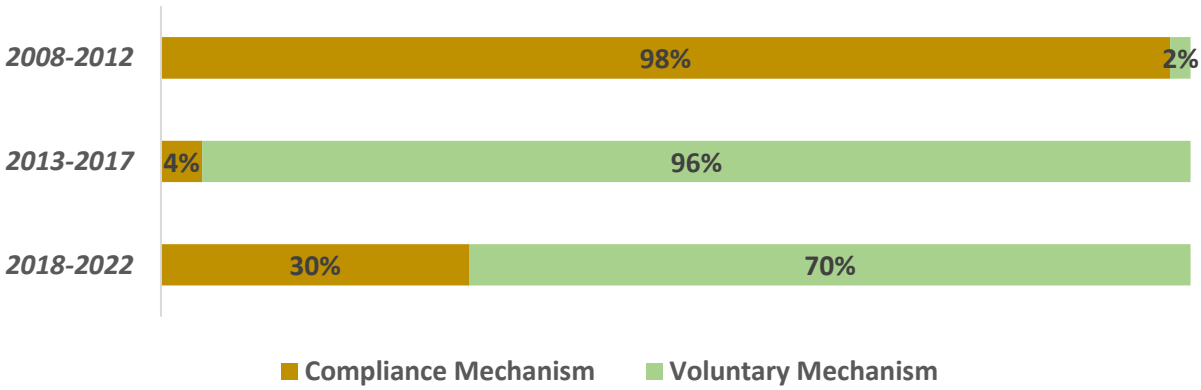
Figure 7: U-Shaped Recovery of MSW Carbon Pricing



As Phase I of the Kyoto Protocol approached its 2012 deadline, project registrations and carbon prices surged, driven by compliance targets in Annex I countries and investor urgency to capitalize on the market. However, after the phase ended, prices collapsed to below USD 2 by 2016. This decline was driven by Europe's economic slowdown, the EU ETS ban on non-EU credits, an oversupply of CDM credits, and weak global demand. Uncertainty around the transition to the Paris Agreement further dampened confidence, prompting some countries to explore domestic markets. As a result, project activity and prices remained subdued through 2020.

From 2018 to 2024, the share of international credits rose again, with their share rising to 30% (Figure 8) of global issuance. This resulted from the UNFCCC's permission to use vintage CDM credits to meet the first wave of NDCs under the Paris Agreement until 2020. In 2020, the CDM officially came to an end.

Figure 8: International Mechanisms Shaping Market Dynamics, in Carbon Credit issuances



(Note: Share is expressed in terms of credit issuances. Data from World Banks' and Ecosystem Marketplace' annual reports on carbon markets. Annual numbers are averaged into three categories but data for the second period contains only 2014-2016 due to limited data availability from these sources.)

4.3 LESSONS LEARNED

1. **Market Integrity:** Ensuring additionality and accurate MRV processes are key to maintaining investor trust.

Many project developers are facing criticism regarding the quality of the issued carbon credits. In response, an Independent governing body, ICVCM, was established in 2021 to create and uphold global standards for high integrity in the voluntary carbon market. These standards are founded upon ten core carbon principles, including additionality, sustainable development, and no double counting. Projects adhering to the core carbon principles are entitled to a 'CCP label' on their carbon credits, signaling higher quality credits that can attract more investments and potentially command a price premium.

Governance	Emissions Impact	Sustainable Development
• Effective Governmance • Tracking • Transperancy • Robust Independent Third-party Validation and Verification	• Additionality • Permanance • Robust Quantification of Emission Reductions and Removals • No Double Counting	• Sustainable Development Benefits and Safeguards • Contribution to Net-Zero Transition

In the VCM, ratings guide buyers in assessing quality across various project types. MSW projects generally receive higher ratings than other project types, such as cookstoves and forestry, due to stronger additionality[55] and more reliable emissions reduction estimates. Agencies like Sylvera, BeZero, Calyx often rate MSW projects in the 'A' category (A, AA+, AAA), while most cookstove projects are rated in B category (B, BB, BBB).[56] These higher ratings could result in increased demand and potentially pricing for MSW projects. However, better ratings do not always guarantee higher prices. Pricing is influenced by supply-demand dynamics and buyer preferences, including geographic focus, project type, perceived quality, and risk tolerance (see Appendix V for a list of potential MSW credit buyers).

Another key challenge is the risk of changes to emission reduction methodologies, which can impact project viability. For example, updates to the AMS.IIIF methodology for organic composting in 2013 significantly reduced estimated emission reductions, discouraging adoption. Developers must follow detailed monitoring protocols set by each methodology, which adds complexity, effort, and cost to project operations.

2. **Price Stability is Critical**: Volatility in carbon markets undermines project viability.

Carbon markets are sensitive to supply and demand dynamics influenced by externalities such as economic slow-down and regulatory uncertainties**. Carbon prices for MSW projects have remained around USD 5 per tonne for an extended period, compared to the high of approximately USD 15** over a 15-20 year period. This past trend may influence the

55. As discussed in previous sections, revenues from sale of products may fail to meet the operating expenditures and require support of carbon finance in developing countries.
56. Sector Snapshots: Cookstoves, Assessing the Quality of Landfill Gas Projects, BeZero (2022,2023), https://bezerocarbon.com/insights/sector-snapshot-cookstoves) https://bezerocarbon.com/insights/assessing-the-quality-of-landfill-gas-projects)

financial models that dictate the decision of developers to pursue carbon financing, but prices may continue to fluctuate. Combining carbon finance with other funding tools (e.g., grants, bonds) enhances project resilience.

3. Restrictions on Accessing Carbon Finance

Regulatory restrictions limit the participation of MSW projects in carbon markets. Under ICVCM guidelines, MSW projects with electricity generation capacities above 10 MW are excluded from eligibility in voluntary markets, as they may not meet additionality criteria due to cost efficiencies at scale. In contrast, smaller plants lacking economies of scale are more likely to be considered additional.

Policy and regulatory barriers also constrain access to international mechanisms, which typically offer more stable, long-term carbon pricing than voluntary markets. Large developing countries—such as India, China, Türkiye, Brazil, and South Africa—are unlikely to issue Letters of Authorization (LoAs) for exporting MSW-related carbon credits under Articles 6.2 and 6.4, as they prioritize using emission reductions to meet their own ambitious NDCs. For example, India has excluded MSW from its approved sectors for credit exports. Conversely, smaller countries with less stringent NDCs are more open to granting LoAs to attract low-cost climate finance, though they often face capacity constraints in implementing MSW projects effectively.

5. SWOT ANALYSIS OF CARBON MECHANISMS FOR THE WASTE SECTOR

The global carbon market is divided into three major sectors: **International Market (IM), Domestic Compliance Market (DCM), and Voluntary Carbon Market (VCM).** Each of these sectors plays a pivotal role in reducing carbon emissions and driving sustainability efforts, yet these markets face unique challenges and opportunities for the MSW sector. The section presents a detailed SWOT analysis of each market, highlighting the critical aspects that shape their current and outlook. A summary table is presented below:

Table 4: Summary SWOT analysis

Mechanism	Strengths	Weaknesses	Opportunities	Threats
International Markets (Art.6)	Greater Liquidity	Higher Compliance Costs	Technology Transfer	Regulatory Uncertainty
	Standardization	Complexity	Higher Pricing	Displacement of Local Solutions
	Support for Developing Countries	Insufficient Consideration of Sector Specific Needs	NDC Alignment	Unequal Access
Domestic Compliance Markets	Regulatory Alignment	Limited Market Size	Policy Integration	Policy Uncertainty
	Cost-effectiveness	Inconsistent Standards	Local innovation	Local Economic Downturns
	Government-Driven Demand	Limited Sectoral Coverage	Policy Support	Impact of Carbon Prices
	Facilitating Linkages to International Markets	Difficulty in Aligning with Global Standards		
	Co-benefits for Sustainable Development			
Voluntary Markets	Flexible Entry	Limited Policy Integration	Increased Corporate Demand	Credibility Issues
	Reputation and CSR	Smaller Market Size	Increased Alignment with International Standards	Price volatility
	Streamlined Project Approval	Unstandardized Market Framework	Support for Decentralized Waste Management	Barriers to long-term investment
	Access to Private Funding	Price Volatility and Shorter Offtake of Carbon Credits	Monetization of Co-Benefits	
	Lower Transaction Costs	Lower Price and Buyer Demand		
		Lack of Public Awareness and Demand		

5.1 INTERNATIONAL MARKET SWOT ANALYSIS

International carbon markets offer greater liquidity, standardized compliance processes, and support for developing countries, enabling waste management projects to access advanced technologies and higher financial incentives. However, they are burdened by high compliance costs, complexity, and regulatory uncertainty, while also potentially displacing local solutions and limiting access for smaller operators, particularly in developing countries.

Strengths

• **Greater Liquidity:** Offer greater liquidity and access to larger pools of buyers compared to compliance and voluntary mechanisms. This can lead to better pricing and more opportunities for waste management firms to sell carbon credits at higher rates, especially for large-scale projects like landfill methane capture.

• **Standardization:** More consistent and transparent standards, helping companies align their projects with global guidelines. For instance, methane capture projects can earn international carbon credits by following widely accepted protocols, streamlining both compliance and credit issuance.

• **Support for Developing Countries:** International carbon markets allow developed countries to invest in emission reduction projects in developing countries. This supports the transfer of technologies, expertise, and best practices, including through capacity building programs.

Weaknesses

• **High Compliance Costs:** Engaging often entails high administrative and compliance costs, including MRV processes. These expenses can be prohibitive for smaller waste management companies, limiting their ability to access international carbon markets unless the companies form partnerships or consortia.

• **Complexity**: The complexity of frameworks can make participation difficult through multiple layers of compliance, certification, and negotiations. Compliance with cross-border regulations may delay project implementation and increase operational costs.

• **Insufficient Consideration of Sector Specific Needs:** Markets are typically structured around the energy and industrial sectors, rather than addressing the distinct characteristics of the waste management sector. This can lead to the use of unsuitable methods for measuring emissions reductions and failure to adequately acknowledge the sector's wider impacts.

Opportunities

• **Technology Transfer:** Access to global technological advancements, such as advanced waste-to-energy technologies or improved recycling systems. For instance, the Joint-Crediting Mechanism developed by Japan mandates the host country to acquire technological know-how from Japan. Moreover, technical assistance and training are often available.

• **Higher Pricing and Longer-term Commitments:** Carbon credits projects can fetch higher prices. For example, the average price in Article 6.2 projects is about USD 30 per ton compared to just USD 4 per ton in the VCM[57]. These higher financial incentives enable waste management operators to invest in long-term infrastructure improvements, such as building composting facilities, anaerobic digestion plants, or recycling centers.

57. As of 20/11/2024, there is no price data specifically on MSW projects under Article 6.2. The average price prediction is based on AGS analysis and interview with Klik Foundation and Perspectives Climate Group

• **NDC Alignment:** Under the Paris Agreement, countries can use international carbon markets to meet their NDC goals more cost-effectively. Waste management projects that reduce GHG emissions can generate carbon credits that contribute to the NDCs, helping countries align their waste management policies with broader climate commitments.

Threats

• **Regulatory Uncertainty:** Uncertainty around international regulatory frameworks continues to challenge the development and investment in carbon credit projects, particularly in the waste management sector. Shifts in global climate agreements—such as the suspension of certain Kyoto Protocol mechanisms—have disrupted market dynamics and affected demand for credits. Several specific regulatory and implementation issues contribute to this uncertainty:

- O **Slow Progress on NDC Updates and Assessments:** Many countries have delayed updating their NDCs and reporting on progress toward existing targets. This lack of clarity complicates investor countries' ability to identify viable project types and creates difficulties for host countries in aligning emissions reductions with their NDC commitments.

- O **Delayed Operationalization of Article 6 Mechanisms:** While COP26 in 2021 resulted in agreement on the rules governing Article 6 of the Paris Agreement, the complexity of these provisions delayed implementation. It was only at COP29 in 2024 that full operationalization of both Article 6.2 (bilateral crediting between countries) and Article 6.4 (centralized mechanism replacing the CDM) was agreed upon.

- O **Uncertainty Beyond 2030:** There is currently no clarity on the crediting period for Article 6.2 projects beyond 2030, raising concerns about the long-term viability of carbon financing under this framework.

- O **Limited National Frameworks:** Only a small number of countries participating in Article 6 have established domestic regulatory frameworks. These are necessary to provide clear guidance on eligible project types, monitoring protocols, and credit transfer mechanisms, leaving most countries—and project developers—without firm direction.

- O **Delays in Article 6.4 Methodologies:** The rollout of applicable methodologies and other key deliverables under Article 6.4 has been significantly delayed. Originally expected by 2020, the mechanism's rulebook was postponed due to complex negotiations and disagreements among parties on governance, accounting, and crediting standards. These ongoing delays further constrain planning and implementation of compliant projects.

• **Displacement of Local Solutions:** Prioritize projects that focus on emissions reductions without considering local waste management needs or solutions. For instance, global carbon finance may prioritize waste-to-energy projects that reduce emissions but ignore local strategies for improving recycling, composting, or other waste diversion practices that are better suited to the local waste challenges.

• **Unequal Access:** Smaller waste management operators often face significant barriers to participating. These include the complexity of MRV requirements, high upfront costs, and the need for specialized technical expertise. Participation under Article 6.2 and 6.4 of the Paris Agreement also requires approval from national governments—a process that many developing countries are not yet equipped to manage effectively due to limited institutional capacity. Moreover, the absence of well-established national frameworks to support Article 6 implementation in these countries creates further challenges for project developers. Without streamlined approval processes, clear guidelines, and administrative support, many viable waste management projects in developing countries may be excluded from carbon trading mechanisms. These risks reinforcing existing global inequalities by concentrating climate finance and market access in wealthier or more administratively advanced countries.

5.2 DOMESTIC COMPLIANCE MARKET SWOT ANALYSIS

Domestic carbon markets offer regulatory alignment, cost-effectiveness for smaller firms, and government-driven demand, while also providing opportunities for local innovation and growth in carbon credit markets. However, challenges which include limited market size, inconsistent standards, and difficulty aligning with global regulations can complicate scalability.

Strengths

• **Regulatory Alignment:** Waste management firms can more easily comply with local environmental laws due to regulations tailored to national contexts. Domestic carbon registries help enforce these regulations by offering specific guidelines for emission reductions in waste management processes like composting and landfill operations. Examples include:

- **Canada Federal GHG Offset System:** Proposed regulations for the Federal GHG Offset System were published on March 6, 2021, in Canada Gazette Part 1, for public consultation. The Government of Canada is advancing offset protocols across sectors including landfill methane management and enhanced soil carbon.
- **Québec Offset Credit Component of The Cap-And-Trade**: The province is assessing other project types for new protocols, including bio-methanation or composting of organic waste and improvements in agricultural fertilization application practices.
- **Transportation and Climate Initiative Program:** This cooperative effort among 13 jurisdictions in the Northeastern and Mid-Atlantic United States allows carbon credits from projects in landfill methane capture and avoided methane emissions in agriculture. These project types are eligible for CO_2 offset allowances under the program.

• **Cost-Effectiveness:** Smaller waste management firms benefit from lower verification and participation costs compared to international markets, often due to government support and simplified verification process. Domestic carbon registries often streamline procedures, reducing the administrative burden and making it easier for smaller entities to engage in carbon credit trading.

• **Government-Driven Demand:** Domestic compliance markets are often part of government-mandated programs, ensuring steady demand for carbon credits generated by the waste management sector. Methane capture from landfills and waste-to-energy projects become integral to meeting regulatory requirements, securing consistent revenue.

• **Facilitating Linkages to International Markets:** Well-designed domestic carbon markets can integrate with international carbon markets [58], potentially providing access to a larger pool of credits and cost-efficient emission reduction opportunities. The access to international finance can both increase market liquidity and help fund low-cost MSW abatement opportunities across the globe.

•**Co-benefits for Sustainable Development:** Domestic carbon markets can encourage projects with broader environmental and social benefits, such as improved waste management systems, which align with SDGs.

Weaknesses

However, domestic markets face several limitations:

• **Limited Market Size:** Domestic carbon registries, especially in smaller countries, may have limited market participants, reducing liquidity.

58. Examples include South Korea' Emission Trading System, Mexico's Pilot Emission Trading System and Colombia' Carbon Tax and Offset System

• **Inconsistent Standards:** The absence of unified standards and varying enforcement mechanisms across domestic markets creates significant challenges. A project registered in one country may not qualify for carbon credits in another due to differing criteria. This fragmentation complicates project scalability, increases operational complexity, and makes it difficult to standardize methodologies, ultimately leading to inefficiencies for companies operating across borders.

• **Difficulty in Aligning with Global Standards:** Aligning a domestic carbon market with international standards, such as the rules set by the Paris Agreement, can be complex. Inconsistent methodologies or verification standards can make it hard to link domestic markets with international carbon markets, limiting global trading opportunities.

• **Limited Sectoral Coverage:** Many domestic carbon markets only cover specific sectors, such as energy or industry, leaving out other significant sources of emissions like waste management. The limited coverage can reduce the overall impact of the market on national emissions.

Opportunities

There is potential for growth within domestic markets:

• **Policy Integration:** Methane capture projects from waste management operations, especially at landfills, are prime candidates for earning carbon credits. As more countries expand their carbon pricing mechanisms, waste management companies that implement methane reduction technologies earlier can gain a long-term competitive edge and revenue from credit sales.

• **Local innovation:** Domestic registries often incentivize local innovation like recycling technologies, composting, and bioenergy, aligning with national environmental goals.

• **Policy Support:** Domestic carbon markets often receive backing through legislation, offering new avenues for waste management companies to develop and expand projects through incentives and an enabling environment.

Threats

Domestic markets also face several risks:

• **Policy Uncertainty:** Domestic markets are subject to political and economic changes. For instance, a government may reduce the scope of its carbon registry or change its carbon pricing strategy, leading to market fluctuations or reduced demand for waste-related carbon credits.

• **Local Economic Downturns:** In cases of economic recession, governments may deprioritize carbon pricing programs to focus on short-term economic recovery, negatively impacting waste management companies reliant on steady credit prices.

• **Impact of Carbon Prices on Recycling Markets: Introducing carbon pricing may have unintended consequences for recycling markets, where the cost of recycled materials may increase due to added carbon costs in the production and transportation process. This could make recycled products less competitive compared to virgin materials, weakening efforts to reduce the overall carbon footprint of the waste cycle.**

5.3 VOLUNTARY CARBON MARKET SWOT ANALYSIS

While VCMs offer growth opportunities for waste management projects due to their flexibility and appeal to non-regulated entities seeking to offset emissions, challenges related to market size, pricing, and credibility must be addressed to ensure greater reliability and uptake.

Strengths

• **Flexible Entry:** Waste management companies have the flexibility to voluntarily join markets, which allows projects like landfill methane capture to be monetized.

• **Reputation and CSR:** Participation in voluntary markets can enhance a company's corporate social responsibility (CSR) profile. Companies may claim carbon neutrality by purchasing voluntary offsets.

• **Faster Project Approval and Implementation:** Simpler and faster project approval processes, making it easier for waste management projects to get off the ground. It can be particularly advantageous for smaller or community-based waste management initiatives that may lack the resources or capacity to navigate the more complex approval processes of international or domestic compliance carbon markets.

• **Access to Private Funding:** Participation in voluntary markets opens access to a growing pool of private capital from companies and organizations seeking to offset their carbon footprints. Waste management projects, such as landfill gas capture, composting, or recycling, can generate carbon credits that are sold to businesses looking to meet their voluntary climate commitments. It may create a substantial revenue stream to projects that might not have access to traditional financing.

• **Lower Transaction Costs:** Voluntary markets often have lower transaction costs than international carbon markets, such as the cost of MRV.

Weaknesses

• **Limited Policy Integration:** VCMs often operate in isolation from national or regional waste management policies. This lack of policy integration can create misalignment between projects and broader waste management or climate strategies. For example, a waste-to-energy project that generates carbon credits might not align with a country's long-term goals to reduce waste generation or promote recycling.

• **Smaller Market Size:** Since participation is optional, voluntary carbon markets are generally smaller and less liquid than international markets.

• **Unstandardized Market Framework:** The VCM operates without a universal standard, resulting in variations in the quality, methodology, and transparency of carbon credits. Different voluntary standards, such as VERRA, Gold Standard, or Verified Carbon Standard (VCS), may apply differing rules, making it difficult for stakeholders to compare the value or environmental integrity of credits from waste management projects. The lack of standardization can reduce trust in the market.

• **Price Volatility and Shorter Offtake of Carbon Credits:** The price of credits can be highly volatile, making it difficult for operators to predict future revenues and plan long-term investments. With volatile pricing, projects may struggle to embed carbon finance as a reliable revenue source within their business models. Moreover, the contracts with buyers are often shorter (typically 2-3 years or even less) compared to the planned lifespan of the projects (around 10 years). This uncertainty in market conditions can create challenges for project developers who rely on carbon credits as a substantial revenue source.

• **Lower Price and Buyer:** MSW projects that participate in VCMs often face pricing challenges. The average price of around USD 5 [59] per credit is generally insufficient to cover operational and capital costs, limiting the projects' ability to establish sustainable revenue models. MSW credits fall under the category of emission reduction credits, while other project types—such as carbon capture and biochar—are classified as removal-based, and typically command higher prices due to buyer preferences for permanent carbon removal. Even within the reduction or avoidance category, MSW credits face competition. Buyers often favour other credit types, such as those from renewable energy or improved cookstove projects, which are perceived as more impactful or scalable. These credit types are also more widely available. For example, in 2022 and 2023, voluntary markets recorded the issuance of approximately 121.3 million renewable energy credits, compared to just 7.7 million MSW credits. [60]

59. Roughly, based on historical prices in voluntary markets (Please refer to Figure 7 for more details)
60. The State of Voluntary Carbon Market 2024, Ecosystem Marketplace (2024), (https://www.ecosystemmarketplace.com/publications/2024-state-of-the-voluntary-carbon-markets-sovcm/)

• **Lack of Public Awareness and Demand**: Voluntary carbon markets rely heavily on CSR initiatives and individual demand for carbon offsets. Without significant consumer pressure or corporate commitment, the demand for carbon credits from MSW projects may remain low.

Opportunities

VCM offers significant potential for growth:

• **Increased Corporate Demand:** The rising emphasis on carbon neutrality among corporations provides new revenue streams. As companies look to offset emissions voluntarily, the waste management sector has opportunities to supply carbon credits from MSW projects.

• **Increased Alignment with International Standards:** Voluntary markets are becoming increasingly aligned with international standards, including with the establishment of the ICVCM.

• **Support for Decentralized Waste Management:** Voluntary markets often have lower entry barriers compared to international markets, facilitating the participation of smaller, decentralized waste management projects.

• **Monetization of Co-Benefits:** Beyond carbon sequestration, waste management projects can yield additional environmental and social benefits, such as improved soil health through composting and job creation in recycling sectors. Voluntary markets can help monetize these co-benefits, attracting more investment into comprehensive waste management solutions.

Threats

Challenges and uncertainties remain:

• **Credibility Issues:** Due to the lack of stringent regulation, there is a risk of double-counting or fraudulent claims in voluntary carbon markets. Waste management companies may find it harder to convince buyers of the legitimacy of their credits, potentially driving down demand.

• **Price Volatility:** Voluntary carbon markets can be unpredictable. Prices may fluctuate based on demand from private companies, making it difficult for waste management firms to forecast revenues reliably from voluntary projects

• **Barriers to long term investment:** Lack of long-term off-takers for these projects often makes it difficult for investors to take long-term business decisions.

6. CARBON FINANCE FOR THE MSW SECTOR: OUTLOOK

Interest in MSW carbon credits has grown significantly in recent years, with annual issuances rising from 5 million credits in 2016 to approximately 23 million in 2024.[61] This growth is driven by a confluence of global policy initiatives and corporate sustainability commitments. A key development is the Global Methane Pledge, through which the United States, the European Union, and over 150 other countries have committed to reducing methane emissions by 30% by 2030, relative to 2020 levels. Notably, 15 countries have already incorporated methane reduction targets into their NDCs—a critical shift given that the MSW sector is responsible for nearly 20% of global methane emissions.

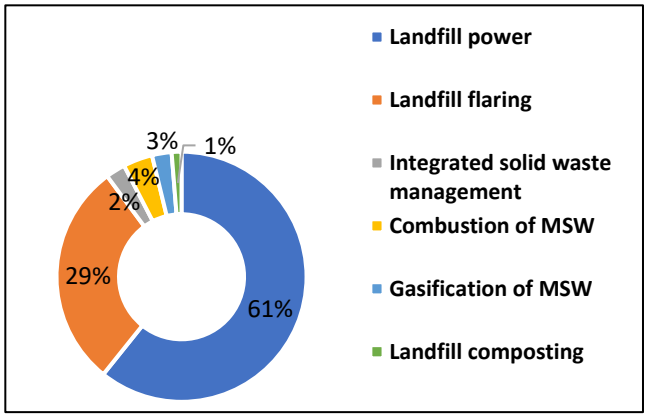
Non-state actors, particularly corporations and industrial players, are also under increasing pressure from shareholders, regulators, and civil society to align with Net-Zero targets. In many developing countries, growing

65. Voluntary Carbon Market Dashboard, Climate Focus (https://app.powerbi.com/view?r=eyJrIjoiMTQwMTBkZWEtOWVmZS00Y2I1LWE1OTktMDQ1MzFjMjU2MzVjIiwidCI6IjUzYTRjNzZkLWI2MjUtNGFhNi1hMTAzLWQ0M2MyYzIxYTMxMiIsImMiOjI9)

implementation of Extended Producer Responsibility (EPR) frameworks is prompting Food and Beverage, Consumer Goods, and Logistics companies—including Amazon, IKEA, Coca-Cola, and PepsiCo—to invest in MSW projects as part of their sustainability strategies. This is expected to further drive demand for MSW-related carbon credits.

At the same time, the transition from the CDM to the new Article 6.4 mechanism under the Paris Agreement is attracting attention from project developers, host countries, and credit buyers. As of August 2024, 2,305 CDM projects, including 79 in the MSW sector, have submitted applications for transition to Article 6.4. The Article 6.4 Supervisory Body released a framework for project registration and credit issuance, which was formally adopted at COP29 in 2024. Although the final list of approved methodologies is still under development- expected by the end of 2025- interest in project registration under Article 6.4 is projected to rise significantly once these methodologies are finalized. Figure 10 illustrates the distribution of MSW project types applying for transition.

Figure 10: Transitioning Projects under different MSW technologies in Article 6.4



Under Article 6.2, which facilitates bilateral carbon market cooperation between countries, 140 projects are currently in various stages of agreement. Among these are 6 MSW projects financed by Switzerland and South Korea in developing countries**.** Unlike Article 6.4, which is overseen by a supervisory body, Article 6.2 offers greater flexibility – allowing participating countries to apply their own methodologies, set monitoring standards, and define crediting through bilaterally agreed terms.

Projects supported under Article 6.2, primarily in renewable energy and energy efficiency [62], have typically benefited from premium carbon prices. For example, Switzerland has agreed to pay:

- USD 30 per credit for an e-mobility project with Thailand[63]
- USD 20–25 per credit for cookstove projects in Ghana and Senegal [64]
- USD 10 per credit for a renewable energy project in Ghana [65]
- USD 40 per credit for a forestry project in Suriname [66]

Similarly, the Swedish Energy Agency has agreed to ~USD 43 per credit for an organic waste project [67]. Across portfolios, the average carbon price under Article 6.2 is approximately USD 30 [68], a level comparable to the cost of recycling (~USD 30/tonne) and waste-to-energy operations (~USD 25/tonne) in developing countries. [69] This positions Article 6.2 as a more viable funding source for MSW projects compared to voluntary markets, which often provide insufficient support.

However, **Article 6.2 transactions often involve shorter contract durations (5–7 years) and lingering uncertainty about credit eligibility beyond 2030**, particularly for sectors like MSW. Stakeholder consultations suggest that carbon finance—along with other results-based finance instruments—should be viewed primarily as a short- to medium-term enabler, rather than a long-term funding solution.

62. AGS Carbon Research based on Article 6.2 database
63. Swiss, Thai groups close first sale of Paris Agreement carbon offsets, Reuters (2024), (https://www.reuters.com/business/environment/swiss-thai-groups-close-first-sale-paris-agreement-carbon-offsets-2024-01-08/)
64. Senegal, Ghana sell cookstove carbon credits to Switzerland in USD 20-25/mtCO2e range, S&P Global (2024), (https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/092923-senegal-ghana-sell-cookstove-carbon-credits-to-switzerland-in-20-25mtco2e-range)
65. ibid
66. Will International Carbon Markets Finally Deliver ? International Institute for Sustainable Development (2023), (https://www.iisd.org/articles/deep-dive/will-international-carbon-markets-finally-deliver)
67. AGS Carbon Interaction with Perspective Climate Group
68. AGS Carbon Interaction with Klik Foundation, Switzerland.
69. Opex is based on AGS Carbon Interaction with Uni Carbo, and Global Waste Management Outlook, UNEP (2024), (https://openknowledge.worldbank.org/bitstreams/df788c58-3c21-52a2-a2241445f0a1850b/download) The waste processing costs in developing are less compared to costs in developed countries. For instance, recycling is reported to cost approximately USD 50-80, and as high as USD 202, while waste to energy projects costs between USD 100 up to USD 200.

Looking ahead, the outlook for carbon finance in the MSW sector is increasingly positive, with rising interest from both national governments and corporate actors aiming to meet ambitious climate targets. Given that host country approvals and corresponding adjustments will play a crucial role in project approvals for compliance, the demand for buyer-friendly eligible credits is expected to exceed supply, potentially driving prices higher after 2030. To fully unlock the potential of carbon finance, however, stakeholders must also address persistent structural barriers—through policy reforms, improved governance, infrastructure upgrades, and capacity building—to ensure better segregation, collection, and processing of waste.

8. CONCLUSION

The MSW sector in developing countries faces significant and multifaceted challenges. From the inefficient segregation of waste at source to limited infrastructure for collection, transportation, and processing, these challenges contribute to operational inefficiencies of waste treatment facilities. Moreover, financial constraints exacerbate the situation, particularly with respect to the financing of OPEX, which often overshadows the initial capital investments. Conventional revenue streams from the user fee, and sale of by-products like compost, recycled materials, or electricity are often insufficient to cover the high operating costs. This shortfall leads to the closure or suboptimal performance of waste management facilities, leaving a growing volume of untreated waste in landfills—further intensifying environmental and public health risks.

Against this backdrop, result-based financing, especially carbon finance, emerges as a potential tool for addressing these financial gaps. By linking payments to the reduction of CO2 emissions, carbon finance offers a performance-driven funding solution. Global efforts to reduce methane emissions as part of international climate pledges, have made this funding stream even more attractive. Moreover, carbon finance can supplement revenue for outputs (e.g., compost, recyclables, biogas) that face low or volatile market prices and help offset operating costs and maintain performance. As this paper highlights, there are examples of MSW projects that have been supported by carbon finance in developing countries, providing both financial viability and environmental benefits.

However, carbon finance alone cannot resolve the deeply entrenched challenges related to the long-term self-sustainability of projects in the MSW sector. Market volatility—driven by macroeconomic fluctuations and regulatory uncertainty—undermines predictability and poses significant risks to long-term financial planning for project developers. This makes it difficult to integrate carbon revenues reliably into project business models. Furthermore, the operational burden of monitoring, reporting, and verifying emission reductions adds another layer of complexity, particularly for smaller or resource-constrained project developers.

The detailed analysis of existing mechanisms reveals critical weaknesses and threats that impact their effectiveness in supporting MSW projects, including:

- **International markets** face high entry costs and complex participation requirements, often deterring smaller projects, while regulatory uncertainties and restrictions on credit exports pose significant risks.

- **Domestic compliance markets** are hindered by limited scope, weak enforcement mechanisms, and insufficient technical capacity, making them vulnerable to political and economic instability. Moreover, compliance markets in developing and emerging countries are not yet operationalized at full scale.

- **Voluntary markets** struggle with inconsistent pricing, variable credit quality, and a lack of robust oversight, undermining investor confidence. Additionally, these markets face reputational risks tied to low-integrity credits and price volatility from oversupply.

Addressing these challenges will require strengthening governance, enhancing market integrity, and aligning mechanisms with the specific needs of developing countries to unlock their full potential for sustainable waste management. For these reasons, carbon finance within the existing mechanisms must be viewed as one part of a broader financial strategy. It should be supplemented with other result-based mechanisms that offer a more stable revenue source for waste management projects while incentivizing the reduction of methane and other SDGs. Upstream and downstream technical assistance and capacity building can complement this by supporting regulatory and policy changes and strengthening the capacity of municipalities, operators, and developers alike.

In conclusion, while carbon finance and other result-based financing mechanisms offer a valuable pathway for alleviating the funding challenges in the MSW sector, markets must be integrated with broader interventions aimed at creating a more financially sustainable and resilient waste management ecosystems. Only through such comprehensive approach can developing countries overcome the financial and operational barriers to sustainable waste management, ultimately contributing to a cleaner, healthier, and more sustainable future for their urban centers.

APPENDIX

APPENDIX I: DETAILED CAPEX AND OPEX ANALYSIS FOR CASE STUDY PROJECTS

Country	Year	Technology	Capacity	CAPEX (USD in million)	OPEX (USD in million)	CAPEX (USD in million)/ TPD or MW	OPEX (USD in million/ Year)/ TPD or MW
India	2021 (commissioning)	Composting	250 TPD	0.83	0.20	0.003 / TPD	0.001 / TPD
Turkey	2019 (commissioning)	Landfill Gas (LFG) – Power	14.14 MW	21.1	4.49	1.492 / MW	0.318 / MW
			1200 TPD	21.1	4.49	0.017 / TPD	0.004 / TPD
Turkey	2019 (commissioning)	LFG - Power	32.34 MW	15.29	8.49	0.473 / MW	0.263 / MW
			4500 TPD	15.29	8.49	0.003 / TPD	0.002 / TPD
Turkey	2021 (commissioning)	LFG - Power	8.848 MW	12.14	2.5	1.373 / MW	0.283 / MW
Turkey	2021 (investment decision)	Waste to Energy, WtE (Anaerobic digestion of MSW and Electricity)	4.8MW	4.09	0.3	0.853 / MW	0.063 /MW
			400 TPD	4.09	0.3	0.010 / TPD	0.001 / TPD
Vietnam	2022 (investment decision)	WtE (Incineration of MSW)	75MW	378.80	27.22	5.051 / MW	0.363 / MW
			4000 TPD	378.80	27.22	0.095 / TPD	0.007 / TPD
India	2024 (commissioning)	Anaerobic digestion to generate bio-CNG and bio-manure	100 TPD	2.81	0.5	0.028 / TPD	0.005 / TPD
Turkey	2021 (commissioning)	WtE (Power, RDF)	18.012 MW	30	7.30	1.665 / MW	0.405 / MW
Turkey	2020 (Investment decision)	ISWM (Power, RDF)	14.14 MW	23.60	6.15	1.670 / MW	0.435 / MW

APPENDIX II: FINANCIERS [NON-EXHAUSTIVE]

WORLD BANK GROUP

- Global mandate
- Instruments: Loans, Guarantees, Equity
- Technical assistance & Capacity Building
- IFC has preference for large projects, normally WtE

gef

- Global scope
- Grants (including blended finance)
- Technical Assistance and Capacity Building

ADB ASIAN DEVELOPMENT BANK

- Asia and Pacific
- Instruments: Loans, Grants, Equity
- Technical Assistance
- Ticket size between $50m and $500m

BANQUE AFRICAINE DE DEVELOPPEMENT AFRICAN DEVELOPMENT BANK

- Africa
- Instruments: Loans, Grants
- Technical Assistance and Capacity Building
- Policy and Institutional Support
- Regional Cooperation

European Investment Bank

- Europe and neighboring countries mostly
- Instruments: Loans, Equity
- Ticket size can range from $10 to $300m

GREEN CLIMATE FUND

- Grants
- Concessional Equity
- Concessional Loans
- Guarantees
- Capacity Building
- Policy support
- Partnership Facilitation

UNEP

- Technical assistance & Capacity Building
- Toolkits and guidance
- Advocacy and Policy support
- Stakeholder Engagement

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

- Technical Assistance and expertise
- Capacity building
- Policy and institutional support
- Financial support and mobilization

KFW

- Global scope
- Instruments: Loans, Grants
- Technical Assistance, Capacity Building, and Project Preparation
- Policy Reforms

JICA

- Global scope but majority of activities in South-East Asia
- Instruments: Loans, Grants
- Technical Assistance, Capacity Building, and Project Preparation
- Technology Transfer

IDB Inter-American Development Bank

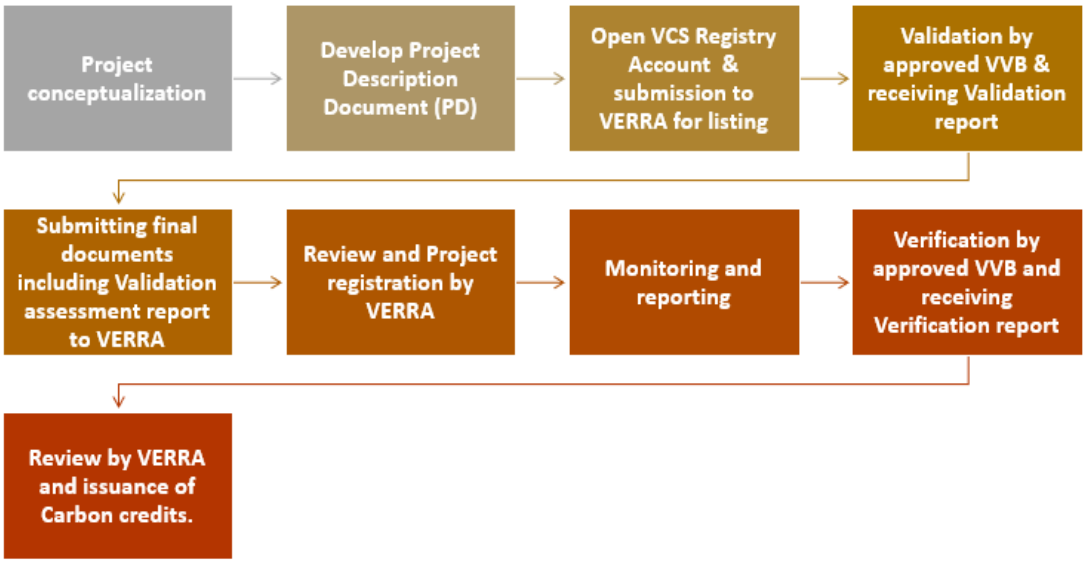
- Latin America
- Instruments: Loans, Grants
- Technical Assistance, Capacity Building, and Project Preparation
- Infrastructure Development
- Policy Reforms

APPENDIX III: KEY MILESTONES FOR PROJECT REGISTRATION

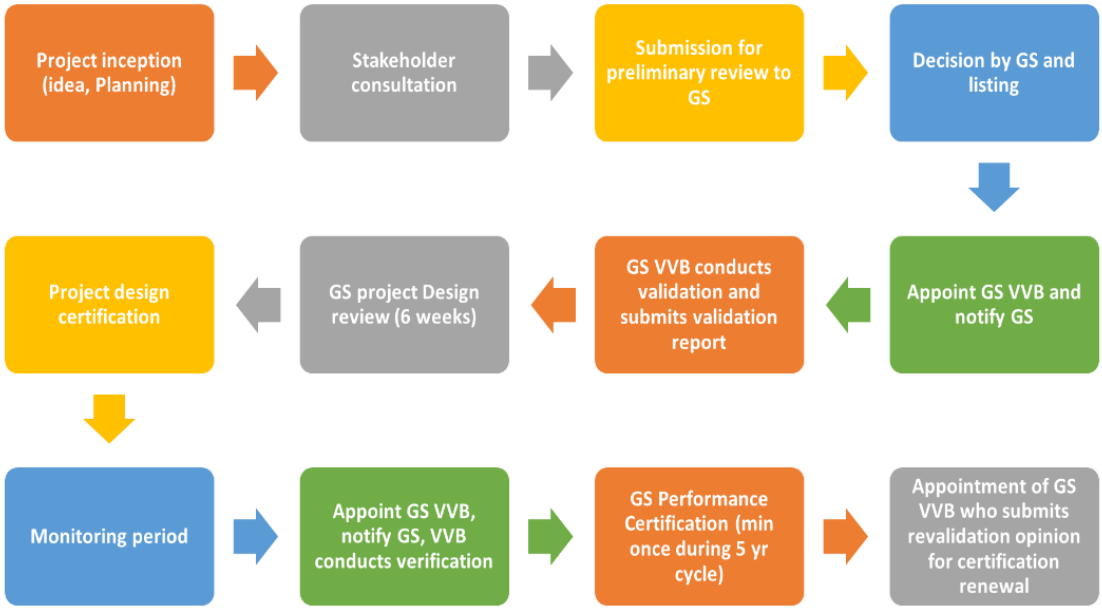
Milestones	VERRA VCS	Gold Standard	Article 6.4
Project Start Date	Date on which the project starts reducing/avoiding emissions through operations (= **commissioning date**)	Date of **first expenditure commitment** for implementation (= signing of first contract to purchase project equipment and/or machinery)	Date on which expenditures for construction of the main equipment/facility or provision of a service are made (either **date of signing of contract /date of actual expenditures**)
Prior Consideration	Not required	Not required	Mandatory to be submitted in stipulated form to registry **within 180 days of the project start date**
Local Stakeholder Consultation	Mandatory to **conduct before project construction / implementation**	Mandatory to conduct **ideally before implementation** but can also be done after the start of construction but not too late	Mandatory to conduct as per host country rules. In their absence (whichever is earlier): i) Before construction/implementation of the project ii) Before submission of first set of documents to DOE
Timeline for Submission of First Set of Project Documents to Registry	No timeline committed. However, the registration needs to be done within 2 years of the project start date.	To be done **within one year** of start date	To be done **within one year** of submission of prior consideration form or release of applicable methodology (whichever is earlier)
Additionality	Needs to be proved through investment or barrier analysis	Needs to be proved through investment or barriers analysis	Tool for demonstration of additionality is yet to be finalized
Timeline for Validation Completion	Within **two years** of project start date	Within **two years** of submission of first set of documents to registry	To be defined

APPENDIX III: Registration and Issuance Process in VERRA and Gold Standard

VERRA



Gold Standard for Global Goals (GS4GG)



Preparation

1. Under VERRA and Gold Standard, the **design**[70] of the project may start with the planning of the project itself.

2. The initiation of the carbon project need not align with the commissioning date of the actual project. For instance, VERRA allows projects which are already functioning to seek registration within two years of their commissioning date. Gold Standard allows projects which are already under implementation to submit for preliminary review within one year of implementation start date and seek design certification within two years of listing with the Standard.

3. Designing a carbon project is followed by conducting stakeholder consultations, both at local and global level. VERRA requires this to be done before the implementation of the project whereas with Gold Standard, stakeholder consultations can be conducted after commissioning (i.e. retroactive projects). Stakeholder consultation involves getting inputs from identified stakeholders - such as government officials, local policymakers, community leaders, NGOs, and others - on the design and implementation of the project and its likely environmental and social impact. Both registries require that the project developer, incorporates feedback from stakeholders if necessary and makes respective amendments in the project plan.

4. Project documents and stakeholder consultation reports are sent to the registries, as applicable, for their preliminary review, This includes a completeness check against applicable guidance and confirmation that all required disclosures have been made. The project must also demonstrate how stakeholder inputs have been addressed prior to final submission.

5. Followed by successful closure of the comments, the project is listed on the Gold Standard or Verra registry, as applicable. In Gold Standard, the project may apply for design certification as a stand-alone project[71] or in the form of a larger program of activities (PoA), with small identical projects as the components of the program, planned to be implemented over a longer period as opposed to one-time stand-alone project.

70. Design may generally refer to scale of the project, technology, geography, operations and maintenance plan and monitoring plan
71. In carbon markets, these projects are generally referred to as the voluntary programme of activities (VPA), and have identical project design: technology, geography, baseline scenario and emission reduction methodology among others guided by overarching PoA

Validation

6. The validation phase is initiated when the project developer engages a third-party Validation and Verification Body (VVB). The VVB independently assesses whether the project complies with Verra or Gold Standard criteria and whether the appropriate methodology has been applied to estimate emission reductions. Based on a review of submitted documents and site visits (either physical or remote), the VVB may raise findings that the developer must address. This may require clarifications or revisions to the project documentation to complete the validation process. After resolving queries from VVB, the project documentation and a validation report approved by the VVB is submitted to VERRA / Gold Standard for review.

7. In addition to the preliminary completeness checks, Verra or Gold Standard conduct a further level of scrutiny to ensure the project meets all applicable principles and requirements. This includes verifying the correct application of the approved methodology for estimating emission reductions and assessing whether the project causes any environmental or social harm. The table below outlines the currently eligible methodologies.

Table 1: Eligible Methodologies across Voluntary Market Standards

• ACM0001 Flaring or use of landfill gas	GS4GG	VCS
• ACM0022 Alternative waste treatment processes	GS4GG	VCS
• ACM0024 Natural gas substitution by biogenic methane produced from the anaerobic digestion of organic waste	GS4GG	VCS
• AM0083 Avoidance of landfill gas emissions by in-situ aeration of landfills	GS4GG	VCS
• GS Reduction in Methane emissions from landfills through decentralized organic waste processing	GS4GG	VCS
• AMS.III.AF Avoidance of methane emissions through excavating and composting of partially decayed municipal solid waste (MSW)	GS4GG	VCS
• AMS.III. AJ Recovery and recycling of materials from solid wastes	GS4GG	VCS
• AMS.III.AO Methane recovery through controlled anaerobic digestion	GS4GG	VCS
• AMS.III.AQ Introduction of Bio-CNG in transportation applications	GS4GG	VCS
• AMS.III.E Avoidance of methane production from decay of biomass through controlled combustion, gasification, mechanical/thermal treatment	GS4GG	VCS
• AMS-III.F - Avoidance of methane emissions through composting	GS4GG	VCS
• AMS.III.G Landfill methane recovery	GS4GG	VCS
• VMR0007 Recovery and recycling of materials from solid wastes	GS4GG	VCS

(Green represents methodologies eligible under GS4GG/VCS, yellow mean conditionally eligible whereas red indicates non-eligible)

Registration

8. Once the above conditions are satisfied, the project is registered and is thus entitled to monitor its operations and request issuance of carbon credits from its operations. This does not mean that the project can directly request credits.

9. To request issuance of carbon credits, the project developer needs to monitor the operation of the project based on pre-defined parameters as per the applicable methodology and registered documentation. The project developer monitors the parameters through representative surveys or measuring equipment during the monitoring period[72]. Each standard under the voluntary and international mechanism has a unique project cycle that must be followed. However, GS4GG and VERRA share common waste methodologies, though some methodologies are exclusive to a particular standard which shall be used for registration of carbon projects to provide a standardized framework that, among other things, include data and parameters to be monitored. Below tables lists technology-wise monitoring parameters as part of emission reduction methodologies.

Monitoring requirements for Landfill gas recovery and utilization

Parameter	Monitoring frequency
The amount of landfill gas collected from the landfill.	Continuously (real-time monitoring via flow meters).
The concentration of methane in the landfill gas collected.	Continuous monitoring with regular calibration of equipment or periodic sampling (e.g., weekly or monthly depending on project design).
The temperature and pressure of the landfill gas, which can affect the volume and density of the gas.	Continuously
The efficiency of the flare in converting methane to carbon dioxide.	Periodically (e.g., quarterly or annually) using direct measurements or default values.
Amount of electricity or heat generated if the landfill gas is used for energy.	Continuous monitoring.
Operational Hours of Gas Collection System	Continuous recording

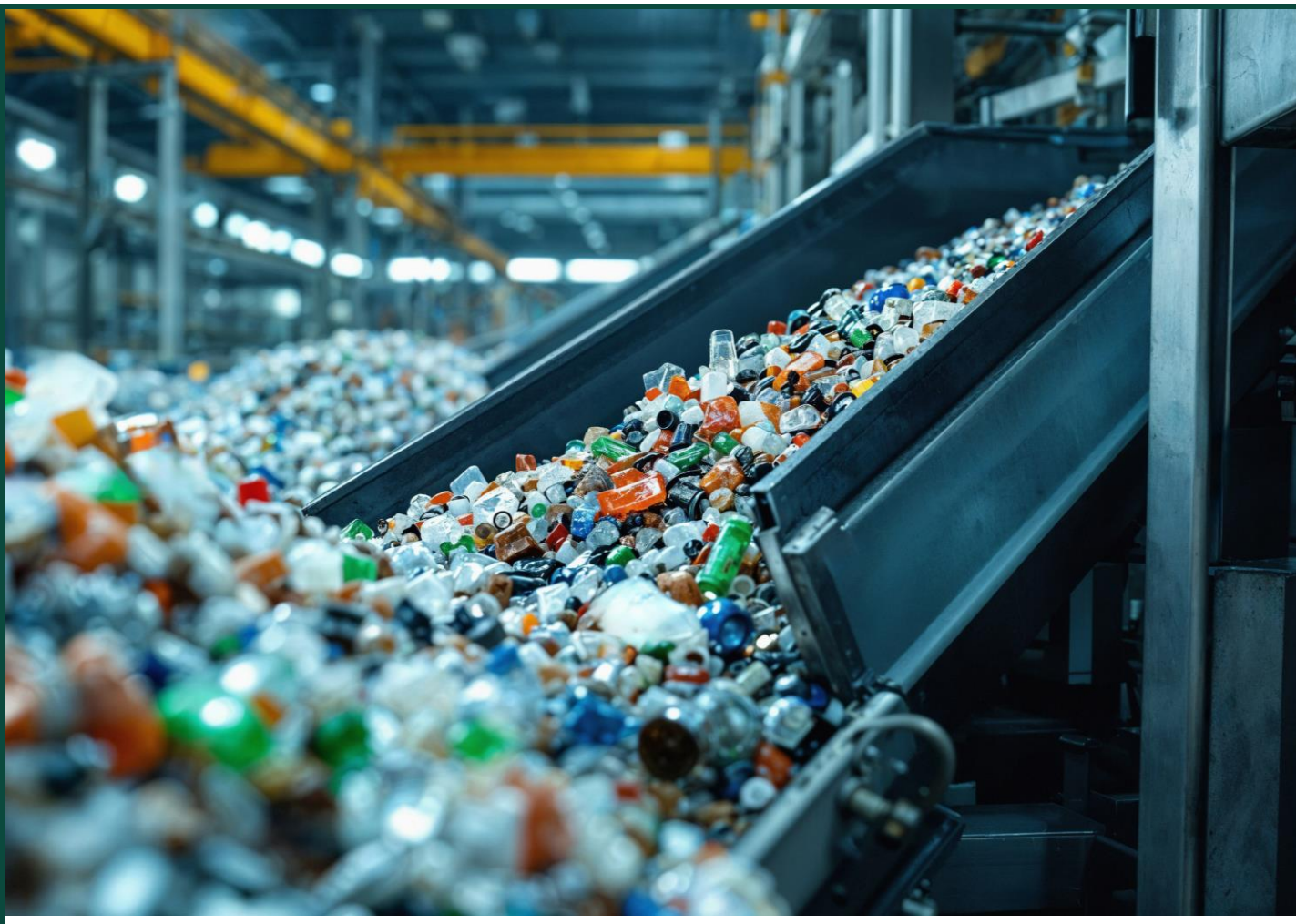
72. Monitoring period is the period over which project operations are monitored to estimate emission reductions, although this is not defined under all standards. As per Gold Standard requirements, the project needs to be verified at least once in three years and in absence of annual verification, Annual Report needs to be provided to Gold Standard by project developer. For VERRA, the verification needs to be done at least once in five years. However, in all cases, the monitoring needs to be done as defined in the registered project document and methodology adopted.

Monitoring requirements for Composting and Anaerobic Digestion

Parameter	Monitoring frequency
Quantity of Waste Processed	Continuous or periodic (e.g., daily or weekly, depending on the project).
Composition of Waste	Periodically (e.g., monthly or quarterly via sampling and laboratory analysis).
Methane Generation Potential of Waste	Periodically (e.g., annually or as required by the methodology using laboratory tests).
GHG Emissions from Residual Waste Disposal	Periodic (e.g., monthly or annually depending on the amount and composition of residual waste).
Methane Recovery (if applicable)	Continuously

Monitoring requirement for Recovery and Recycling

Parameter	Monitoring frequency
Quantity of Waste Recovered for Recycling	Continuous or periodic (e.g., daily, weekly, or monthly, depending on the facility's operational practices).
Types and Composition of Waste Recovered	Periodic (e.g., monthly or quarterly via sampling and material categorization).
Recycled Product Output	Continuous or periodic (e.g., weekly or monthly, depending on production schedules).
Amount of Residual Waste Sent to Landfill	Periodic (e.g., monthly or annually, depending on project operations).



10. Post-monitoring, the project developer appoints the VVB to independently conduct the verification of the monitored results.

11. The VVB may raise certain queries /comments based on its assessment of the monitoring. This may involve queries pertaining to calibration of equipment, failure rate of devices, etc. The project developer is required to resolve all the queries raised by VVB to its satisfaction

12. On successful closure of all comments, the VVB releases the verification report which is sent to VERRA or Gold Standard alongside the along with the project documentation for review.

13. VERRA assesses the verification report, the monitoring results and project documentation submitted by the project developer and VVB.

14. The project developer may receive certain comments/ queries on the monitoring or VVB assessment to which the project developer is obliged to respond followed by VVB verification.

Credit Issuance

15. Upon satisfactory closure of comments, carbon credits are issued by VERRA/Gold Standard to the project developer account.

16. Once issued, carbon credits can be sold by project developers to third-party buyers, either through market platforms or bilateral agreements. Trading platforms such as Carbon Trade Exchange and Xpansiv allow developers to list credits directly from their registry accounts and transact globally on a spot basis. Some platforms also offer access to historical trade data and pricing information, often for a fee. However, the majority of voluntary carbon market transactions occur via bilateral agreements, which take two primary forms: contracts with trading intermediaries or direct agreements with end buyers. These are typically structured as forward contracts - commonly referred to as Emission Reduction Purchase Agreements (ERPAs) - in which a developer commits to deliver a specified volume of credits at a fixed or variable price on a future date. These delivery obligations may extend over multiple years. Trading agencies often act as intermediaries seeking to resell credits, while end buyers generally retire the credits to offset their own emissions.

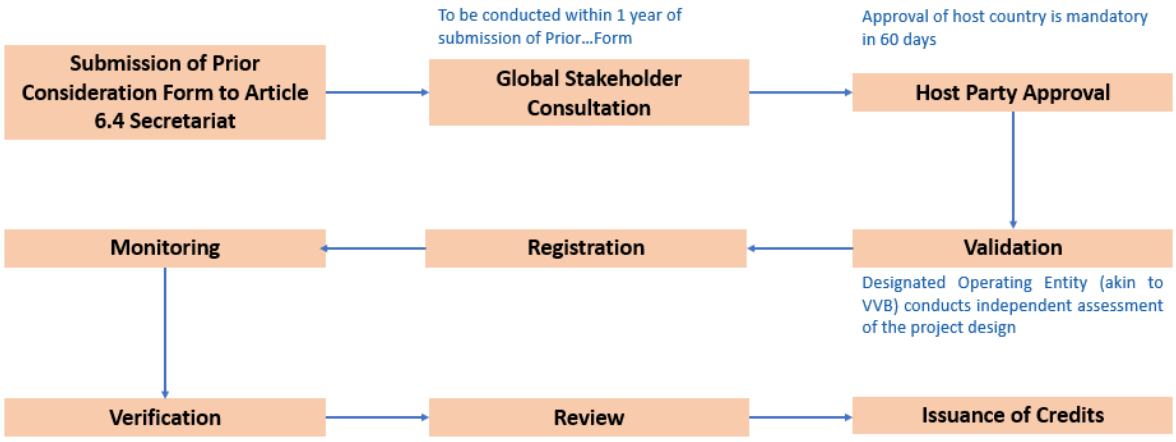
17. The project developer may enter into agreement with a trader who buys and bundles carbon credits from a pool of different projects. The trader sells these credits to buyers at higher price, benefiting from the price arbitrage. In some cases, the trader identifies a buyer and facilitates the transaction between project developer and buyer, charging commission fees (in monetary terms or as a % of carbon credits).

18. In the other pathway where a buyer is directly involved, the project developer strikes an agreement with the buyer (corporate, bank etc) to deliver pre-agreed volume of credits at a fixed price at a future date.

19. Other than the Standard for GHG emission reduction projects, VERRA has also put in place a Standard which assesses and certifies projects based on the environmental, social, and economic impacts beyond carbon emission reductions. It ensures that projects contribute to the SDGs, providing added value through verified social and environmental co-benefits (jobs creation, reduction in air pollution and water pollution). This Standard is called SD- Vista[73] . A project must undergo similar process of certification under SD-Vista as defined above for carbon credit issuance.

73. https://verra.org/programs/sd-verified-impact-standard/sd-program-details/

APPENDIX-IV REGISTRATION PROCESS IN ARTICLE 6



Article 6.4: Registration and Issuance Process

Preparation

1. To claim carbon benefits under Article 6.4, the project developer should demonstrate that Article 6.4 mechanism benefits were considered necessary in the decision-making of the project. This requires the developer to submit a "prior consideration notification" to the UNFCCC secretariat within 6 months of project implementation start date. The form contains a summary of the project information in accordance with Article 6.4 procedures. The start date is defined as the date on which expenditures for the construction of the main equipment/facility or provision of a service are made (either the date of signing of contract or the date of actual expenditure).

2. This is followed by a stakeholder consultation for which the developer needs to submit preliminary project documents to the secretariat. The secretariat will promptly publish the documentation as submitted on the UNFCCC website for consultation round. Time frame for seeking inputs or feedback from stakeholders is 60 days.

3. The host Party Country, through its agency, should promptly respond to the publication within 60 days along with its letter of approval, confirming the eligibility of the project as per its rules and providing consent to give up emission reductions from the country's own NDC targets. The secretariat should then inform the developer.

Validation

4. The Designated Operating Entity (DOE)[74] would then perform a validation of the project activities – including through desk review and site visits - with regards to Article 6.4 rules, standards and applicable methodology and submitted project documents. After validating that the proposed activities meet all relevant requirements for registration, the DOE submits a request for registration of the project to the UNFCCC secretariat.
Registration

Registration

5. The UNFCCC Supervisory body runs a completeness check on the documents and information shared by the DOE. After satisfactory responses from DOE/developer, the project is registered in the UNFCCC registry.

6. The project developer needs to monitor the operation of the project based on pre-defined parameters as per the applicable methodology and registered documentation. The project developer monitors the parameters through representative surveys or measuring equipment, in accordance with the applied methodology, during the monitoring period.

7. Post-monitoring, the project developer appoints DOE to independently conduct the verification of monitoring results. The DOE performs verification of whether the implementation of the projects, and the monitoring and calculation of GHG emission reductions or net GHG removals comply with the relevant requirements in the activity standard and any other applicable Article 6.4 mechanism rules and requirements based on the information provided in the monitoring report(s) and any supporting documentation.

8. The DOE may raise certain queries /comments based on its assessment of the monitoring. This may involve queries pertaining to monitoring results, supporting evidences, or assumptions made for the computation of emission reductions etc. The project developer is required to resolve all the queries raised by DOE to its satisfaction

9. On successful closure of all comments, the DOE releases verification report which along with the project documentation is sent to Article 6.4 secretariat for its review

10. The secretariat commences completeness check and substantive check on the documents and information shared by DOE.

74. Validation and Verification Agency appointed by the project developer, or counterpart of VVB in Article 6.4)

Credit Issuance

11. Upon satisfactory closure of both completeness and substantive checks, the secretariat requests the Article 6.4 Supervisory Body, the issuance of Carbon credits (Art 6.4 ERs) to the account of the project developer.

12. Any host Party, other participating Parties, and any member or alternate member of the Supervisory Body, reserve the right to review the request for issuance. The project developer and the DOE then provides responses to the issues identified in the request for review no later than 28 days after the notification of the request for issuance having been placed under review. An independent expert review team assesses the responses shared by the project developer or the DOE and submits a report to the Supervisory Body through the secretariat.

13.The Supervisory body after giving due regard to the project documentation package, DOE report, assessment made during review of request for issuance and independent opinion provided by expert technical review team, issues Article 6.4 ERs in the account of the project developer.

14. The project developer can then sell these credits to any other third-party buyer and earn revenue. If the project developer sells these credits to a country or an entity in a country, other than the host country, the host country waives off the emission reductions equaling the sold credits by a process called 'Corresponding Adjustment'. The corresponding adjustment requires the host country to report its decision of waiving off the corresponding emission reductions from its NDC along with the quantum of such emission reductions. It implies that the emission reductions achieved in the host country, resulting from the project activity, will not be counted towards its own NDCs. This information is reported to the UNFCCC Conference of Parties to Paris Agreement biennially in a Progress report on NDCs.

15. The receiver country of the carbon credits under Article 6.4 makes similar disclosure in its Progress Report to UNFCCC, about the use of carbon credits towards its own NDCs.

16. As per the current status, UNFCCC is in the process to finalize methodologies to be used under Article 6.4. Only after finalization, developers will be able to avail Article 6.4 mechanism for the carbon benefits. Until Article 6.4 methodologies are published, CDM projects can still transition using existing CDM methodologies. To do so, developers must follow the transition standard and submit specific documents to the Article 6.4 Secretariat within 180 days of host country approval. If developers prefer to use the new Article 6.4 methodologies, they must wait until these are published. Once available, they have one year to complete the transition.

Article 6.2 Mechanism

This mechanism enables countries to make mutual agreements that permit them to generate and transfer emission reduction units—known as Internationally ITMOs. Article 6.2 does not have its own procedure for registration and issuance of credits. Rather, it is bilaterally decided which registry (e.g. Gold Standard, VERRA) the project should be registered in for issuance of credits. The process for these registries has already been described in Appendix III.

APPENDIX-V KEY BUYERS OF MSW CARBON CREDITS

There are a diverse set of buyers of MSW carbon credits, reflecting the growing recognition of waste management as a credible and impactful source of carbon credits, particularly in efforts to reduce methane emissions and support broader climate goals.

1. Corporations with Sustainability Goals

• Tech Companies: Firms such as Microsoft, Google, and Amazon purchase carbon credits to meet net-zero targets, often sourcing from projects that reduce methane emissions from landfills.

• Consumer Goods Companies: Companies like Unilever and Procter & Gamble offset emissions across their supply chains, including those linked to waste generation and disposal.

• Energy Companies: Corporations such as Shell and BP integrate carbon credits into their broader decarbonization strategies, offsetting emissions from fossil fuel activities.

2. Financial Institutions

• Banks and Asset Managers: Institutions like ADB, HSBC, and BNP Paribas purchase credits to offset operational emissions or to structure carbon-neutral investment products.

• Carbon Credit Funds: Vehicles such as the Future Carbon Fund (ADB) acquire large volumes of credits—including from MSW projects—for resale or bundling into climate finance offerings.

3. Retail and Food & Beverage Companies

• Retailers: Companies such as Walmart and IKEA purchase credits to offset emissions from logistics and operations, including waste-related sources.

• Food & Beverage Companies: Firms like PepsiCo and Nestlé buy credits to address emissions across their value chains, particularly from packaging and food waste.

4. Governments and Public Agencies

• Municipalities and Government Entities: In some jurisdictions, public bodies purchase credits from MSW projects to meet regulatory mandates or voluntary climate commitments in the public sector.

• National Governments: Countries, such as Switzerland and South Korea are active buyers under Article 6.2
5. Airlines and Transportation Companies

• Airlines: Carriers such as Delta and Lufthansa acquire credits—including from landfill gas and organic waste projects—to comply with CORSIA and other aviation-related offset schemes.

6. Voluntary Carbon Market Participants

• Individuals and Small Businesses: Through online platforms (e.g., Verra, Gold Standard), individuals and SMEs purchase credits to offset personal or business-related emissions, often choosing MSW-related projects for their tangible local benefits.

APPENDIX-VI: CASE STUDIES

Country	Registry	Project ID	Project Developer	Crediting period	Operational/ Non operational	Issuance (year and frequency)	Source/ link	Status	Meth	Additionality / carbon revenue percentage
Vietnam	**Gold Standard**	**GS2525**	Vietstar Joint Stock Company	2013-2023	operational	2024 (5) 2023 (1) 2021 (4) 2019 (2) 2017 (2) 2016 (4)	https://registry.goldstandard.org/projects/details/403	Gold Standard Certified Project	AM0025	This project has transitioned from CDM. Benchmark analysis performed but as per values in 2007. Most SWM projects are funded using ODA funds. Collection and treatment are responsibility of govt. in Vietnam hence costs are borne by Govt. No private capital available due to perceived risks of implementation, operation and current policies of host country
Vietnam	**VERRA**	**2567**	Ha Noi Thien Y Environmental Energy Joint Stock Company	23-08-2023	Operational	no issuance	https://registry.verra.org/app/projectDetail/VCS/2567	Registered	ACM0022	Benchmark Rate: 11%. Only by having 24% increased treatment price, or 18% increased electricity tariff for product, or 18% increased electricity tariff is the benchmark cost of 11% arrived.
Thailand	**VERRA**	**585**	Jaroensompong Corporation	06-04-2020	Non operational	13	https://registry.verra.org/app/projectDetail/VCS/585	Registered	ACM0001	Jaroensompong Corporation financed the required capital with 100% equity under the judgement that the Project Activity would gain additional revenue from the registration as a CDM activity.

Country	Registry	Project ID	Project Developer	Crediting period	Operational/ Non operational	Issuance (year and frequency)	Source/ link	Status	Meth	Additionality / carbon revenue percentage
Indonesia	**Gold Standard**	**GS7561**	Yayasan Pemilahan Sampah Temesi	2018-2023		3	https://registry.goldstandard.org/projects/details/2066	Gold Standard Certified Project	AMSIIIF	Barrier analysis - Financial barriers: The capital investment in the compost plant is primarily for the civil structures, mechanical equipment and vehicles which is high and the financial prospects too low to attract any private investment. The operation and maintenance cost are fairly high compared to the uncertain market price and demand of compost (end product). Market barriers: In Indonesia and Bali, the concept of soil conditioner is still not widely known amongst the farmers, the largest potential client/ user group of the composting facility, and compost from municipal waste is still considered as being "dirty". This coupled with the low levels of certain plant nutrients on a per tonne basis in comparison to the chemical fertilizers leads to low market price of compost. The additional costs for building the distribution network and the current lack of a sales network and experience pose other significant barriers for the market entry of the project organisation.
Indonesia	**Gold Standard**	**GS1295**	atmosfair gGmbH	2013-2023		9	https://registry.goldstandard.org/projects/details/170	Gold Standard Certified Project	AMSIIIF	Partly funded by ODA from Canadian Govt. through IDRC, partly by German Govt. through BORDA. Building infrastructure funded by local Govt for MRF while operational expenses are borne by PP

Country	Registry	Project ID	Project Developer	Crediting period	Operational/ Non operational	Issuance (year and frequency)	Source/ link	Status	Meth	Additionality / carbon revenue percentage
Turkey	**VERRA**	**3867**	Vega Hereko Enerji Üretim Sanayi ve Ticaret Anonim Şirketi	05-04-2024	Operational	no issuance	https://registry.verra.org/app/projectDetail/VCS/3867	Registered	ACM0022	Benchmark Analysis - Benchmark equity is 11.75% Equity IRR for the project activity is less than the Benchmark Equity IRR. Investment cost = -34% (Breaching Value) O&M = - 35% Plant load factor (PLF) = 21% Tariff rate = 21%
Turkey	**VERRA**	**2932**	4B Enerji Taahhüt Atık Toplama Geri Dönüşüm Sanayi ve Ticaret A.Ş	08-08-2023	Operational	no issuance	https://registry.verra.org/app/projectDetail/VCS/2932	Registered	ACM0001	Auto additional - no need to prove additionality
Madagascar	**VERRA**	**353**	MADACOM POST	10-04-2012	non operational	11	https://registry.verra.org/app/projectDetail/VCS/353	Registered	AMS-III.F	NA, project completed by 2020
Madagascar	**Gold Standard**	**GS11201**	GoodPlanet Foundation	2022-2026	operational	no issuance	https://registry.goldstandard.org/projects/details/3189	Registered	AMS-III.F.	Auto additional, no details on investment analysis
India	**VERRA**	**4478**	Ghaziabad Nagar Nigam	2022-2029	operational	No issuance	https://registry.verra.org/app/projectDetail/VCS/4478	Registration requested	AMS-III.F.	Benchmark analysis - Project equity IRR i.e. 4.58% is less than the Benchmark expected rate of return on equity i.e. 15.04% The project will breach the benchmark value on decrease of project cost by 65.0%, The project will breach the benchmark value on negative value. The project will breach the benchmark value on increase of sale price of compost more than 150%, which is not a likely scenario as per market trend the price considered is based on trend. Hence, the variation beyond 10% increase is not a possibility.

Country	Registry	Project ID	Project Developer	Crediting period	Operational/ Non operational	Issuance (year and frequency)	Source/ link	Status	Meth	Additionality / carbon revenue percentage
India	**VERRA**	**4368**	Srinivas Waste Management Services Private Limited	2021-2028	operational	No issuance	https://registry.verra.org/app/projectDetail/VCS/4368	Registered	ACM0022	Benchmark analysis - Default Value as per latest version of Investment Analysis Tool version 12 is 9.77%. The Project equity IRR was calculated to be 8.36%. The sensitivity analysis reveals that even with significant changes in various parameters, the Equity IRR does not cross benchmark rate.
Pakistan	**VERRA**	**651**	Lahore Compost (Pvt) Limited	2022-2028	operational	2	https://registry.verra.org/app/projectDetail/VCS/651	Registered	AM0025	This project has transitioned from CDM to VERRA (crediting period till 2028). Project IRR (without carbon) is 13.18%, lower than the benchmark rate 18%.
Myanmar	**JCM**		#N/A			No information available	https://www.jcm.go.jp/mm-jp/projects/56	registered	MM_AM001 Ver1.0	50% of initial funding by Japan environmental ministry

Country	Registry	Project ID	Project Developer	Crediting period	Operational/ Non operational	Issuance (year and frequency)	Source/ link	Status	Meth	Additionality / carbon revenue percentage
South Africa	**VERRA**	**1817**	Recarbon Ground Trading (Pty) Ltd	2018-2028	Operational	04 (Monitoring period)	https://registry.verra.org/app/projectDetail/VCS/1817	Registered	AMS. III F	A predictive model of Reliance's cash-flow (Annex C) up to the year 2024 was established to evaluate the future impact of VCUs generated on Reliance's profitability. The model conservatively assumes a revenue growth of 7% per annum. Net worth growth in a particular year is assumed to be directly attributable to the total profit in that year. The ratios of Costs of Goods Sold (COGS) and operating expenses to revenue were determined from historical data and applied to growing revenue. Finance costs and other income were shown to be highly variable and thus disregarded. The model overestimated Reliance's profits considerably and was therefore conservative in estimating the impact of carbon credits on the company's financial bottom line. Overestimations were attributable to the exclusion of finance costs, which have a significant impact on taxable income. While other income was also excluded, finance costs are, on average, 192% of other income. Therefore, excluding both other income and finance costs will result in an overestimation of profits. The ROI for Reliance is not expected to exceed the yields of government bonds without the sale of VCUs. With the sale of VCUs, the company's ROI is predicted to increase to ~9% before the end of the crediting period. Under this scenario, returns from the composting operations would exceed returns from government bonds and continuing operations would become more economically feasible. The profitability of the Reliance composting project is subject to the risks associated with agricultural projects, including those related to production and market prices. To compensate for these risks, the applicable ROI should be greater than the interest rate of the CAPM quoted above. Additionally, following discussions with financial experts, the return on companies – particularly start-up projects – are expected to be above the return determined by the CAPM rate.

Country	Registry	Project ID	Project Developer	Crediting period	Operational/ Non operational	Issuance (year and frequency)	Source/ link	Status	Meth	Additionality / carbon revenue percentage
Brazil	**VERRA**	**4138**	RECICLE CATARIN ENSE DE RESÍDUO S LTDA.	2022-2029	Operation al	No issuance	https://registry.verra.org/app/projectDetail/VCS/4138	Register ed	ACM0001	Auto additional, no details on investment analysis
Brazil	**VERRA**	**3448**	MARCA CONSTR UTORA E SERVIÇO S LTDA	2020-2027	Operation al	No issuance	https://registry.verra.org/app/projectDetail/VCS/3448	Register ed	ACM0001	Auto additional, no details on investment analysis
Mexico	**GS**	**11173**	Buen Manejo del Campo S.A de C.V (Sistema. bio)	2023-2027	Operation al	No credits	https://registry.goldstandard.org/projects/details/3160	registere d	GS TPDDTEC v3.1	Auto additional, no details on investment analysis
Indonesia	**VERRA**	**3297**	Gree Energy Limited	2021-2027	operation al	no issuance	https://registry.verra.org/app/projectDetail/VCS/3297	Register ed	AMS IIIH	Funded by carbon revenue
South Africa	**VERRA**	**2601**	EnviroSer v Waste Manage ment	2015-2022	Complete d	1 (2024)	https://registry.verra.org/app/projectDetail/VCS/2601	Register ed		Auto additional, no details on investment analysis
Turkey	**VERRA**	**2605**	BIOTREN D Çevre ve Enerji Yatırımla rı Anonim Şirketi	26-10-2022		5	https://registry.verra.org/app/projectDetail/VCS/2605	Register ed	ACM0001	Benchmark analysis - The equity IRR for the project activity has been calculated as 12. 66%. Investment cost is fixed, therefore unlikely that the investment cost would be lower than 19 %. O&M cost is fixed, therefore unlikely that the investment cost would be lower than 220 %. Variation in PLF of more than 1 1 % is unlikely to happen as the PLF has been reported as per the third-party report based on long term data.