"SUSTAINABLE FINANCE" IN THE SELECTIVE COLLECTION OF BIO-WASTE IN CO-COLLECTION AND BIOGAS PRODUCTION SCHEME

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ABSTRACT

As the impacts of climate change intensify, the need to invest in sustainability becomes increasingly urgent. It is essential to align investment projects with sustainable practices, enhancing their resilience and integrating new economic activities into green and blue economy models. In this context, sustainable finance emerges as a fundamental concept, considering environmental, social and governance (ESG) factors in investment decisions, while also ensuring financial returns and positive impacts on society and the environment.

Keywords: sustainable finance, selective collection, biogas, sustainability, ESG

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"SUSTAINABLE FINANCE" NA RECOLHA SELETIVA DE BIORRESÍDUOS EM REGIME DE CO-COLECÇÃO E PRODUÇÃO DE BIOGÁS

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RESUMO

Com o aumento dos impactos das alterações climáticas, a urgência de investir em sustentabilidade torna-se clara. É essencial alinhar projectos de investimento com práticas sustentáveis, aumentando a sua resiliência e integrando novas actividades económicas nos modelos de economia verde e azul. Nesse contexto, as finanças sustentáveis emergem como um conceito fundamental, considerando factores ambientais, sociais e de governança (ESG) nas decisões de investimento, sem descuidar do retorno financeiro e do impacto positivo na sociedade e no meio ambiente.

Palavras-Chave: Finanças sustentáveis, recolha selectiva, biogás, sustentabilidade, ESG

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1 Introduction

As the challenges posed by climate change become increasingly urgent, the need to transition to practices that promote all aspects of sustainability emerges unequivocally.

This work aims to illustrate the intersection between sustainable finance and efficient waste management, with a focus on the selective collection of biowaste, particularly in systems that utilize co-collection and biogas production.

By aligning investments with sustainable practices, the aim is to mitigate not only environmental impacts but also foster the development of new economic initiatives within green economy models, seeking to offer a different perspective from the typical “business as usual” approach based on purely extractive economic models and highlighting new alternatives found in regenerative economic models.

In this context, sustainable finance arises as an essential tool, considering environmental, social, and governance (ESG) factors in investment decisions, and gradually increasing awareness of their importance in decision-making and in the way organizations interact with their various stakeholders.

This article aims to demonstrate the viability of applying sustainable finance to the waste sector, while also highlighting its impact on investment strategies and financial sustainability in biogas production.

This work will likely contribute to the discussion on the importance of integrating sustainable financial practices into waste management, while also emphasizing the environmental, social, and economic benefits resulting from the model of selective co-collection of biowaste in the Tratolixo system.

The study aims to analyse the feasibility of applying green financial instruments to the urban waste sector and explore the model’s potential for replication, based on ESG indicators and alignment with European Taxonomy.

2 Theoretical and conceptual context

Sustainable finance is based on the concept of aligning financial flows with the Sustainable Development Goals, while simultaneously considering both financial returns and environmental, social, and governance (ESG) impacts. According to Schoenmaker and Schramade (2019), it involves a systemic transformation of the financial system, aiming to internalize environmental and social externalities into investment decisions.

Elkington (1997), with the "Triple Bottom Line" concept, reinforces the need to consider profit, planet, and people in an integrated way.

Concerning bioeconomy—understood as the sustainable use of renewable biological resources—this vision overlaps, offering circular solutions to complex environmental problems. Geissdoerfer et al. (2017) explore the connections between the circular economy, sustainability, and innovation, demonstrating that regenerative models are essential for meeting the demands of ecological transition.

In the context of waste management, the literature highlights the importance of selective biowaste collection and its energetic valorization, particularly through anaerobic digestion (Mata-Alvarez et al., 2011). This practice not only reduces landfill disposal, it also generates renewable energy, promoting decarbonization and resource efficiency—pillars of the circular economy (Honkasalo et al., 2017).

In terms of public policy, Fischer and Pascucci (2017) stress the need for multi-level and integrated governance that promotes coherence between climate objectives and local waste management.

The European Taxonomy, in turn, represents an unprecedented regulatory effort to guide investments toward sustainability, as detailed by Ehlers et al. (2021).

Taken together, this theoretical framework provides the conceptual foundations for understanding the interconnections between sustainable finance, ESG, circular economy, and public waste policies, forming the backdrop for the case study applied to the Tratolixo system.

3 Methodology

The approach of this work is intended to be qualitative and descriptive, structured as a case study that focuses on the experience of the Tratolixo waste management system, an intermunicipal entity responsible for managing waste from four municipalities in the Greater Lisbon region.

The unit of analysis is the selective collection model of biowaste through co-collection and its corresponding energy recovery via anaerobic digestion, which has been fully implemented since January 1, 2024. The time frame considered is from 2020 to 2024, with an emphasis on operational data from 2024, and 2023 as the reference year. The data sources include:

- Internal technical and operational documentation from Tratolixo
- Annual reports and institutional documents (e.g., IAPMEI, ICMA, UNFCCC)
- Methodological references for the voluntary carbon market
- Cross-reference with relevant scientific literature

Although based on real data, this work also includes normative and prospective analysis and is therefore structured in two dimensions: (i) factual description and (ii) strategic recommendations aligned with the European sustainability agenda.

4 Selective Collection of Bio-waste in a Co-collection System and its Valorization in Waste Treatment

4.1 Concept and relevance of a separate collection of Biowaste

Biowaste can be defined as biodegradable waste originating from food waste, gardening, and similar sources, such as food processing units, which account for more than 50% of unsorted waste in the Tratolixo system.

Regarding the relevance of selective co-collection of biowaste in the Tratolixo system, several environmental, social, and economic benefits are associated with this practice.

Figure 1. Biowaste selective co-collection scheme in Tratolixo system

4.2 Process of Biowaste Valorisation in the Tratolixo System

From an economic perspective, the selective collection activity for biowaste in a co-collection regime relies on two primary valorization methods available at Tratolixo's ecoparks (in Trajouce, Cascais and in Abrunheira, Mafra):

a) At the Trajouce Ecopark (Cascais), there is a new Green Waste Composting Plant with a capacity to receive and treat 50,000 tons per year of green waste, where an aerobic composting process is developed. In the complete operational phase, this plant produces 15,000 tons per year of compost, suitable for use as an organic fertilizer, which is ideal for application in organic farming.

b) At the Abrunheira Ecopark (Mafra), there is an Anaerobic Digestion Plant, with a maximum treatment capacity of 120,000 tons per year, where an anaerobic biowaste decomposition process is carried out. In 2024, this process generated approximately

10,000,000 m³ of biogas and biofertilizer, promoting the production of renewable energy (21 GWh/year—sufficient to provide “100% green” electricity with a guarantee of origin for 15,000 people) and recycling of nutrients.

These types of biowaste valorization developments have several positive impacts within the Tratolixo system context:

- Extended service life of the Abrunheira landfill
- Reduced greenhouse gas (GHG) emissions
- Improved waste management and financial optimization of operational activities.

5 Green financE INSTRUMENTS

The following section will delve deeper into some of the instruments applicable to the waste management and treatment sector, specifically focusing on the management and treatment of biowaste and biogas production.

5.1 Green Bonds and Carbon Credits

Green Bonds in the waste management sector are alternative debt securities designed to finance or refinance projects with transparent, measurable, and auditable environmental benefits throughout their operations. Also known as green or climate bonds, their issuance must align with the Green Bond Principles (ICMA 2021). It can support various project types, prominently including pollution prevention and control, atmospheric pollution reduction, greenhouse gas control, soil recovery, waste prevention, recycling, and energy production from biowaste with a positive emissions balance. These bonds do not rely on structural investment programs or third-party financial packages and benefit from growing investor interest in portfolio diversification.

Carbon Credits represent certified units recognized by carbon credit programs, each indicating the reduction or removal of one metric ton of CO2 or equivalent greenhouse gases from specific Project Activities - PoAs (PwC 2023). These credits are tradable in voluntary carbon markets and are applicable in biowaste valorization projects that produce biogas via anaerobic digestion, thereby generating additional revenue and helping offset project deficits.

The methodology for applying these financial instruments to waste management projects must rigorously follow frameworks such as the Clean Development Mechanism (CDM) Methodology Booklet (UNFCCC, 2020). In Tratolixo's case, the AMS-III.AO methodology ("Methane recovery through controlled anaerobic digestion", version 1) is employed, referencing 2023 data and regulated under the Verra standard.

Operational and regulatory risks stem from the existence or absence of applicable regulations and the project's technical compliance with approved methodologies. Tratolixo's biogas production process was validated in accordance with relevant standards, taking into account process eligibility and ancillary benefits.

Biogas composition depends on the feedstock and production processes, primarily using biodigesters—sealed tanks where organic material decomposes anaerobically—and landfill gas recovery systems that capture biogas produced under anaerobic landfill conditions.

In 2024, the project generated approximately 7,226 tons of CO_2e emissions (Scope 1), primarily from methane leaks (≈approximately 5,343 tCO_2e), residual combustion emissions (≈approximately 502 tCO_2e), diesel consumption (≈approximately 1,258 tCO_2e), and N_2O emissions from the digestate (≈approximately 69 tCO_2e). Scope 2 emissions associated with electricity purchased from the grid accounted for about 1,617 tCO_2e, based

on Portugal's 2023 emission factor (0.19 tCO_2e/MWh). Total non-avoided emissions sum to roughly 8,843 tCO_2e.

Compared to approximately 110,000 tCO_2e emissions avoided by diverting biowaste from landfill, the project's net emission balance is -101,000 tCO_2e, equivalent to holding 101,000 carbon credits for voluntary market trading. This establishes the project as "carbon negative," thereby justifying its eligibility in voluntary carbon markets and aligning with the European Taxonomy objectives.1

Scope 3 emissions, which encompass the entire value chain, are less well accounted for due to data limitations; however, according to the GHG Protocol Project, Protocol, and AMS-III.AO methodology does not require Scope 3 accounting for carbon footprint evaluations, focusing instead on Scopes 1 and 2 to ensure methodological consistency and international comparability. Hence, Scope 3 data are excluded due to considerations of reliability and relevance.

During the project in question, four barriers to entry into the Voluntary Carbon Market (VCM) were identified:

- Interference from public funding for the VCM;
- Legal framework requirements at the national and European levels;
- Lack of credible standards in the market; and
- Absence of methodologies for submitting the project to the VCM.

Based on the analysis of these barriers and their associated risk levels, it was determined that the AMS-III.AO methodology—"Methane recovery through controlled anaerobic digestion," version 1—presented a medium risk regarding national initiatives (mainly due to the lack of current regulation) and a low risk regarding international initiatives (due to the possibility of aligning the project, methodology, and standard with existing rules). Following this analysis, Tratolixo successfully overcame these barriers, choosing to focus on the international VCM.

In the next phase, Tratolixo encountered further barriers:

1. Legal barriers;
2. Financial barriers.

The first barrier posed a possible risk of double financial benefit, resulting from the fact that the Abrunheira Anaerobic Digestion Plant (ADP) had benefited from structural investment funds. After studying the issue, it was concluded that this could be overcome through a conceptual analysis of what carbon credits are and their purpose. As noted above, the benefit resulting from issuing and trading carbon credits applies only to covering operational expenses, so this potential constraint was resolved.

Regarding the second barrier, related to carbon credit market rules (i.e., the VCM itself, whether national or international), it was concluded that the market value uncertainty of the credit was not a significant obstacle given the project's added value, although the trading price remained a topic of interest. After studying the market and consulting with international market analysts, this barrier was deemed irrelevant to the decision to proceed with the carbon credit issuance program.

[1] The calculations presented follow the guidelines of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, the GHG Protocol, as well as reference emission factors (EEA/DEFRA for fossil fuels and APA/Eurostat for electricity in Portugal).

Lastly, and related to the above, it is essential to highlight that the carbon credit principles (ICROA 2025) require that credits be always verified according to the following criteria:

- Unique: carbon credit must be unique and cannot be double-issued in any other electronic registry;
- Real: they must represent actual emission reductions or removals;
- Permanent: issued for permanent emission reductions or removals;
- Additionality: emission reductions or removals go beyond what would have occurred without the project;

Measurable: emission reductions or removals must be quantifiable and supported by data.

A detailed analysis shows that Tratolixo's biogas production at the Abrunheira ADP is real (consolidated over more than 10 years of continuous production), permanent (as it reduces emissions from biowaste decomposition to the atmosphere), additional (capacity increased by 50% in 2024 compared to 2023), and measurable and auditable at all times.

Based on these conclusions, the project proceeded to the implementation phase, meeting the established methodological requirements.

5.2 Connection to European Taxonomy and European Funding Support

The European Taxonomy can be understood as the European Union's classification system for environmentally sustainable economic activities. Its main objective is to promote sustainable investments, providing transparency, mitigating greenwashing, and supporting the transition to a green economy.

The European Taxonomy Regulation establishes six environmental objectives:

1. Mitigation of climate change;
2. Adaptation to climate change;
3. Sustainable use and protection of water and marine resources;
4. Transition to a circular economy;
5. Pollution prevention and control;
6. Protection and restoration of biodiversity and ecosystems.

A fundamental principle is that any activity significantly contributing to one of these objectives must not cause significant harm to any other objectives.

5.3 Impact on the Allocation of European Investment Support Funds

Sustainability currently holds a central place in European political agendas. European regulatory trends on sustainability underscore the pivotal role of the financial system and sustainable finance in accelerating transitions to socially, ethically, and environmentally responsible business models.

Consequently, financiers—public and private—are responsible for redirecting financial flows toward investments that support business strategies aligned with Environmental, Social, and Governance (ESG) factors.

Access to EU funds comes with regulatory demands, and companies must understand that failing to align their activities with sustainability goals may jeopardize their continuity (IAPMEI 2023).

Accordingly, green financial instruments apply only to projects promoting sustainability across all dimensions, with claims that must be demonstrable, auditable, and reported according to specific reporting rules under the Corporate Sustainability Reporting Directive (CSRD), the European Taxonomy, the Corporate Sustainability Due Diligence Directive (CSDDD), and most recently, the OMNIBUS.

5.4 ESG Indicators and Their Application to the Waste Sector, Specifically Biogas from Biowaste

ESG indicators are environmental, social, and corporate governance metrics designed to measure an organization's commitment to achieving sustainable development goals (IAPMEI 2024).

In the context of biowaste collection and biogas production, relevant ESG indicators include:

- **Environmental:**
  - Greenhouse gas emission reductions
  - Energy efficiency
  - Use of renewable energy
  - Waste management—reducing landfill deposition, increasing recycling and reuse rates
- **Social:**
  - Creation of green jobs
  - Occupational health and safety
  - Community engagement
  - Working conditions, education level, age, equal opportunity, training
- **Governance:**
  - Transparency and anti-corruption mechanisms
  - Ethics and legal compliance
  - Board diversity
  - Risk management

At Tratolixo, sustainability reports demonstrate the objective integration of ESG indicators into strategic decisions, influencing the definition, execution, and operationalization of activities. This aligns fully with European Green Taxonomy assumptions.

6 Conclusions

This article demonstrates that the selective collection of biowaste for biogas production not only contributes to reducing greenhouse gas emissions but also promotes social and economic benefits.

The biogas production project (PoAs) may access alternative/complementary operational revenue streams beyond the main financial flow from biogas-to-energy conversion. This includes trading approximately 101,000 carbon credits, reinforcing the project's "carbon negative" nature.

In the Tratolixo urban waste management system, the selective collection of biowaste has been fully implemented throughout its territory since January 1, 2024. Collected biowaste

is used to produce biogas through anaerobic digestion, which is then converted into electricity.

Sustainable finance principles also offer investment capital alternatives in the form of green bonds, which support investments that promote and guarantee continuous compliance with the main ESG rules, without significantly harming any other ESG principles.

Finally, the benefits and impacts of selective co-collection at Tratolixo, as well as the capacity for treatment and management at its facilities for the collected biowaste flow, are made clear.

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