

MAPPING INFORMATION GAPS IN ENVIRONMENTAL REPORTING AMONG ECUADORIAN HIGHER EDUCATION INSTITUTIONS

MAPEO DE BRECHAS DE INFORMACIÓN EN LOS REPORTE AMBIENTALES DE LAS INSTITUCIONES DE EDUCACIÓN SUPERIOR ECUATORIANAS

Edgar Leonardo Salas Luzuriaga^{1*}, Kimberly Aryani Rizzo Ochoa¹

ABSTRACT

This research evaluates the critical information gap in environmental disclosure among Ecuadorian Higher Education Institutions (HEIs) through the lens of the circular economy. Utilizing a census-based institutional filtering process, the study initially screened 272 institutional records to focus on a rigorous sample of 63 universities and polytechnic schools. Data were analyzed using descriptive statistics and Fisher's Exact Test to explore associations between institutional variables and transparency. The results identify a pattern described as a "Transparency Paradox", despite their vast resources and academic influence, the primary urban hubs of Pichincha and Guayas exhibit reporting rates below 30%, indicating that institutional density is not associated with data accountability. Conversely, the Amazonía region, achieves a full 100% transparency rate, suggesting a regional trend ($p = 0.092$) that aligns institutional identity with environmental preservation. The investigation identifies composting as the dominant valorization strategy due to its low capital requirements, while technologies like biodigestion remain confined to isolated pilot projects. The inferential analysis demonstrates that institutional funding models are not significantly associated with the likelihood of reporting ($p = 1.000$), while larger campuses tends to generate vast waste volumes without equivalent public disclosure. Consequently, the study advocates for the creation of territorial waste management networks and a national observatory to harmonize reporting metrics. By transforming universities from passive waste generators into active nodes of territorial governance, Ecuador can bridge the current data void, ensuring that sustainability moves beyond pilot-scale rhetoric toward a systemic, measurable reality.

Keywords: academic accountability, circular economy, transparency paradox.

RESUMEN

Esta investigación evalúa la brecha de información crítica en la divulgación ambiental entre las Instituciones de Educación Superior (IES) de Ecuador a través de la lente de la economía circular. Utilizando un proceso de filtrado institucional basado en censo, el estudio evaluó inicialmente 272 registros para enfocarse en una muestra de 63 universidades y escuelas politécnicas. Los datos se analizaron mediante estadística descriptiva y la Prueba Exacta de Fisher para explorar asociaciones entre variables institucionales y la transparencia. Los resultados identifican un patrón descrito como la "Paradoja de la Transparencia"; a pesar de sus recursos, los principales centros urbanos de Pichincha y Guayas presentan tasas de reporte inferiores al 30%, lo que indica que la densidad institucional no se asocia con la rendición de cuentas de datos. Por el contrario, la región Amazónica muestra una tasa de transparencia del 100%, lo que sugiere una tendencia regional ($p = 0.092$) que alinea la identidad institucional con la preservación ambiental. La investigación identifica al compostaje como la estrategia de valorización dominante debido a sus bajos requerimientos de capital, mientras que tecnologías como la biodigestión permanecen confinadas a proyectos piloto aislados en un grupo selecto de instituciones líderes. El análisis inferencial revela que los modelos de financiamiento institucional no están significativamente asociados con la probabilidad de reporte ($p = 1.000$), mientras que los campus más grandes tienden a generar vastos volúmenes de residuos sin una divulgación pública equivalente. En consecuencia, el estudio aboga por la creación de redes territoriales de gestión de residuos y un observatorio nacional para armonizar las métricas de reporte. Al transformar a las universidades de generadores pasivos de residuos en nodos activos de gobernanza territorial, Ecuador puede cerrar el vacío de datos actual, asegurando que la sostenibilidad pase de una retórica a escala piloto hacia una realidad sistémica y medible.

Palabras clave: rendición de cuentas académica, economía circular, paradoja de la transparencia.

¹ Universidad Ecotec, Km. 13.5 Samborondón, Samborondón, EC092302, Ecuador.

* Corresponding Author: esalas@ecotec.edu.ec

1. INTRODUCTION

The transition toward a circular economy represents one of the most significant challenges for the 21st-century academic sector, where Higher Education Institutions (HEIs) are expected to transcend their traditional educational roles to become active agents of territorial sustainability. As “living laboratories” universities serve as the testing ground for innovative waste management strategies that can later be scaled to municipal or national levels. However, the effectiveness of these institutional efforts is frequently hindered by a lack of transparency and a significant “information gap” that prevents a clear understanding of the environmental reality across different geographical regions. In the case of Ecuador, this disparity is particularly evident, as the diverse territorial conditions of the Sierra, Costa, and Amazonía influence how universities report and manage their waste streams.

1.1. Higher Education as a Catalyst for the Circular Economy

Waste generation in Higher Education Institutions (HEIs) has grown steadily due to increased campus populations, intensified research activity, and expanded service operations. Globally, universities are recognized as living laboratories for sustainability and play a pivotal role in modeling circular behaviors. In the framework of the 2030 Agenda, HEIs are tasked with modeling circular behaviors and ensuring environmental accountability (Morales et al., 2023; Tercanli & Jongbloed, 2022). Globally, the “Closing the Loop” ideal transforming waste from a burden into a resource, is the benchmark for campus excellence (Jakimiuk et al., 2023). This involves not only technical solutions like composting but also the governance structures that allow these practices to be measured and shared.

1.2. The Ecuadorian Landscape: Waste and Institutional Reality

Ecuador faces a complex waste scenario, generating approximately 14193 tons of solid waste daily. Organic matter constitutes more than half of the total waste stream, with organic residues, such as food waste, accounting for 56%, while inorganic materials comprise the remaining 44%. Regarding inorganic waste streams, plastics represent a primary component, accounting for 12% of total discards (Instituto Nacional de Estadística y Censos [INEC], 2024), but there are not reports about Ecuadorian HEIs generation. While local research, such as the characterization at ESPOL, has shown that up to 62% of campus waste is organic (Merchán-Sanmartín et al., 2021), this data remains fragmented. Most national studies focus on municipal governance (Villalba Ferreira et al., 2022; Jaramillo et al., 2023; Peñafiel et al., 2025), leaving the specific environmental footprint of the 63 registered HEIs largely unmapped.

1.3. Territoriality and the Information Gap

The maturity of environmental reporting is not uniform; it is a geographical phenomenon. Institutional transparency often correlates with regional development poles and the specific socio-environmental pressures of the territory (Leal Filho et al., 2025; Ndou et al; 2021; Shrestha, 2025; Woldeesenbet, 2021). In Ecuador, the vast differences in institutional density between the urban hubs of the Sierra and Costa, compared to the ecologically sensitive Amazonía, create a “transparency paradox” that hinders the creation of national sustainability networks. However, sustainable waste management remains uneven across institutions, with initiatives ranging from isolated recycling programs to more comprehensive environmental management systems (Aguirre et al., 2023; Falcones et al., 2024). The proposal for solid waste management at ESPOL quantified campus waste (780 kg/day) and assessed composition (62% organic, 19% plastic, 13% paper, remainder metal, glass, etc.), pointing to high potential for composting and recycling, along with awareness and training programs (Merchán-Sanmartín et al., 2021). These precedents show both what is possible and highlight gaps: data on waste flows is not always systematic, awareness does not always translate into behavior, and infrastructure or institutional commitment often lags policy statements.

1.4. Research Questions and Hypotheses

To address this gap, this study seeks to answer the following questions:

- How is the reporting of waste management policies spatially distributed across the 63 Ecuadorian HEIs?
- Is there a statistically significant association between the geographical region or the type of funding **and** the public disclosure of environmental practices?
- What is the current state of organic waste valorization within the analyzed reports?

To guide the inferential analysis, the following research hypotheses are proposed:

- H1: The geographical region of the institution is significantly associated with the frequency of environmental reporting.
- H2: Public HEIs exhibit higher levels of environmental transparency compared to private institutions due to national regulatory frameworks.

1.5. Objective and Scope

The objective of this article is to map the information gap by conducting a spatial analysis of environmental reporting in Ecuadorian HEIs. Adopting a descriptive-exploratory design with an inferential component, this research identifies regional patterns in transparency through a census-based approach of the 63 universities registered in the country, and analyzes the adoption of organic waste valorization strategies.

2. THEORETICAL FRAMEWORK

The study of waste management in Higher Education Institutions (HEIs) requires a multi-dimensional theoretical approach that integrates environmental engineering, public governance, and economic geography. While technical solutions provide the means for waste valorization, it is the institutional framework and its territorial context that determine the success and visibility of these practices. By examining the intersection of circularity, transparency, and spatiality, this framework provides the analytical tools necessary to understand why some institutions lead the transition toward sustainability while others remain in an information void.

2.1. Circular Economy and the “Closing the Loop” Concept

The transition toward a circular economy (CE) in university campuses is conceptually defined as “closing the loop”. This framework shifts waste management from a linear model to a restorative system where materials, particularly organic waste, are valorized through composting or anaerobic digestion (Jakimiuk et al., 2023; Rodríguez-Guerreiro et al., 2024). Within HEIs, this process is not merely technical; it represents a cultural and operational shift where the campus acts as a “living laboratory” to test circularity before it is scaled to municipal levels (Morales et al., 2023; Save et al., 2021,).

2.2. Reality Environmental Governance and the Information Gap

Environmental governance in the academic sector refers to the internal policies, leadership, and reporting mechanisms that drive sustainability. A critical pillar of effective governance is transparency. The information gap theory (Loewenstein, 1994) posits that the absence of public data is a structural barrier that prevents the evaluation of institutional performance and the creation of collaborative networks (Ramdan et al., 2023). In this context, a waste management practice that is not publicly disclosed or mapped constitutes a failure in environmental accountability, hindering the development of national sustainability benchmarks.

2.3. Territoriality and the Geography of Sustainability

From a geographical perspective, sustainability is not a spatially uniform process. The geography of transitions (Hansen & Coenen, 2015; Murphy, 2015) suggests that institutional behaviors are heavily influenced by their

socio-environmental and physical context. This framework emphasizes that transitions toward circularity are place-based processes, where local institutional thickness and territorial specificities dictate the pace of change (Truffer et al., 2015). In the case of Ecuador, the territoriality of HEIs, whether they are situated in high-density urban poles (Sierra and Costa) or ecologically sensitive regions (Amazonía), dictates different logistical pressures and regulatory expectations. Therefore, the spatial analysis of reporting practices allows for the identification of transparency hubs versus shadow regions, providing a clearer picture of how geography shapes institutional commitment.

3. MATERIALS AND METHODS

3.1. *Design and Scope*

This study adopted a non-experimental, cross-sectional, and descriptive-exploratory design. Its primary objective is to map the current state of environmental reporting among Higher Education Institutions (HEIs) in Ecuador. While the core of the study is descriptive, inferential statistical tools were employed to identify significant associations between institutional variables and reporting patterns, providing a baseline for university sustainability governance. To ensure the reproducibility and rigor of the data collection, the research was operationalized through a census-based institutional filtering protocol visualized in the procedural flowchart (Figure 1). This multi-stage screening process allows for a transparent evaluation of the institutional universe through the following sequential logical phases:

- **Step 1: Identification of the Initial Institutional Universe.** This phase established the baseline by mapping the total macro-universe of HEIs registered within the national educational system, ensuring that no active entity was omitted from the primary tracking stage.
- **Step 2: Screening and Typology Filter.** In this phase, a systematic categorization was applied to exclude entities whose organizational structures, academic mandates, and operational scales do not align with complex university-level ecosystems, thereby narrowing the focus to eligible universities and polytechnic schools.
- **Step 3: Evaluation of Digital Information Availability.** This stage involved an exhaustive audit of active official web domains and public transparency portals for each screened institution. The objective was to verify the presence of accessible institutional repositories or data structures dedicated to environmental reporting.
- **Step 4: Final Sample for Environmental Census.** The protocol concluded with the determination of the final analytical sample, comprising institutions with fully comparable public records, which forms the empirical foundation for the subsequent spatial and inferential analyses.

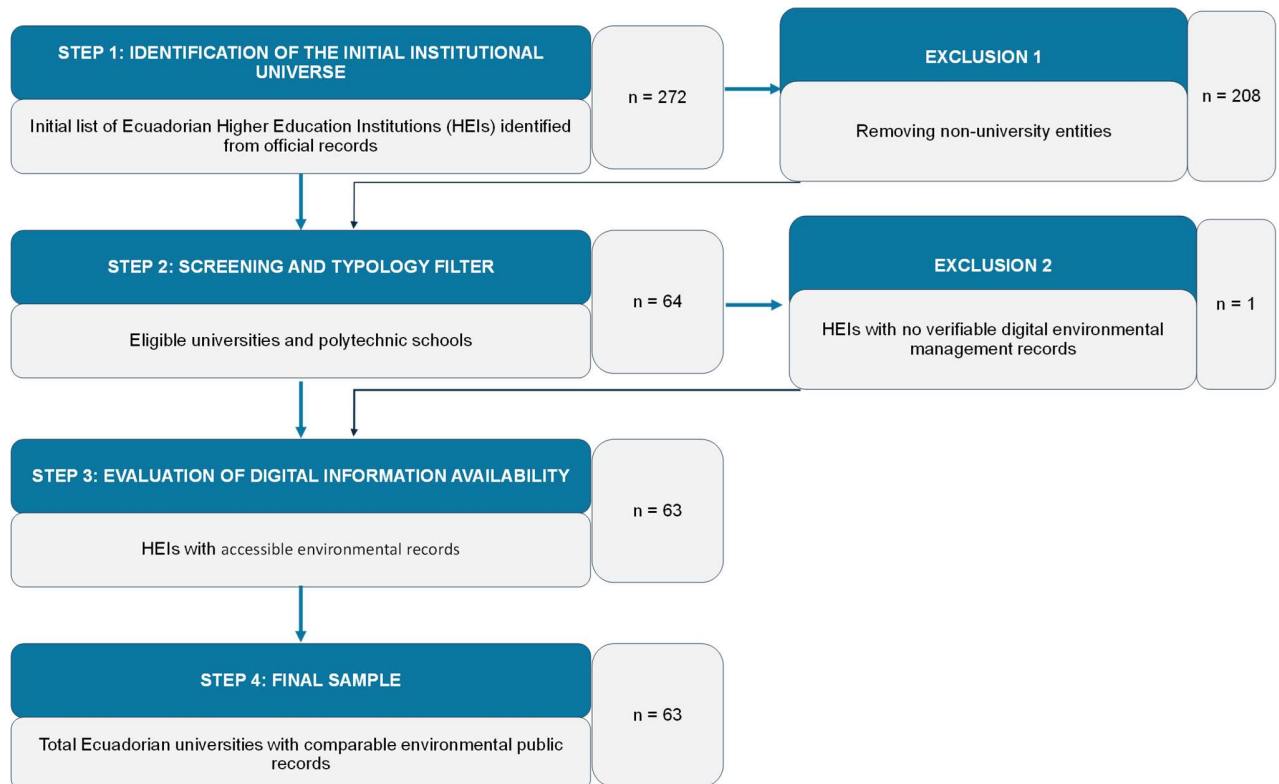


Figure 1. Institutional filtering flow diagram

3.2. Study Universe and Territorial Scope

To ensure the highest standards of transparency and reproducibility in the sample selection, a census-based institutional filtering process was applied. It is important to clarify that this study does not constitute a systematic literature review (SLR); rather, it adapts the structural reporting logic of the PRISMA statement to provide a rigorous and systematic account of how the institutional census was derived. By utilizing this adapted framework, the study identifies, screens, and determines the eligibility of Higher Education Institutions (HEIs) through a clear, multi-stage workflow (Figure 1).

The empirical phase began with an initial macro-universe of 272 institutional records retrieved from national higher education administrative registries. Following strict eligibility criteria, 208 records were systematically excluded because they corresponded to Technical and Technological Institutes. This exclusion was methodologically necessary to maintain a homogeneous institutional sample, focusing strictly on Universities and Polytechnic Schools, which are subject to rigorous research mandates and specific environmental accountability standards that differ significantly from those of technical vocational centers. Additionally, institutions presenting inactive digital portals or missing digital records at the time of the audit ($n = 1$) were excluded. This rigorous filtering resulted in a final census sample of 63 HEIs officially recognized by the Higher Education Council (CES) of Ecuador.

3.3. Data Collection and Information Sources

The empirical data collection was systematically executed within a distinct temporal window between October 2025 and January 2026. To ensure data triangulation, traceability, and institutional transparency, the search infrastructure targeted three primary digital operational levels across the 63 selected HEIs:

- **Official Institutional Portals:** A rigorous digital audit was conducted across the active official web domains of the 63 universities. The protocol focused on screening dedicated operational units, such as "Sustainability", "Campus Verde", or "Environmental Management" sections, to verify the active publication of internal waste management protocols.
- **Institutional Accountability Reports:** Public and mandatory transparency repositories (*Informes de Rendición de Cuentas*) were reviewed. Within the national transparency framework, these compliance documents were evaluated to determine whether HEIs publicly disclose annual management goals, environmental indicators, and institutional waste streams tracking.
- **Complementary Academic Validation (Scopus Tracking):** To complement the gray literature and institutional reporting data, the Scopus database was used as an external validation baseline (Timeframe: 2020–2026). A targeted search was deployed using the string ("Waste management" OR "Circular economy" OR "Composting" OR "Biodigestion") AND ("University" OR "Higher Education") AND ("Ecuador") in English and Spanish. This tracking allowed the study to cross-reference whether the presence (or absence) of public institutional environmental records correlates with active peer-reviewed scientific production regarding waste valorization within those specific campus ecosystems.

3.4. Variable Operationalization and Statistical Framework

To operationalize the spatial analysis of the "Information Gap" and map potential structural barriers in transparency, the 63 HEIs were categorized according to two core analytical variables:

- **Territorial Scope:** Institutions were mapped by their main campus location across the natural regions of the country (Sierra, Costa, and Amazonía). This categorization allows the study to evaluate whether high institutional density in urban hubs correlates with environmental disclosure or if ecologically sensitive areas present distinct reporting dynamics.
- **Funding Typology:** HEIs were classified by their financial regime into public and private institutions to assess the influence of state regulatory frameworks on sustainability accountability.

Following this categorization, the data analysis was performed in two stages. First, descriptive statistics (frequencies and percentages) were used to characterize the current state of environmental reporting across regions and funding models. Second, an inferential analysis was conducted to explore potential associations between institutional variables and reporting status. Given the sample size ($N = 63$) and the presence of categories with zero observations and low expected frequencies, Fisher's Exact Test was employed for all categorical comparisons. This test was selected over the Pearson's Chi-square due to its ability to provide exact p -values without the requirement of minimum expected frequencies per cell. All inferential findings are interpreted as observed trends and associations rather than definitive causal relationships, in accordance with the exploratory nature of the study. Statistical significance was set at $p < 0.05$.

4. RESULTS

The analysis of the 63 Higher Education Institutions (HEIs) in Ecuador shows a non-uniform distribution reveals a significant disparity between institutional presence and environmental transparency. While the university system is physically distributed across the national territory, variations in public reporting levels are observed across the sector. The following sections detail the spatial distribution of these institutions and the reported state of their public reporting regarding waste management and circular practices.

4.1. Territorial Distribution and Institutional Profile

The mapping process identified 63 HEIs, showing a high concentration in the Sierra and Costa regions. The Sierra region hosts the largest number of institutions ($n=36$), followed by the Costa ($n=25$) and the Amazonía ($n=2$) (Figure 2).

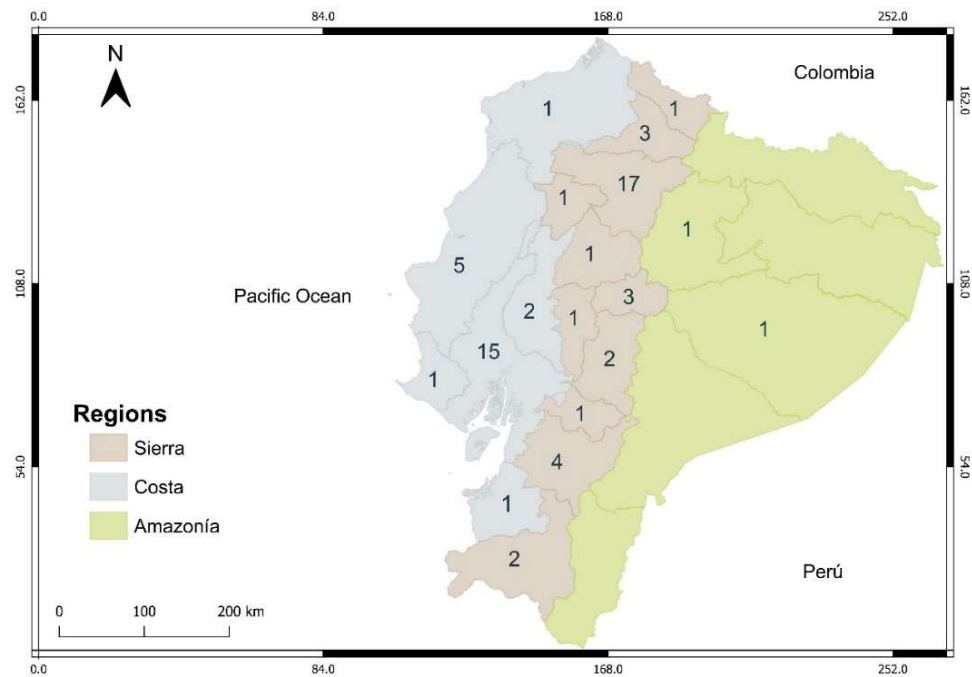


Figure 2. Distribution of Ecuadorian HEIs by province and regions.

In terms of funding, public entities represent the majority ($n=35$), with a strong presence in the Sierra ($n=19$) and Costa ($n=14$). Private self-financed institutions ($n=20$) and co-financed entities ($n=8$) are similarly concentrated in the urban poles of Pichincha and Guayas (Figure 3). The distribution of these institutions in urban centers aligns with areas of high municipal waste demand, where HEIs act as significant generators.

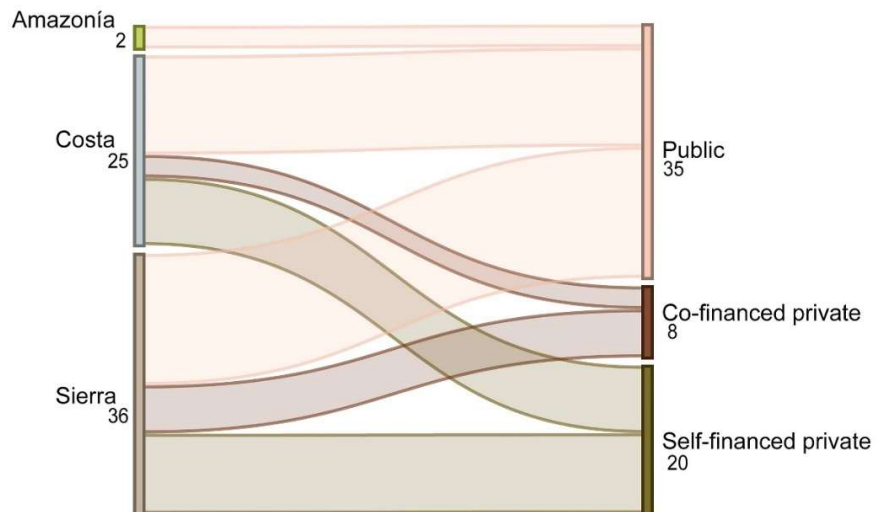


Figure 3. Number of Ecuadorian public and private HEIs present in the Costa, Sierra and Amazonia regions

4.2. The Transparency Gap: Regional Reporting Trends

Data analysis reveals a low frequency of public environmental disclosure across the Ecuadorian academic landscape. Out of the 63 HEIs analyzed, 44 (70%) do not publicly disclose their non-hazardous waste management policies. Only 19 (30%) institutions, representing a mere 30% of the sample, provide accessible data on their practices, as illustrated in Figure 4.

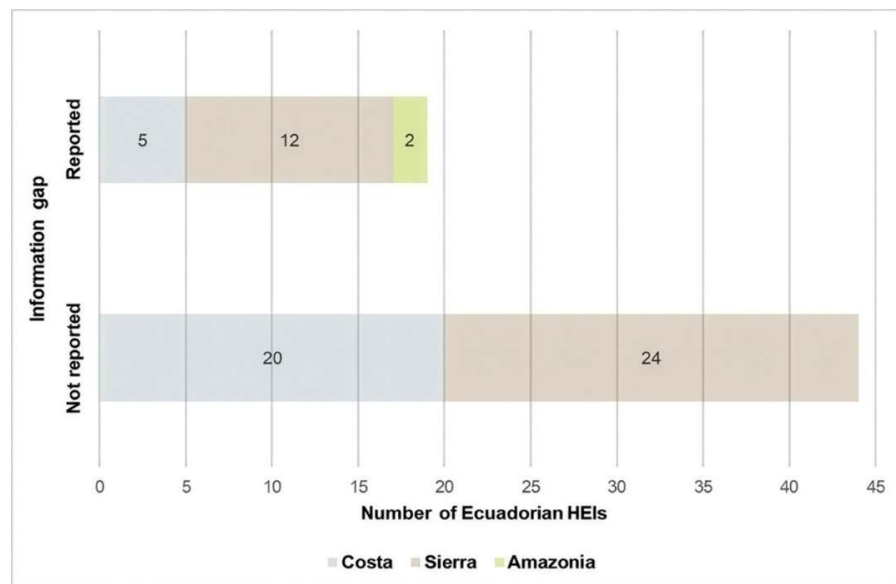


Figure 4. Reporting status of non-hazardous waste management policies among Ecuadorian HEIs

This regional disparity was analyzed using Fisher's Exact Test to explore the association between geographical location and reporting status. The Amazonía region, despite hosting the fewest institutions ($n = 2$), achieves a 100% reporting rate. When comparing the Amazonía against the rest of the country (Costa and Sierra), a regional trend was identified ($p = 0.092$), although it does not reach the standard threshold for statistical significance (Table 1).

Table 1. Regional distribution of environmental reporting

Funding type	Reported	Not reported	Total
Amazonía	2	0	2
No Amazonía (Costa and Sierra)	17	44	61
Total	19	44	63
<i>p</i> -value	0.092*		

Note: *Fisher's Exact Test.

In the Sierra, 12 (33%) institutions report their data while 25 remain without public records. In the Costa region, only 5 out of 25 institutions (20%) disclose environmental data, representing the lowest reporting rate among the regions. Additionally, the association between funding type (Public vs. Private) and reporting was evaluated using Fisher's Exact Test, yielding a $p = 1.000$, which indicates that the type of funding is not associated with

the likelihood of reporting in this sample (Table 2).

Table 2. Association between funding type and environmental reporting

Funding type	Reported	Not reported	Total
Public	11	24	35
Private	8	20	28
Total	19	44	63
<i>p</i> -value	1.000*		

Note: *Fisher's Exact Test.

The current levels of disclosure across the nation limit the tracking of national circular economy goals and the visibility of the environmental footprint of the higher education sector. Without standardized reporting mandates, the data availability remains limited, constraining the analysis of successful waste valorization models at a national level. The spatial concentration of HEIs in dominant administrative and economic provinces such as Pichincha and Guayas highlight a gap between institutional scale and environmental disclosure, where physical density is not proportionally matched by informational transparency. Although these specific provinces host the largest and most influential universities in Ecuador, less than 30% of their institutions maintain a high level of transparency regarding the public reporting of non-hazardous waste management practices, as depicted in Figure 5.

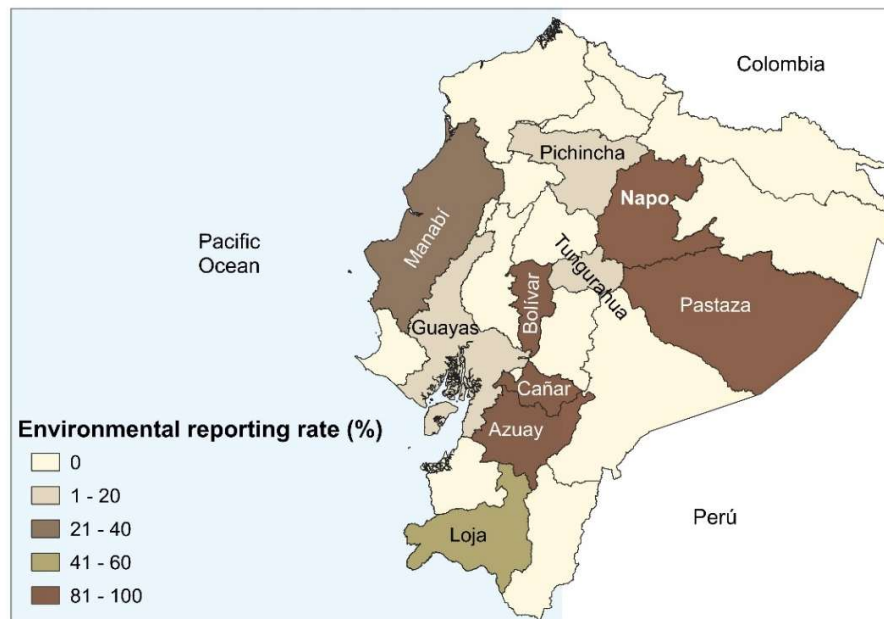


Figure 5. Environmental reporting rate by province in Ecuadorian HEIs

4.3. Pathways for Organic Waste Valorization

Regarding technical "Closing the loop" initiatives, organic waste remains the primary focus of institutional efforts. The data reveals a pattern in technology adoption, where composting stands out as the most prevalent strategy (n=14). As shown in Figure 6, observations suggest a difference between institutional density and transparency. In major urban hubs like Pichincha and Guayas, the number of HEIs reporting waste treatment is low relative

to their total density, whereas the Amazonía provinces (Napo and Pastaza) achieve a full reporting rate, within their institutional context.

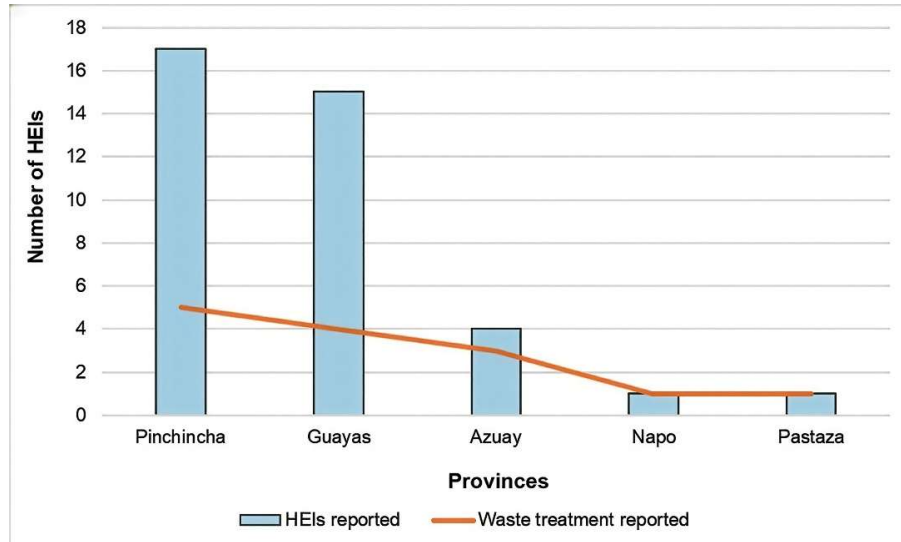


Figure 6. Comparison between total institutional density and public waste treatment reporting by province

5. DISCUSSION

5.1. Assessment of Funding Models and Administrative Patterns

The research suggests that the environmental information gap within Ecuadorian Higher Education Institutions (HEIs) is a phenomenon that may be influenced by the institutional funding models and administrative structures. However, the inferential analysis conducted in this study ($p = 1.000$) indicates no statistically significant association between the type of funding (public vs. private) and the frequency of environmental reporting. This finding contrasts with the observations of Singun (2025), who suggests that private institutions exhibit greater agility in adopting digital transparency portals and international sustainability frameworks. While private HEIs might theoretically possess more flexibility for institutional branding, the data in the Ecuadorian context shows that both sectors face similar challenges in systematic disclosure. In the public sector, the emphasis on financial compliance often stems from institutional structures that prioritize legalistic reporting over voluntary environmental disclosure (Ceulemans et al., 2015; Larrán Jorge et al., 2015). This orientation is frequently associated with bureaucratic frameworks and funding rigidities that, while demanding exhaustive accountability for resource allocation, may lack standardized incentives for sustainability transparency (Bozeman, 2000).

5.2. The Geography of Transparency and the Observation of Scale

In provinces such as Pichincha and Guayas, the volume of waste generated and the administrative complexity of large-scale operations are associated with a pattern where the most influential universities exhibit lower levels of transparency regarding their circular footprints. This phenomenon, described by Poma et al. (2025) as a structural opacity of scale, corresponds with the "Transparency Paradox" identified in this study, which complicates the formal publication of circular practices. The regional analysis suggests a distinctive trend in the Amazonía ($p = 0.092$). Despite hosting fewer institutions, the 100% reporting rate in this region suggests an association between territorial governance and institutional identity. While the Amazonian sample size is small ($n=2$), it represents a full regional census, reflecting a localized trend that contrasts with the larger, more opaque urban hubs. Consequently, these findings should be interpreted as a preliminary regional pattern rather than a

definitive comparative law, highlighting the need for further qualitative studies on institutional identity in ecosystemically sensitive areas. These observations indicate that accountability may be prioritized in regions where ecosystem fragility is more immediate, regardless of the institutional budget.

5.3. Technical Pathways: Composting Frequency and Operational Reality

This investigation confirms that composting remains the predominant treatment method across the 14 analyzed institutions, likely due to its low capital requirements and operational simplicity (Craveiro et al., 2025). In contrast, advanced valorization technologies such as anaerobic biodigestion exhibit limited implementation (Uddin, 2024). These systems are currently concentrated in specific institutions, such as Universidad San Francisco de Quito (USFQ) and the Universidad Técnica Estatal de Quevedo (UTEQ), where they function primarily as high-level research tools or energy-recovery prototypes rather than as systemic, integrated national practices. This observation highlights a gap between the high-level. "Closing the Loop" rhetoric found in institutional strategic plans and the actual levels of institutional disclosure available to the public.

5.4. Territorial Processing Hubs and Regional Networks

The concentration of these technologies in specialized research hubs represents a potential opportunity to establish territorial processing hubs. In this framework, larger universities with established infrastructure and technical expertise could act as regional anchors for smaller institutions. The closing the loop concept, implementing circular economy pathways that ensure waste is minimized, reused, recycled, or composted at source, has been successfully implemented in international campus case studies (Jakimiuk et al., 2023; Rodríguez-Guerreiro et al., 2024). For example, at the Warsaw University of Life Sciences, selective waste collection and nudging strategies demonstrated that a campus can move toward waste neutrality under appropriate policies (Jakimiuk et al., 2023). As argued by Abu et al. (2022) and reinforced by Velásquez-Pinas et al. (2025), the transition to a cohesive national circular economy strategy in the Global South requires moving away from isolated initiatives toward interconnected regional waste-sharing networks.

5.5. Challenges and Limitations

The execution of this territorial mapping identified several structural barriers that fundamentally define the current state of environmental data in Ecuador, revealing a systemic challenge that transcends simple administrative oversight. A primary obstacle is the severe fragmentation of information, as the absence of a standardized reporting framework for HEIs constrains cross-institutional performance comparisons. Environmental data is often presented in non-searchable formats or integrated into general reports structured for legal compliance rather than proactive disclosure. This structural limitation is further compounded by significant digital opacity, where institutional websites are designed more for institutional branding than for public accountability, frequently lacking dedicated sustainability repositories and leaving researchers dependent on government-mandated transparency portals that are often poorly maintained or critically outdated. Most importantly, the mapping revealed a pervasive lack of quantitative detail; even among the 14 institutions that demonstrated verifiable environmental practices, there was a stark absence of rigorous metrics, such as the exact tonnage of organic waste diverted from landfills or the cubic meters of biogas recovered for energy, limiting this investigation to a qualitative diagnostic of "presence versus absence." These barriers collectively illustrate that the "Information Gap" is not merely a lack of documents, but a lack of usable, granular, and standardized data, suggesting that without a national mandate for environmental reporting, the transition to a sustainable campus model will remain trapped in a cycle of pilot-scale initiatives and fragmented transparency, failing to achieve the systemic territorial integration required for national sustainable development goals.

5.6. Future Research Directions

To bridge the identified "Information Gap" and transition from a qualitative diagnostic to a transformative policy tool, future research must adopt an integrated, multi-dimensional, and highly quantitative framework that addresses the structural deficiencies of the current reporting landscape. A primary avenue for development lies in the conceptualization and establishment of a National Sustainability Observatory for Higher Education to

function as a centralized repository for harmonized environmental data.

Furthermore, subsequent investigations should explore the critical socio-economic correlations between institutional budget allocation and the long-term viability of high-tech interventions, such as anaerobic digestion. By examining the funding-innovation nexus, researchers can better understand the underlying drivers of technology adoption in private versus public spheres and identify the specific financial catalysts required to de-risk sustainability investments in the public sector. Additionally, there is a pressing need to move beyond simple inventory-based reporting toward the application of rigorous scientific methodologies such as Life Cycle Assessment (LCA). Implementing LCA frameworks to evaluate the environmental burdens and benefits of existing waste management systems would provide the empirical weight necessary to validate these models as scalable national benchmarks (Jaglan et al., 2022).

By quantifying parameters such as carbon footprint reduction, nutrient recovery rates, and energy return on investment, future studies can transform isolated pilot projects into evidence-based blueprints for a national circular economy strategy. Such an expanded research agenda would not only close the existing information void but also elevate the role of Ecuadorian universities as catalysts for territorial sustainable development, ensuring that institutional actions are scientifically grounded, economically viable, and transparently communicated to the public.

6. CONCLUSION

This investigation concludes that while the discourse of the circular economy is becoming increasingly embedded in the institutional missions of Ecuadorian Higher Education Institutions, a profound information gap remains the primary barrier to achieving a systemic national transition toward sustainability. The study reveals a significant reporting paradox where the Amazonía region, despite its limited institutional presence, demonstrates a 100% transparency rate that stands in stark contrast to the "reporting shadows" found in major urban hubs like Pichincha and Guayas. In these metropolitan centers, the logistical complexity of managing waste at scale, coupled with bureaucratic rigidities in public institutions and the lack of standardized disclosure mandates, results in a critical scarcity of quantitative data that obscures the true environmental footprint of the academic sector. While composting has successfully emerged as a predominant, low-cost valorization strategy due to its operational simplicity, high-tech interventions like anaerobic biodigestion remain restricted to a selective group of "leader" institutions, such as USFQ and UTEQ, functioning more as specialized research prototypes than as integrated institutional practices. To overcome this fragmentation, Ecuador must move beyond sustainability islands by adopting rigorous tools such as Life Cycle Assessment (LCA). Furthermore, the proposed model of Territorial Processing Hubs offers a strategic pathway for regional synergy, where larger universities leverage their technical infrastructure to act as processing anchors for smaller, neighboring institutions. This shift from passive waste generation to proactive territorial governance is not a luxury but a fundamental necessity for national environmental accountability. Ultimately, closing the information gap is the first step toward aligning the Ecuadorian academic landscape with the global 2030 Agenda, ensuring that the closing the loop vision transcends the laboratory to become a measurable, replicable, and transparent reality across all provinces. By formalizing this accountability, Ecuadorian universities can finally fulfill their role as true catalysts for a resilient, decentralized, and scientifically grounded circular economy.

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