An Agentic ESG Decision-Support System for Urban Waste Management and Circular Economy in Small Businesses

Adharsh P

Edunet Foundation

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Abstract

Small and medium-sized businesses (SMBs) face increasing pressure to adopt Environmental, Social, and Governance (ESG) practices, particularly in urban waste management and circular economy adoption. However, limited expertise and financial constraints often prevent effective ESG implementation. This project proposes an agentic ESG decision-support system that assists small businesses in assessing ESG readiness and prioritizing low-cost, high-impact actions. The system leverages GenAI-based reasoning to provide explainable and practical recommendations through a lightweight Streamlit application.

1   Introduction and Background

Environmental, Social, and Governance (ESG) considerations have become increasingly important for businesses due to rising regulatory expectations, supply chain pressures, and financial risk awareness. While large organizations often have dedicated teams and tools to manage ESG compliance, small and medium-sized businesses (SMBs) face significant challenges in understanding and adopting ESG practices in a structured manner.

In urban environments, waste management is one of the most visible and critical sustainability challenges for SMBs. Informal waste handling, lack of segregation, unauthorized disposal, and limited awareness of circular economy principles expose businesses to regulatory penalties, operational inefficiencies, and reputational risks. Despite these challenges, many SMBs perceive ESG as complex, costly, and relevant only to large corporations.

In reality, ESG adoption for small businesses is less about comprehensive reporting and more about early-stage readiness and prioritization of actions. There is a clear need for practical decision-support systems that help SMBs identify key ESG risk areas and implement low-cost, high-impact sustainability practices. This project addresses this gap by proposing an agentic ESG decision-support system focused on urban waste management and circular economy adoption.

2   Problem Statement

Small and medium-sized businesses often operate with limited awareness and informal practices related to ESG compliance. In the context of urban waste management, this results in several challenges:

- Lack of structured waste segregation and disposal practices

- Limited understanding of regulatory and compliance risks

- High dependence on informal or unauthorized waste handling channels

- Absence of guidance on prioritizing sustainability actions based on cost and impact

Existing ESG solutions are largely designed for large enterprises and focus on reporting, certification, or complex analytics, making them inaccessible and impractical for small businesses. As a result, SMBs struggle to determine where to begin and which ESG actions are most critical for their operations.

There is a clear need for a lightweight, cost-effective, and explainable decision-support system that helps small businesses assess ESG readiness and prioritize actionable improvements, particularly in waste management and circular economy practices.

3 Objectives of the Project

The primary objectives of this project are as follows:

- To assess the ESG readiness of small and medium-sized businesses with a focus on urban waste management

- To identify key environmental and governance-related risk areas affecting sustainability

- To prioritize low-cost, high-impact ESG actions suitable for small businesses

- To provide explainable recommendations using GenAI-based reasoning

- To develop a deployable and user-friendly Streamlit-based ESG advisory system

4 Proposed Solution and Methodology

4.1 System Overview

The proposed solution is an Agentic ESG Decision-Support System designed to assist small businesses in understanding and improving their ESG readiness. The system focuses on urban waste management and circular economy adoption as primary sustainability dimensions.

The system is described as *agentic* because it does not merely present static information. Instead, it interprets business-specific inputs, reasons over ESG risk factors, prioritizes actionable recommendations, and explains the rationale behind each suggested action. This approach enables informed decision-making rather than generic sustainability guidance.

4.2 Inputs to the System

The system collects simple, non-intrusive inputs from users to understand the business context. These inputs are designed to avoid the need for detailed documentation or technical measurements. Key inputs include:

- Type of business operation (e.g., manufacturing, retail, service)

- Size of the business (micro, small, or medium)

- Categories of waste generated (organic, plastic, e-waste, mixed)

- Energy usage type (electricity, diesel, or mixed)

- Current waste handling and disposal practices

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4.3 Agent Reasoning Logic

The ESG advisory agent follows a structured reasoning process to generate recommendations. The reasoning flow consists of the following steps:

1. Identification of applicable ESG dimensions based on business context

2. Assessment of potential environmental and governance risks related to waste management

3. Evaluation of possible ESG actions based on cost, feasibility, and sustainability impact

4. Prioritization of actions to focus on low-cost and high-impact improvements

5. Generation of explainable advisory outputs describing both recommendations and their rationale

4.4 Backend Workflow and Execution Flow

The backend workflow of the proposed system is designed to ensure structured reasoning, transparency, and ease of deployment. The workflow consists of the following stages:

1. **User Input Collection:** The user interacts with a Streamlit-based interface to provide basic business information such as business type, size, waste categories, energy usage, and current waste management practices.

2. **Input Validation and Preprocessing:** The backend validates the inputs to ensure completeness and consistency. User responses are normalized into predefined categories to support structured ESG reasoning.

3. **ESG Context Construction:** Based on the validated inputs, the system constructs an internal ESG context that summarizes environmental exposure, governance maturity, and waste-related risk indicators relevant to the business.

4. **Agentic ESG Reasoning:** The constructed ESG context is passed to a GenAI-based reasoning agent. The agent evaluates ESG risk areas, assesses cost and feasibility of possible actions, and prioritizes sustainability recommendations using a decision-oriented approach.

5. **Response Structuring and Output Generation:** The agent's output is structured into clear advisory sections, including ESG readiness level, prioritized action plans, and cost–impact explanations. These outputs are rendered to the user through the Streamlit interface in an explainable format.

4.5 System Outputs

The system provides clear and structured outputs to users, including:

- ESG readiness classification (Low, Moderate, or High)

- A prioritized action plan for improving waste management practices

- Explanation of cost versus sustainability impact for each recommendation

- Awareness-oriented insights related to circular economy practices
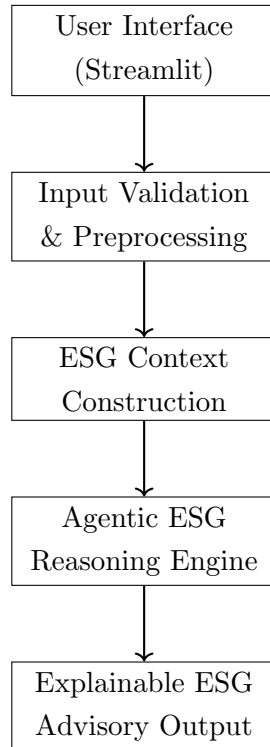
5   System Architecture

Figure 1: Backend Workflow of the Agentic ESG Decision-Support System

The proposed system follows a lightweight and modular architecture to ensure ease of deployment and cost-effectiveness. The architecture is designed to support explainable decision-making without requiring heavy computational resources.

The key components of the system include:

- **User Interface:** A Streamlit-based web interface that allows users to input basic business information and view ESG advisory outputs.

- **Backend Logic:** A Python-based processing layer that handles input validation and orchestration of the ESG reasoning flow.

- **Agent Layer:** A GenAI-powered reasoning module that evaluates ESG risks, prioritizes actions, and generates explainable recommendations using prompt-driven logic.

- **Output Layer:** A structured advisory report presented in text format, highlighting ESG readiness, prioritized actions, and cost–impact considerations.

(Optional: Include a simple architecture diagram.)

6 Expected Outcomes and Impact

6.1 Technical Outcomes

The expected technical outcomes of the project include:

- A functional and deployable Streamlit-based ESG advisory application

- An agentic reasoning workflow capable of prioritizing ESG actions

- Explainable AI outputs that support user understanding and trust

- A lightweight system requiring minimal computational resources

6.2 Practical Impact

From a practical perspective, the system is expected to:

- Improve ESG awareness among small and medium-sized businesses

- Support better waste management and circular economy practices

- Reduce regulatory, operational, and reputational risks

- Enable cost-effective sustainability decision-making

7 Innovation and Uniqueness

The key innovation of this project lies in its focus on agentic decision support rather than prediction or reporting. Unlike traditional ESG tools that emphasize compliance documentation or certification, the proposed system prioritizes actionable guidance tailored to the operational realities of small businesses.

The system uniquely combines:

- Agentic reasoning for ESG action prioritization

- Cost-aware sustainability recommendations

- A focused emphasis on urban waste management and circular economy

- A lightweight and accessible deployment model

8   Conclusion and Future Scope

This project presents an agentic ESG decision-support system designed to assist small businesses in improving their sustainability readiness, with a specific focus on urban waste management and circular economy practices. By combining GenAI-based reasoning with a simple and deployable architecture, the system addresses a critical gap in ESG adoption for resource-constrained organizations.

Future enhancements may include extending the advisory scope to additional ESG dimensions, incorporating supplier-level sustainability insights, and integrating region-specific regulatory awareness. These extensions can further strengthen the system's applicability while maintaining its core focus on practicality and cost-effectiveness.