

SmartBin AI

An AI-Powered Smart Waste Segregation Assistant

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Program: B.Tech Computer Science (4th Year)

Internship: 1M1B – IBM SkillsBuild AI for Sustainability Virtual Internship

SDG Alignment

Primary SDG: SDG 12 – Responsible Consumption and Production

SmartBin AI primarily aligns with SDG 12 by promoting responsible waste segregation and sustainable consumption practices at the household level. By guiding users to correctly classify and dispose of waste, the system helps reduce material wastage, improves recycling efficiency, and encourages the responsible use of resources. Proper segregation at the source ensures that recyclable and compostable materials are recovered effectively, minimizing the environmental footprint of consumption and reducing dependency on landfills.

Secondary SDG: SDG 11 – Sustainable Cities and Communities

SmartBin AI supports the development of cleaner, safer, and more sustainable cities by reducing unmanaged waste, improving urban sanitation, and supporting efficient municipal waste management systems. Improved segregation enhances waste processing efficiency and reduces public health risks in densely populated areas.

Secondary SDG: SDG 13 – Climate Action

By reducing landfill waste and promoting recycling and composting, SmartBin AI helps lower greenhouse gas emissions, particularly methane from organic waste, thereby contributing to climate change mitigation efforts.

Problem Statement

Improper household waste segregation is a major challenge faced by urban and semi-urban communities, particularly in developing countries. Despite the availability of waste management systems, a significant portion of recyclable and compostable waste ends up in landfills due to incorrect segregation at the source. Many households lack clear, real-time guidance on how to categorize waste items such as plastics, food leftovers, electronic waste, and hazardous materials. This confusion leads to contamination of recyclable materials, reduced efficiency of recycling processes, increased landfill burden, and serious environmental pollution affecting soil, water, and public health.

Traditional awareness methods such as posters, manuals, and campaigns are often static, limited in reach, and unable to address user-specific queries. As a result, individuals are willing to act sustainably but fail to do so due to lack of clarity at the moment of disposal.

This project explores how Artificial Intelligence can be used to provide intelligent, interactive, and context-aware guidance to users for correct household waste segregation. By offering instant, explainable, and accessible recommendations, an AI-based system can empower individuals to make environmentally responsible decisions, improve recycling efficiency, and significantly reduce the amount of waste sent to landfills.

AI Solution Overview

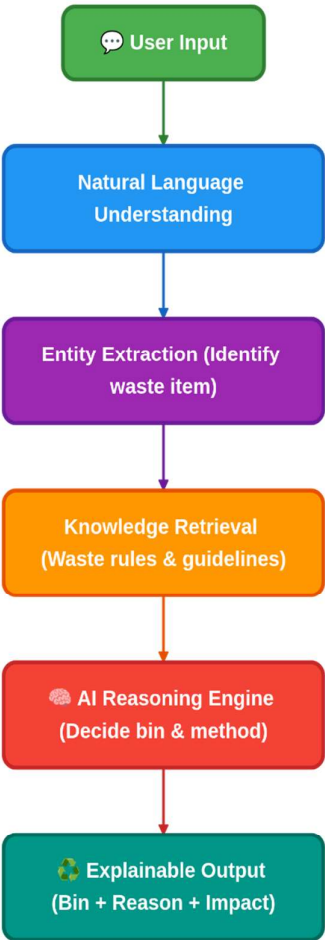
SmartBin AI is a conversational Artificial Intelligence–based assistant designed to provide real-time, intelligent guidance for household waste segregation. The system allows users to interact using natural language and ask questions about how to dispose of various waste items commonly generated in daily life. SmartBin AI analyzes user inputs, identifies the type of waste item mentioned, and classifies it into appropriate categories such as wet waste, dry waste, recyclable waste, or hazardous waste.

Using verified waste management guidelines and sustainability principles, the assistant recommends correct disposal methods and explains the reasoning behind each recommendation to ensure transparency and user trust. In addition to disposal guidance, SmartBin AI includes an environmental awareness layer that educates users about the environmental impact of proper waste segregation, such as reduced landfill usage, improved recycling efficiency, and prevention of soil and water pollution.

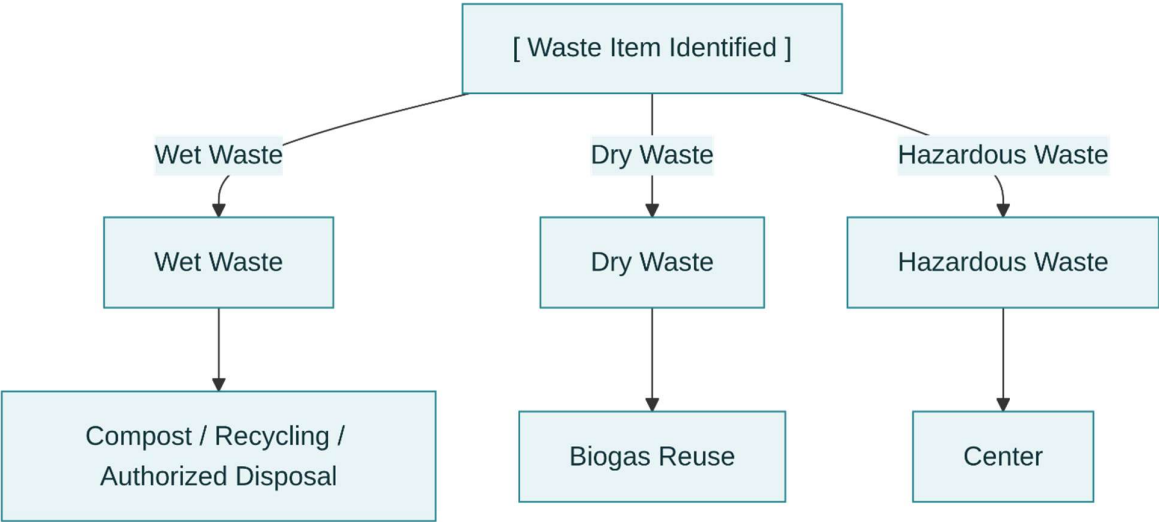
By providing instant, accessible, and explainable recommendations, SmartBin AI bridges the gap between environmental intent and correct action, enabling individuals and communities to adopt more responsible and sustainable waste management practices.

AI Flowchart Diagrams

Data Flow of the Model-



How the Waste items are identified-



Prompt Engineering Workflows

Workflow 1: Waste Identification

System Prompt:

You are an AI-based sustainability assistant designed to support responsible waste management. Your task is to identify the waste item mentioned by the user and accurately classify it as wet waste, dry waste, recyclable waste, or hazardous waste. Provide clear, safe, and environmentally responsible disposal guidance. Ensure transparency in your explanation and avoid misleading information.

User Prompt:

Where should I throw a used face mask?

AI Response:

Used face masks are classified as **hazardous waste** because they may contain biological contaminants and pose health risks if handled improperly. They should not be disposed of with regular household wet or dry waste. The recommended disposal method is to place the used face mask in a sealed bag and hand it over to authorized waste collectors or follow local biomedical waste disposal guidelines. By correctly identifying and segregating such waste, individuals contribute to safer communities and more effective waste management systems.

Workflow 2: Environmental Awareness

System Prompt:

You are an AI-powered environmental awareness assistant. After identifying the waste item and recommending the correct disposal method, explain the environmental and health impact of proper waste disposal in simple and understandable language. Emphasize why responsible disposal is important for sustainability and public safety.

User Prompt:

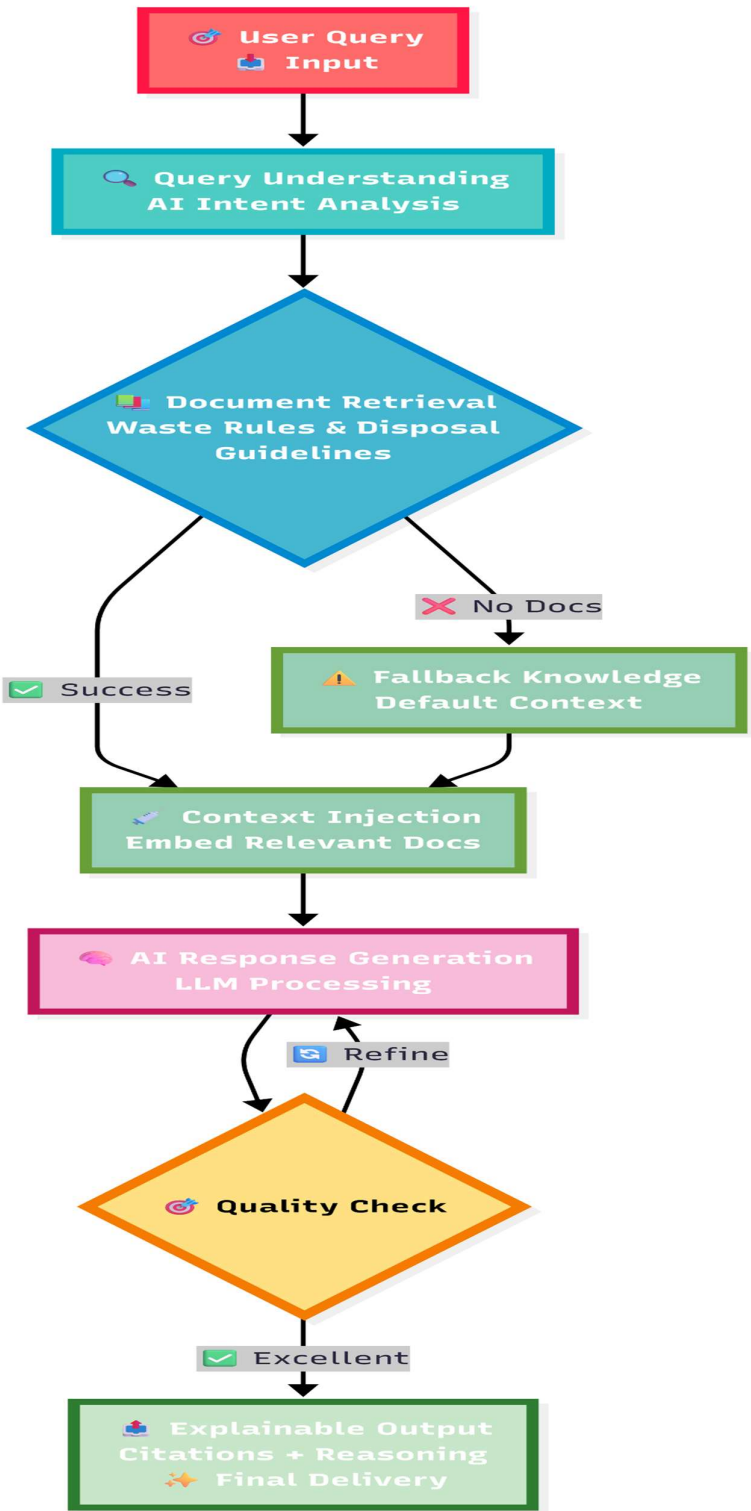
What should I do with used batteries?

AI Response:

Used batteries are classified as **hazardous waste** because they contain toxic substances such as mercury, lead, lithium, and cadmium. If disposed of in regular household waste, these harmful chemicals can leak into the soil and groundwater, causing long-term environmental damage and posing serious risks to human and animal health. Used batteries should be collected separately and disposed of at **authorized battery collection points or e-waste disposal centers**. Proper disposal allows valuable materials to be safely recovered through recycling while preventing pollution. This awareness-driven approach encourages responsible behavior and contributes to cleaner, safer communities.

RAG Demo: SmartBin AI Waste Disposal Assistant

Retrieval-Augmented Generation (RAG) is used in SmartBin AI to provide accurate, up-to-date, and explainable waste disposal guidance by combining information retrieval with AI-generated responses. Instead of relying only on pre-trained knowledge, the system retrieves relevant waste management rules and sustainability guidelines before generating an answer.



Sample Inputs & Outputs

Input: Is a pizza box recyclable?

Output: A pizza box can be recycled if it is clean and free from food residue or oil stains. In such cases, it should be placed in the **dry waste or recyclable waste bin**. However, if the pizza box is greasy or contaminated with leftover food, it should not be recycled, as grease weakens the quality of recyclable paper materials. Greasy pizza boxes should be disposed of as **wet waste**. Correct segregation helps improve recycling efficiency and prevents contamination of recyclable waste streams.

Input: Where should I throw expired medicines?

Output: Expired medicines are classified as **hazardous waste** and should never be thrown into household wet or dry waste bins. These medicines contain chemical substances that can contaminate soil and water if disposed of improperly. The recommended method is to return expired medicines to pharmacies, medical stores, or authorized medical waste disposal centers. Proper disposal ensures environmental safety and helps prevent misuse or accidental consumption, thereby protecting both public health and the ecosystem.

Input: Where should I dispose of used batteries?

Output: Used batteries are considered hazardous waste because they contain toxic metals such as mercury, lead, and cadmium. These substances can cause serious soil and groundwater pollution if batteries are disposed of with regular household waste. Used batteries should be collected separately and deposited at authorized battery collection points or e-waste disposal centers. Proper disposal helps prevent environmental contamination and supports safe recycling of valuable materials.

Input: What should I do with leftover food waste?

Output: Leftover food waste is classified as **wet waste** and should be disposed of in the wet waste or compost bin. This type of waste can be composted or processed in biogas plants to generate organic manure or renewable energy. Proper disposal of food waste reduces landfill load, minimizes methane emissions, and contributes to sustainable waste management practices.

Expected Impact

The implementation of SmartBin AI is expected to create significant positive environmental, social, and economic impacts. By providing real-time and accurate guidance on household waste segregation, the system can substantially reduce the amount of improperly sorted waste sent to landfills. Improved segregation at the source enhances recycling efficiency, allowing recyclable materials to be processed effectively without contamination. This leads to better utilization of resources and reduced dependency on raw materials.

From a social perspective, SmartBin AI increases public awareness about responsible waste disposal and encourages environmentally conscious behavior among individuals and communities. The assistant empowers users to make informed decisions, bridging the gap between sustainability awareness and practical action. Additionally, proper waste segregation improves working conditions and safety for waste management personnel by reducing exposure to hazardous materials.

At an urban level, widespread adoption of SmartBin AI supports the development of cleaner, smarter, and more sustainable cities. Reduced landfill pressure, lower pollution levels, and improved waste management practices contribute to better public health, environmental protection, and long-term sustainability goals.