Terms of Reference

1. Project Name
   The name and slogan of the project is “EcoSortAI: Sorting a Sustainable Future, One Image at a Time!”. A name and slogan were chosen to describe the content of the project.

2. Overview
   In today's world, waste segregation has become increasingly challenging due to the growing amount of waste being generated. However, advancements in artificial intelligence (AI) present an opportunity to address this issue and provide convenience in the waste sorting process.
   By implementing an AI application that utilizes visualized waste data sets, incorporating fields such as machine learning, deep learning, and statistics, we can improve the efficiency and accuracy of waste segregation. One popular approach is the use of Convolutional Neural Networks (CNNs), which have proven to be effective in image recognition tasks. Through the utilization of CNNs, the AI application can identify and categorize different types of waste into biodegradable and non-biodegradable categories. This categorization is crucial for optimizing recycling processes and reducing landfill usage. Additionally, by accurately identifying non-biodegradable waste such as plastics, steps can be taken to minimize their impact on the environment and reduce methane emissions.

3. Background
   In recent years, the application of artificial intelligence (AI) in waste management has garnered significant attention due to its potential to revolutionize traditional waste separation processes. One of the critical challenges in waste management is the accurate identification and classification of different types of waste, particularly in natural environments where a myriad of materials coexist. This has prompted researchers and environmentalists to explore innovative solutions, and the integration of AI, specifically image processing, has emerged as a promising avenue.
   Recent advancements in AI, particularly in computer vision and image processing, have opened up new possibilities for automating waste separation. Machine learning algorithms can be trained to recognize and categorize different types of waste based on visual characteristics. This has the potential to enhance the accuracy and speed of waste separation processes, leading to more effective recycling and disposal strategies. While significant progress has been made in the application of AI for waste separation, there are still research gaps that need to be addressed. Future studies should focus on refining algorithms, expanding datasets for training models, and exploring real-world implementations to ensure the scalability and reliability of AI-driven waste separation systems. In conclusion, the intersection of artificial intelligence and waste management holds immense promise for creating sustainable and efficient solutions. By harnessing the power of image processing, we can develop intelligent systems capable of identifying soluble and insoluble wastes in natural environments, contributing to a cleaner and healthier planet.

4. Key Objectives / Business Objectives
   a. Research Questions
      i. How can artificial intelligence and image processing be used to successfully identify soluble and insoluble wastes in natural environments?

ii. What are the main obstacles to deploying AI-based waste segregation systems, and how may these obstacles be overcome?
iii. How does trash identification accuracy affect downstream recycling operations, and what are the possible environmental and economic benefits of enhanced waste separation?
iv. What are the best parameters to use when training machine learning algorithms to enable robust and adaptive garbage detection in a variety of environmental conditions?

b. Key Steps

We can divide the key steps into 8 parts for this Project:

1) Literature Review: Conduct a thorough examination of existing waste segregation systems, with an emphasis on the difficulties encountered in natural contexts. Identify significant advances and shortcomings in the use of image processing and artificial intelligence in trash management.
2) Dataset Collection and Preparation: Collect a diverse dataset of images representing different types of waste in natural settings.
3) Algorithm Development: Develop or select appropriate image processing algorithms for waste segregation, considering factors such as accuracy, speed, and adaptability to varying environmental conditions. Implement machine learning models to train the system for recognizing and classifying different waste materials.
4) Performance Evaluation: Assess the performance of the developed algorithms through rigorous testing using the annotated dataset. Measure accuracy, precision, recall, and other relevant metrics to evaluate the effectiveness of the image processing techniques.
5) Integration with Existing Systems: Explore ways to integrate the developed image processing system with existing waste management infrastructure.
6) User Interface Design (if applicable): If the system involves user interaction, design an intuitive and user-friendly interface for operators overseeing the waste segregation process.
7) Optimization and Fine-Tuning: Optimize the algorithms and parameters based on feedback from the testing phase. Fine-tune the system to adapt to different environmental conditions and improve overall performance.
8) Documentation and Knowledge Transfer: Facilitate knowledge transfer to stakeholders, ensuring that the solution can be maintained and improved upon in the future.

5. Methods and Workflow

a. Datasets

For this project, two primary datasets will be utilized to train and evaluate the waste segregation model:

Dataset A: https://www.kaggle.com/datasets/aashidutt3/waste-segregation-image-dataset/data

This dataset contains a diverse collection of images representing waste materials in various natural environments.

Dataset B: https://www.kaggle.com/datasets/techsash/waste-classification-data

Dataset B complements Dataset A, providing additional instances of waste materials for a more comprehensive training process.

b. Data cleaning/Preprocessing

   The data cleaning and preprocessing phase is crucial for preparing the datasets for model training. Steps include:

   i. Image Quality Assessment: Identify and remove low-quality images to ensure a high standard for model training. Address any issues related to image resolution, brightness, or distortion.

   ii. Data Augmentation: Apply data augmentation techniques to artificially increase the size of the dataset. Rotate, flip, or introduce minor variations to images to enhance model generalization.

c. Modelling

   The core of the project involves creating a 3-layer Convolutional Neural Network (CNN) model for waste segregation:

   i. Model Architecture:
      - Design a 3-layer CNN architecture suitable for image classification, considering the complexity of waste materials.

   ii. Training:
      - Split the annotated dataset into training and validation sets.
      - Train the CNN model on the training set, monitoring metrics such as accuracy and loss during the training process.

   iii. Evaluation:
      - Assess the model's performance on the validation set, adjusting parameters if necessary to improve accuracy.
      - Evaluate the model on the test set to ensure its effectiveness in real-world scenarios.

d. Deliverables

   After the waste segregation project is completed successfully, a comprehensive set of deliverables will be delivered to assure transparency, repeatability, and simplicity of implementation. A rigorously trained 3-layer Convolutional Neural Network (CNN) model capable of reliably distinguishing soluble and insoluble waste materials in natural situations would be the major output. This model will be supported by extensive documentation, including complete explanations of the datasets, exhaustive data cleaning and preparation techniques, and insights into the CNN model's design and architecture.

   A full model assessment report will also be provided, including performance data for validation and test sets and providing actionable recommendations for model improvement. A prototype of the user interface for operators managing waste segregation operations will be supplied if relevant. The deliverables will finish with recommendations for future work, including a roadmap for prospective additions and real-world implementation and scaling concerns.