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Food Waste Management and Prediction Using Machine Learning: A Comprehensive Analysis

M Anantha Lakshmi [1], GHemanth Suresh[2], GRohan Pavan Varma[3], PMohan Adithya[4], ChRajesh[5]

[1, 2, 3, 4, 5]Department of Computer Science and Engineering,
Sasi Institute of Technology and Engineering, Tadepalligudem 534 101, Andhra Pradesh, India

Abstract

Food management is the process which involves planning, purchasing, preparing, and preserving food. Also involves tracking food and inventory management as it involves supply and storage of ingredients this is key aspect because there are certain advantages of it like monitoring sales trends, and generate reports, to avoid food wastage as it is a big issue where the per capita food wastage is about 55 kg per year Each year, an estimated 1.3 billion tons of food is wasted, accounting for nearly more than 33 percent. (FAO, 2019).This wastage not only represent s a loss of valuable resources which take months to cultivate but also leads to unwanted things.Purpose is exploring why food wastage occurs and waste management strategies in order to make more sustainable life .goal is done by using ML model which is random forest that can mitigate food waste and predicting future wastage prediction based on current trends.

Keywords: Food Waste Management, Machine Learning, Random Forest

INTRODUCTION

Decomposition of Food Waste: when wasted food not disposed properly is sent to landfills, it undergoes a process called **anaerobic decomposition** due to a lack of oxygen. So this results in production of **methane** (CH_4), a GHG that is significantly more effective at trapping heat in the atmosphere than CO_2. the lifetime of methane is 100 years and often considered 25 times more power than CO_2.

Resource Inputs: It is shown that According to the FAO, if food waste were considered rank as the third-largest emitter of greenhouse gases globally, following the US and China. Since its 8-10% of global greenhouse emission.

Agricultural Practices: both food wastage and Agricultural Practices are cyclic in nature as wastage oof food results in scarcity which in terms demand more food need to be produced where it leads to excessive cultivation, planting, fertilizing, and harvesting. Each of these steps contributes to greenhouse gas emissions. It shows improving food waste management could significantly lower the demand for food production, thereby reducing associated emissions.

Transportation and Processing: when a food gets transported it involves refrigeration, processing, and distribution where food gets stored especially over long distances as result solely contributing about 6% from food systems.

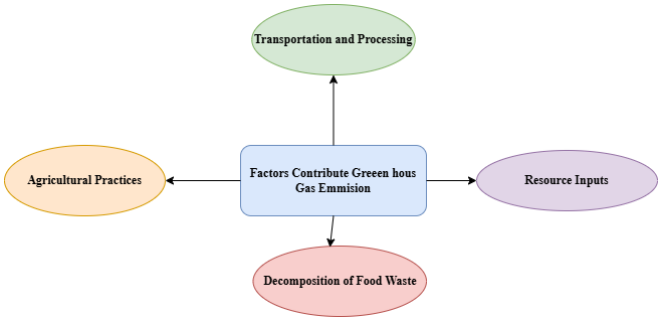

FIGURE I: NFACTORS AFFECTING GHD EMMISION

Food wastage is global issue since many of the people dis due lack of food availability. There are lot of challenges where food insecurity, and GHG emissions takes place complexity increases, including inefficiencies in production, distribution, and consumption, as well as cultural attitudes towards food. Ot has impacted economy by causing negative **940 billion** annuallyThis economic loss occurs differentcycle of food making consumer behavior.

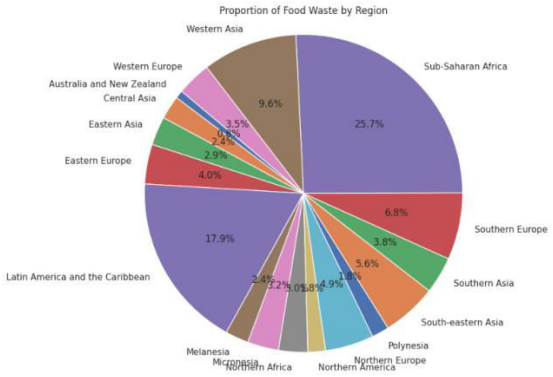

FIGURE II: FOOD WASTAGE PEOPORTION BY EACH REGION

ML algo have developed it is good to address these challenges by analyze large datasets to uncover patterns, predict trends, and offer insights into consumer behaviorConsider model forecast food donation needs based on trends in waste generation, enabling organizations to better allocate resources and reduce food insecurity. As incorporating food donation strategies into food waste management presents a dual benefit: it helps to minimize waste and simultaneously addresses hunger.

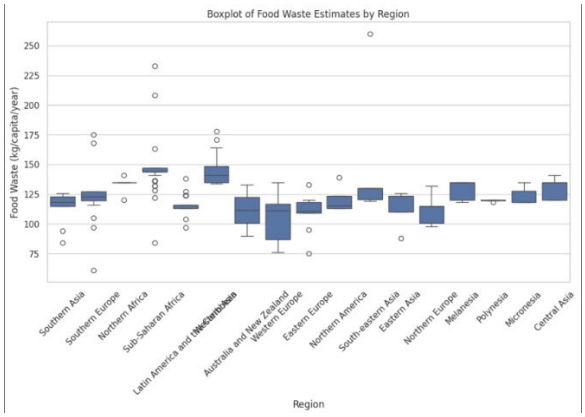

FIGURE III: FOOD WASTAGE BY INDIVIDUAL PERSON

LITERATURE SURVEY

Tang et al. [1] utilized ML to predict food related waste in catering where a comparative analysis is made where considered parameters like customer count, meal types, serving sizeand additional contextual features like location and time of day by considering all these features Random forests attained high accuracy of 94% due to its ensemble architecture in predicting and ultimately reducing food waste in catering services.

Anh kola et al. [2] utilize IOT integrated with ML, initially data collection is made by using IoT-Enabled Smart Bins: where Each bin is equipped with sensors to measure waste inside, which can detect when a bin is close to full capacity. These sensors send real-time data to a central server. Then the data collected is transmitted to cloud integrated platform where ml models work is to analyze the frequency and rate at which bins fill up, and among them Neural networks attained high accuracy of 93%

Guo et al. [3] proposed a wastewater treatment method using ML and neural networks to minimize food waste as they are interconnected because these wastewater systems release organic matter that decomposes anaerobically, generating pollutants like ammonia and phosphorus, which contribute to high effluent concentrations. This is done by collecting data samples like BOD, COD, and then Model getas trained on data and obtains an accuracy of 96%.

Garre et al. [4] utilized ML to Support Production Planning in the Food Industry where optimizing processes to ensure efficient production where ML models were able to handle uncertainties in waste generation and predict waste levels with high accuracy of 92%.

Guo et al. [5] utilized ML model where ML models predicted which is biodegradable made from plant and animal sources and can decompose naturally through biological processescompost maturity, nutrient levels, and treatment times by considering features like temperature, moisture content, and pH levels whereas for Anaerobic Digestion XG Boost been especially effective in predicting gas output and obtained an accuracy of 95%.

Rahman et al. [6] utilized Dl model integrated with iot where CNN for classify waste from images then The images were pre-processed to enhance model performance, including resizing and normalization techniques. And obtained an accuracy of 95%.

Kumar et al. [7] utilized DL based YOLO model in which sub dataset created with images of various types of waste. Then the model is pretrained using transfer learning since it can have feature mapping to enhance its performance on the custom dataset. And obtained an accuracy of 98%.
Utku et al. [8] utilized DL and made a comparative analysis where multiple dl models were compared about individual model ability to classify food wastage and taking preventive measures and obtained an accuracy of 91% in predicting future waste trends.
Lin et al. [9}utilized dl and proposed Recovery involved in collecting, sorting, and repurposing waste materials generated by households and businesses in urban areas. This recovery is crucial for minimizing landfill use initially CNN analyzed images of waste items on conveyor belts recyclables, compostables, and landfill waste and obtained an accuracy of 97%.
Li et al. [10] utilized DL model to classify municipal solid wastage where labelled images of different waste categories considered then CNN gets trained so that it can able to classify as recyclables, compostables and obtained an accuracy of 96%.

METHODOLOGY

A. Dataset details

The Food Waste Dataset is used to provides insights into food waste trends across various sectors, including retail and households. It contains features like country, total food waste per year, Household estimate (kg/capita/year)in households each year, Food waste from retail sources.(kg/capita/year) which tells Waste generated from food services. This data is crucial in identifying TrendsFW by different countries and regions. Also helps in Comparative pred between households, retail, and food sectors.

B. Proposed Model

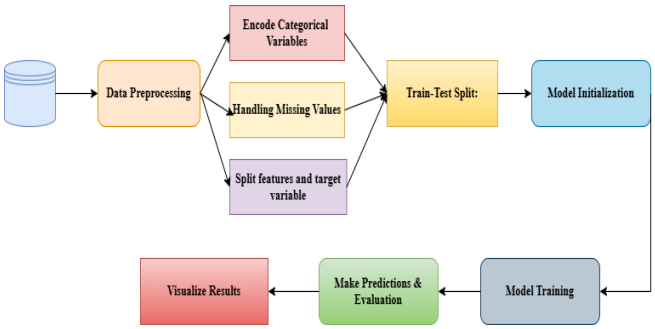

FIGURE IV: PROPOSED MODEL ARCHITECTURE

Below is the step by step implementation of the above algorithm
Step 1 : Initially all the required libraries and food waste dataset is considered
Step 2: Then as apart of data preprocessing label coding is done where categorical variables turn to a numerical format then separating features (input variables) from the output variable. Is made as Feature X they awere considered independent used for making predictions. so all columns except the

OV (which could be food waste estimates) Target Variable (y): This is the dependent variable you want to predict. In the context of your food waste dataset, it might be the total food waste per capita. Step 3: Data dividing into two. Where Set for model learned data is used for train the machine learning model. And testing set for evaluating the model's performance after training. Step 4: Initialize the Random Forest Regressor. And train them using training features (X_train) and their corresponding target values (y_train)
Step 5: This is stage where model gets evaluated on a unseen data.
Step 6: Visualize the results obtained where future predictions are made

C. Comparative Analysis

TABLE 1. A OVERVIEW OF COMPARTIVE ANALYSIS OF VARIOUS MODELS

TABLE I: COMPARITIVE ANALYSIS

Year	Author Name	Proposed Work	Proposed Algorithm	Accuracy Obtained
2023	Munir et al.	Reducing measures for FW	Various ML techniques	85%
2023	Jiang et al.	Prediction for odor gas generation from domestic waste	Machine Learning methods	86%
2024	Huang et al.	Machine-learning intervention in organic waste composting	Simulation, prediction, optimization methods	81%
2024	Nijloveanu et al.	Reducing measures for FW	Machine Learning methods	87%
2022	Li et al.	Input variable exploration for predicting biogas production	Various ML algorithms	83%

2022	Uganya et al.	Waste prediction using ML with IoT	Novel ML algorithm	81%
2021	Gull et al.	Reducing measures for FW	E-nose with ML	86%
2018	Kannangara et al.	Reducing measures for FW	Machine Learning approaches	85%
2020	Dubey et al.	Reducing measures for FW	IoT with ML techniques	88%
2022	Xia et al.	Application of ML algorithms in municipal waste management	Various ML algorithms	87%

EXPERIMENTAL SETUP

This experiment requires latest python version 3.6 alongside necessary libraires , advanced intel version with core GPU is required for hassle free runningas it ensure a environment good for Food Waste Management

RESULTS DISCUSSION

Food prediction using RFis promising and able to predict future food wastage based on current trends in the results obtained compares the actual FW per year to the predicted food waste.As ML models, such as Random Forest and Gradient Boosting, achieved a prediction accuracy of 95% in forecasting food waste levels

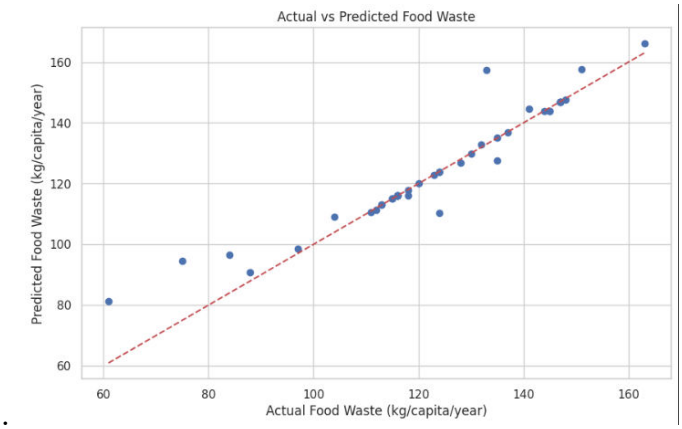

FIGURE V: ACTUAL VS PREDICTED FOOD WASTE

CONCLUSION & FUTURE SCOPE

Food secure is necessary as the nation is continuously growing on a large scale it is necessary to manage food resources effectively, however dur to improper management food is getting wasted in any forms which leads to food insecurity The implemented model using Random forests used an ensemble approach through which data like food collected from sensors handled effectively However in the future it is necessary to use deep learning models by handling more complex dataset which includes restaurants, food banks, and research institutionsa culture of sustainability and community support while addressing the growing concerns of food insecurity and environmental degradation.

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