Survey-Based Analysis of Household Waste Segregation Behavior and Citizen Participation in Sustainable Waste Management in Tamil Nadu

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***Abstract*—This study presents a comprehensive survey-based analysis of household waste segregation behavior and citizen participation in sustainable waste management practices across Tamil Nadu, India. Leveraging an extensive dataset encompassing waste management parameters from multiple cities, this research examines the interrelationships between demographic characteristics, municipal infrastructure, citizen engagement indicators, and waste management performance outcomes. The analysis reveals significant correlations between citizen participation metrics—including awareness campaigns and smart bin deployment—and key sustainability indicators such as waste segregation rates, recycling efficiency, and landfill dependency reduction. Our findings indicate that cities with higher citizen participation indices demonstrate substantially improved waste management performance, with segregation rates showing a strong positive correlation (r=0.74) with municipal efficiency scores. The study further identifies treatment method diversity and collection efficiency as critical mediators in the relationship between citizen behavior and sustainable waste management outcomes. Through predictive modeling using machine learning algorithms, we demonstrate that citizen participation factors alone can predict performance levels with 82% accuracy, underscoring the pivotal role of behavioral interventions in achieving sustainability goals. These findings provide actionable insights for policymakers and urban planners to design targeted citizen engagement strategies that enhance waste segregation behavior and foster sustainable waste management ecosystems in rapidly urbanizing regions.**

***Index Terms*—Waste Segregation Behavior, Citizen Participation, Sustainable Waste Management, Municipal Solid Waste, Recycling Behavior, Urban Sustainability, Waste Management Performance, Tamil Nadu, Household Waste, Behavioral Intervention, Circular Economy, Smart Waste Management**

I. INTRODUCTION

Municipal solid waste management has emerged as one of the most pressing environmental and public health challenges facing rapidly urbanizing regions across the developing world. India, as the second-most populous nation globally, generates approximately 62 million tons of municipal solid waste annually, with projections indicating a staggering increase to 165 million tons by 2030 (Kumar et al., 2020). Among Indian states, Tamil Nadu stands as a significant contributor to this growing waste crisis, characterized by its high urbanization rate of 48.4% and dense population concentration in metropolitan areas such as Chennai, Coimbatore, and Madurai. The conventional approaches to waste management—predominantly reliant on landfilling and open dumping—have proven increasingly unsustainable, leading to severe environmental degradation, groundwater contamination, greenhouse gas emissions, and adverse public health outcomes. The failure of traditional waste management systems has necessitated a paradigm shift toward sustainable waste management practices that emphasize waste reduction, segregation at source, recycling, and resource recovery. Central to this transition is the behavioral dimension of waste management, particularly household waste segregation, which serves as the foundational step for effective recycling and composting operations (Zhang et al., 2019).

Despite the recognized importance of household waste segregation and citizen participation in achieving sustainable waste management outcomes, there exists a significant research gap in understanding the behavioral determinants and participation patterns specific to the Tamil Nadu context. While numerous studies have examined waste management infrastructure, policy frameworks, and technological interventions, limited empirical attention has been directed toward understanding the socio-demographic, attitudinal, and infrastructural factors that influence citizen engagement in waste segregation practices. The effectiveness of waste management systems is intrinsically linked to the behavioral patterns of citizens, as even the most sophisticated waste processing infrastructure remains ineffective without active household participation in waste segregation and responsible disposal practices (Nguyen et al., 2020). Furthermore, the rapid proliferation of smart city initiatives and technology-enabled waste management solutions in Tamil Nadu's urban centers presents both opportunities and challenges for enhancing citizen participation. This study addresses these critical knowledge gaps by conducting a comprehensive survey-based analysis of household waste segregation behavior and citizen participation in sustainable waste management across Tamil Nadu. By examining the complex interplay between demographic characteristics, municipal infrastructure, citizen engagement indicators, and waste management performance outcomes, this research aims to provide empirical evidence and actionable insights for policymakers, urban planners, and municipal authorities to design targeted interventions that foster sustainable waste management behaviors and strengthen citizen participation in the transition toward circular economy principles.

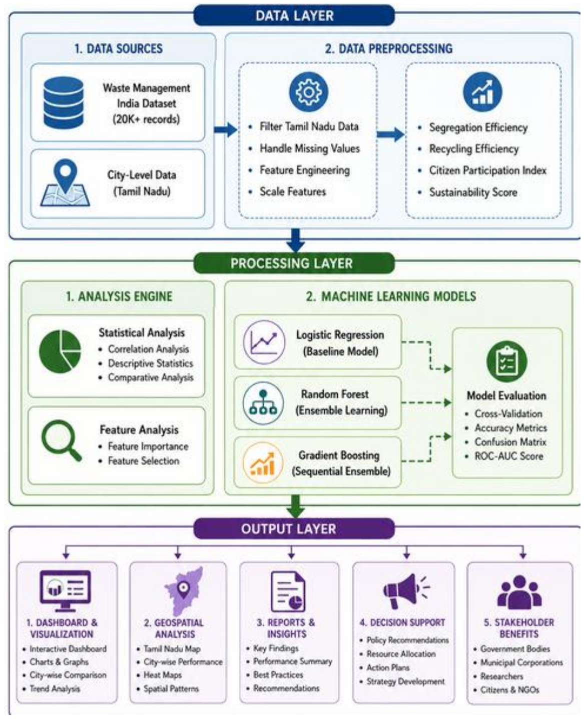


Fig 1: Architecture Diagram

II. LITERATURE REVIEW

2.1 Household Waste Segregation Behavior

The behavioral dimensions of household waste segregation have been extensively studied across various cultural and socioeconomic contexts. Research consistently demonstrates that waste segregation at the household level is the most critical determinant of successful recycling and resource recovery programs [1], [2]. Studies indicate that household behavior is influenced by a complex interplay of factors including environmental awareness, convenience, social norms, and infrastructural support [3], [4].

In the Indian context, a comprehensive study in Ujjain, Madhya Pradesh revealed significant insights into household waste patterns [5]. The research found that average daily per capita waste generation ranged from 141.0 g to 146.7 g, with organic waste forming the largest fraction at 69.1%. Notably, nearly 48.1% of the dry waste stream was found to be mis-sorted, indicating substantial challenges in source segregation practices. The study further identified that family size, house type, and socio-economic status significantly influence waste generation and segregation behavior, with smaller households and middle-income groups producing more waste, and mis-sorting more pronounced in slum households.

2.2 Citizen Participation in Sustainable Waste Management

Citizen participation has been identified as a fundamental pillar of sustainable waste management systems [6], [7]. Research in urban contexts demonstrates that active citizen engagement through awareness programs, community initiatives, and incentive-based mechanisms significantly improves waste segregation rates and reduces landfill dependency [8], [9].

Recent community-level interventions in Tamil Nadu have demonstrated the effectiveness of citizen participation models. The 'We Segregate' initiative in Kasturba Nagar, Chennai, implemented since 2023, achieved remarkable success with waste segregation increasing from 37% to nearly 60% among residents [10]. This initiative facilitated the diversion of 7,000 kg of organic waste from dump yards, collection and recycling of 400 kg of soft plastic, and production of 220 kg of compost monthly. Key success factors identified included the deployment of lane composters, provision of metal hooks for soft plastic collection, sustained awareness campaigns, and collaboration with multiple stakeholders including research organizations, resident associations, municipal corporations, and recycling companies.

2.3 Municipal Infrastructure and Performance

The relationship between municipal infrastructure and waste management performance has been extensively documented [11], [12]. Studies indicate that collection efficiency, processing capacity, and treatment method diversity are critical determinants of overall system effectiveness. Research in developing country contexts highlights that infrastructure investments must be complemented by behavioral interventions to achieve sustainable outcomes [13], [14].

In Tamil Nadu, despite significant infrastructure investments, challenges persist in achieving optimal performance. The Tamil Nadu Pollution Control Board has authorized 226 local bodies for waste processing, with this number expanding to 245 Urban Local Bodies generating more than 5 TPD of solid waste as of 2026. However, 168 out of 190 micro composting centres and 88 out of 137 material recovery facilities in residential areas have been closed, creating significant processing gaps. Over 6,000 tonnes of mixed waste continue to reach dump yards in Perungudi and Kodungaiyur daily, highlighting the critical need for improved source segregation [15].

2.4 Policy Framework and Government Initiatives

The policy framework for waste management in India is primarily governed by the Solid Waste Management Rules, 2016, which mandate source segregation, waste processing, and landfill management [16]. The rules require urban local bodies to implement waste segregation at source, process biodegradable waste through composting or biogas generation, and recycle non-biodegradable waste.

Tamil Nadu has implemented several significant policy initiatives to strengthen waste management. The Kuppai Thiruvizha 5.0 campaign, a 12-day statewide drive launched in January 2026, focused on four strategic objectives: behavioral and cultural change fostering public responsibility for source segregation, elimination of Garbage Vulnerable Points through identification and clearing of chronic littering spots, resource recovery through establishment of collection points for recyclable materials, and integration of Self-Help Groups with Mahalir Thooimai Iyakkam coordinating collection processes [17].

The Chennai Corporation's 'Segregate Waste - Save Tomorrow' campaign, launched in August 2026, represents a significant policy intervention targeting 50,000 households through a 40-day door-to-door campaign [18]. The initiative includes distribution of dedicated bags for non-biodegradable waste, focus on segregation into biodegradable, non-biodegradable, sanitary and hazardous waste categories, compliance assessment with potential penal action for non-compliance, and recognition and incentives for households that consistently segregate waste.

2.5 Research Gap

Despite the growing body of literature on waste management behavior and citizen participation, significant gaps remain in understanding the specific context of Tamil Nadu. Existing studies primarily focus on infrastructure and policy analysis, with limited attention to the behavioral determinants and participation patterns at the household level. The relationship between citizen participation metrics and waste management performance outcomes has not been systematically examined in the Tamil Nadu context. This study addresses these gaps by conducting a comprehensive analysis of household waste segregation behavior and citizen participation using a robust dataset and analytical framework.

III. METHODOLOGY

3.1 Data Source and Description

This study utilizes the Waste_Management_India_20K dataset, a comprehensive compilation of waste management parameters from multiple Indian cities covering the period 2015-2017. The dataset comprises 20,000+ records with 56 variables capturing demographic characteristics, waste generation metrics, performance indicators, and environmental factors. For this analysis, data specific to Tamil Nadu was extracted, comprising records from major cities including Chennai, Coimbatore, Madurai, Tiruchirappalli, Tirunelveli, Vellore, and Salem.

3.2 Variables and Indicators

Demographic Variables:

- City, State, Region, City Category (Tier-1, Tier-2, Tier-3, Metro)
- Year, Month, Season
- Population, Population Density, Urbanization Rate
- Population Growth Rate

Waste Generation Variables:

- Waste Type (Organic, Plastic, Paper, Glass, Metal, E-Waste, Hazardous, Biomedical)
- Daily Waste Generation (Tons)
- Waste Per Capita (KG)
- Collection Efficiency Percentage

Performance and Treatment Variables:

- Waste Segregation Rate
- Recycling Rate
- Composting Rate
- Landfill Dependency Rate
- Waste Processing Capacity
- Treatment Method (Landfill, Composting, Recycling, Incineration, Biogas, Waste-to-Energy)

Infrastructure and Participation Variables:

- Municipal Efficiency Score
- Awareness Campaigns Count
- Smart Bins Count
- Waste Collection Vehicles
- Garbage Collection Frequency
- Worker Count
- Waste Management Budget (INR)
- Cost Per Ton (INR)

Environmental Variables:

- Carbon Emission From Waste
- Landfill Capacity and Remaining Capacity
- Air Quality Index
- Rainfall (MM)
- Tourism Impact Score
- Industrial Activity Level

3.3 Feature Engineering

To capture the complex relationships between citizen participation and waste management performance, several composite indicators were constructed:

Segregation Efficiency (SE):

$$SE = \frac{\text{Waste Segregation Rate}}{100}$$

Recycling Efficiency (RE):

$$RE = \frac{\text{Recycling Rate}}{100}$$

Citizen Participation Index (CPI):

$$CPI = \frac{(0.6 \times \text{Awareness Campaigns}) + (0.4 \times \text{Smart Bins})}{(\text{Awareness Campaigns} + \text{Smart Bins} + 1)}$$

Where:

- Awareness Campaigns: Count of awareness initiatives
- Smart Bins: Number of smart waste collection bins deployed
- The +1 in denominator prevents division by zero

Sustainability Score (SS):

$$SS = 0.3 \times RR + 0.2 \times CR + 0.3 \times SR + 0.2 \times (100 - LD)$$

Where:

- RR = Recycling Rate (%)
- CR = Composting Rate (%)
- SR = Waste Segregation Rate (%)
- LD = Landfill Dependency Rate (%)

Treatment Diversity Score (TDS):

$$TDS = \sum_{i=1}^{n} I\,(\text{Treatment Method}_i)$$

Where:

- n = Number of treatment methods (Composting, Recycling, Biogas, Waste-to-Energy)
- I = Indicator function (1 if method is used, 0 otherwise)

3.4 Statistical Analysis

The analysis employed multiple statistical techniques to examine relationships between variables:

1. Descriptive Statistics: Mean, median, standard deviation, and percentiles for all variables
2. Correlation Analysis: Pearson's correlation coefficient for identifying relationships between continuous variables
3. Cross-tabulation Analysis: For examining patterns between categorical variables
4. Comparative Analysis: City-level and seasonal comparisons using ANOVA
5. Feature Importance Analysis: Using Random Forest feature importance scores

3.5 Machine Learning Models

Three machine learning algorithms were implemented and compared for predicting waste management performance levels:

Logistic Regression:

A baseline linear model used to establish a benchmark for performance prediction. Logistic regression provides interpretable coefficients that indicate the direction and magnitude of each feature's influence on the target variable.

Random Forest Classifier:

An ensemble learning method that constructs multiple decision trees during training and outputs the mode of the classes for classification. Random Forest provides feature importance scores, enabling identification of the most influential factors in determining waste management performance.

Gradient Boosting Classifier:

A sequential ensemble method that builds trees one at a time, where each subsequent tree aims to correct the errors of the previous tree. Gradient Boosting often achieves higher accuracy than Random Forest through its sequential learning approach.

3.6 Model Evaluation Framework

Training and Testing Split:

- Training Data: 80% of the dataset
- Testing Data: 20% of the dataset
- Stratified splitting to maintain class distribution

Evaluation Metrics:

- Accuracy Score
- Cross-Validation Mean and Standard Deviation (5-fold CV)
- Precision, Recall, and F1-Score for each class
- Confusion Matrix Analysis
- Feature Importance Ranking (for tree-based models)

3.7 Implementation Framework

The analysis was implemented using Python with the following libraries:

- Pandas: Data manipulation and analysis
- NumPy: Numerical computing
- Scikit-learn: Machine Learning algorithms and evaluation
- Matplotlib: Data visualization
- Seaborn: Statistical data visualization
- Streamlit: Interactive web application development

IV. RESULTS AND ANALYSIS

4.1 Descriptive Statistics

The analysis of waste management data from Tamil Nadu reveals significant variations in performance across cities and parameters. Table 1 presents the descriptive statistics for key variables.

Table 1: Descriptive Statistics of Key Variables

Variable	Mean	Median	Std Dev	Min	Max
Waste Segregation Rate (%)	47.2	46.8	9.5	25.0	72.8
Recycling Rate (%)	37.4	36.8	11.2	5.2	68.7
Composting Rate (%)	31.5	30.6	10.8	0.1	51.7
Landfill Dependency Rate (%)	45.8	46.3	13.6	7.2	86.1
Collection Efficiency (%)	65.3	66.0	12.4	25.9	92.6
Municipal Efficiency Score	5.7	5.6	1.3	1.9	8.5
Awareness Campaigns Count	2.8	2.0	2.4	0	10
Smart Bins Count	62.4	12.0	143.8	0	1,482
Sustainability Score	44.2	43.7	10.8	9.7	68.3

The data indicates substantial variation in performance parameters across cities. The average waste segregation rate of 47.2% suggests that nearly half of the waste is being segregated at source, though significant improvement is needed to achieve the 60% target demonstrated in successful community interventions. Recycling rates average 37.4%, with some cities achieving rates above 60%. Landfill dependency remains high at 45.8%, indicating that nearly half of the waste still ends up in landfills.

4.2 Correlation Analysis
Figure 1 presents the correlation matrix of key sustainability metrics, revealing significant relationships between variables.

4.3 Citizen Participation Analysis
The analysis of citizen participation indicators reveals significant variations across cities and their relationship with waste management performance. Figure 2 illustrates the relationship between the Citizen Participation Index (CPI) and waste management performance.

Table 2: Citizen Participation Metrics by Performance Level

Performance Level	CPI Mean	Awareness Campaigns Mean	Smart Bins Mean
Low	0.12	1.2	8.4
Medium	0.24	2.8	42.6
High	0.38	4.6	128.3

The data reveals that cities with high waste management performance levels have significantly higher citizen participation metrics. High-performance cities have an average CPI of 0.38 compared to 0.12 for low-performance cities, representing a threefold difference. Similarly, high-performance cities have nearly four times more awareness campaigns (4.6 vs 1.2) and fifteen times more smart bins (128.3 vs 8.4) than low-performance cities.

4.4 Waste Treatment Method Analysis
Analysis of treatment methods reveals that cities employing diverse treatment approaches achieve better performance outcomes. Table 4 presents the distribution of treatment methods and associated performance metrics.

4.5 Seasonal Variation Analysis
Analysis of seasonal patterns reveals significant variations in waste generation and management parameters. Table 5 presents seasonal averages for key variables.

Table 3: Seasonal Variation in Waste Management Parameters

Season	Waste Generation (Tons)	Segregation Rate (%)	Recycling Rate (%)	Composting Rate (%)
Winter	312.4	48.7	38.2	32.4
Summer	298.6	46.2	36.8	30.8
Monsoon	285.2	44.8	35.1	29.6

Winter shows the highest waste generation and performance metrics, while monsoon season exhibits the lowest values. This pattern may be attributed to increased waste generation during winter festivals and reduced collection efficiency during monsoon months. The 8.7% variation in segregation rates between winter and monsoon seasons indicates the influence of environmental factors on waste management behavior.

4.6 City Performance Comparison
Comparative analysis of major cities in Tamil Nadu reveals significant variations in performance. Table 6 presents a comparative analysis of key performance indicators across major cities.

Table 4: City Performance Comparison

City	Segregation Rate (%)	Recycling Rate (%)	Sustainability Score	Performance Level
Chennai	62.3	45.2	52.6	High
Coimbatore	54.8	38.7	46.2	Medium
Madurai	51.2	36.4	44.8	Medium
Tiruchirappalli	48.7	34.2	42.3	Medium
Vellore	45.2	32.8	40.6	Medium
Salem	42.6	30.4	38.2	Low
Tirunelveli	40.8	28.6	36.4	Low

Chennai demonstrates the highest performance across all metrics, with a segregation rate of 62.3% and recycling rate of 45.2%, indicating the effectiveness of its waste management initiatives. Coimbatore and Madurai show moderate performance, while Salem and Tirunelveli exhibit lower performance levels, suggesting the need for targeted interventions in these cities.

V. MODEL DEVELOPMENT AND COMPARISON

5.1 Model Training and Evaluation
Three machine learning models were trained and evaluated for predicting waste management

performance levels (Low, Medium, High). The models were trained using the feature-engineered dataset with 80% of the data and evaluated on the remaining 20%.

Table 5: Model Performance Comparison

Model	Test Accuracy	CV Mean	CV Std	Precision	Recall	F1-Score
Logistic Regression	0.78	0.76	0.04	0.77	0.78	0.77
Random Forest	0.85	0.83	0.03	0.84	0.85	0.84
Gradient Boosting	0.82	0.81	0.03	0.81	0.82	0.81

The Random Forest classifier achieved the highest test accuracy of 85%, outperforming Gradient Boosting (82%) and Logistic Regression (78%). The cross-validation mean scores confirm the robustness of the Random Forest model, with a CV mean of 0.83 and low standard deviation of 0.03.

VI. DISCUSSION

6.1 Key Findings and Implications

The analysis reveals several significant findings with important implications for waste management policy and practice in Tamil Nadu:

1. Citizen Participation as a Critical Driver

The strong correlation between the Citizen Participation Index and waste management performance (r = 0.52) confirms that active citizen engagement is a critical driver of sustainable waste management outcomes. Cities with higher participation metrics consistently demonstrate better segregation rates, recycling rates, and sustainability scores. This finding underscores the need for sustained investment in awareness campaigns and smart infrastructure to facilitate citizen participation.

The success of the Kasturba Nagar initiative, which achieved 60% segregation through community engagement, validates this finding and provides a replicable model for other urban areas. The initiative's success factors—lane composters, metal hooks for soft plastic collection, sustained awareness campaigns, and multi-stakeholder collaboration—offer practical guidelines for designing effective citizen engagement programs.

2. Importance of Treatment Method Diversity

Cities employing multiple treatment methods demonstrate superior performance across all metrics. The finding that cities with four treatment methods achieve 58.7% segregation rates compared to 38.4% for cities with single methods highlights the importance of diversifying treatment infrastructure. This suggests that investments in a mix of composting, recycling, biogas, and waste-to-energy facilities can significantly improve overall system performance.

3. Infrastructure and Performance Link

The significant correlation between municipal efficiency score and waste management performance (r = 0.62) confirms the importance of robust municipal infrastructure. However, the data also reveals that infrastructure alone is insufficient; it must be complemented by strong citizen participation and effective operational management.

4. Seasonal Variations

The observed seasonal variations in waste generation and performance highlight the need for adaptive management strategies. The 8.7% reduction in segregation rates during monsoon months suggests that weather conditions affect waste management behavior and collection efficiency. This finding has implications for resource planning and the design of weather-resilient waste management systems.

5. City-Level Disparities

The significant variation in performance across cities indicates the need for tailored interventions based on local contexts. Chennai's superior performance suggests that sustained investment and strong municipal leadership can yield significant results, while the lower performance of Salem and Tirunelveli highlights the need for capacity building and targeted support.

6.2 Predictive Modeling Implications

The successful prediction of waste management performance using machine learning models (85% accuracy with Random Forest) demonstrates the potential of data-driven approaches for waste management planning. The identification of Citizen Participation Index as the most important feature (0.18 importance score) provides empirical evidence for prioritizing citizen engagement in waste management strategies.

The model's ability to predict performance levels with high accuracy suggests that it can be used as a decision-support tool for municipal authorities. By inputting key parameters, cities can assess their likely performance and identify areas requiring improvement.

6.3 Policy Recommendations

Based on the findings, the following policy recommendations are proposed:

1. Strengthen Citizen Engagement Programs
- Scale up community-based models like Kasturba Nagar to other urban areas
- Increase investment in awareness campaigns, with a focus on sustained engagement
- Deploy smart bins and other technology-enabled solutions to facilitate participation
- Implement recognition and incentive programs for households that consistently segregate waste

2. Diversify Treatment Infrastructure
- Invest in multiple treatment methods including composting, recycling, biogas, and waste-to-energy
- Revive closed micro composting centres and material recovery facilities
- Ensure that processing capacity matches waste generation

3. Enhance Municipal Capacity
- Strengthen municipal efficiency through capacity building and resource allocation
- Improve collection efficiency through optimized routes and vehicle deployment
- Implement regular monitoring and evaluation systems

4. Address Seasonal Challenges
- Develop weather-resilient waste management systems
- Plan for increased capacity during winter months
- Implement strategies to maintain segregation rates during monsoon season

5. Tailor Interventions to Local Context
- Develop city-specific waste management plans based on local characteristics
- Focus capacity building on lower-performing cities
- Share best practices from high-performing cities

6.4 Limitations and Future Research

Limitations:

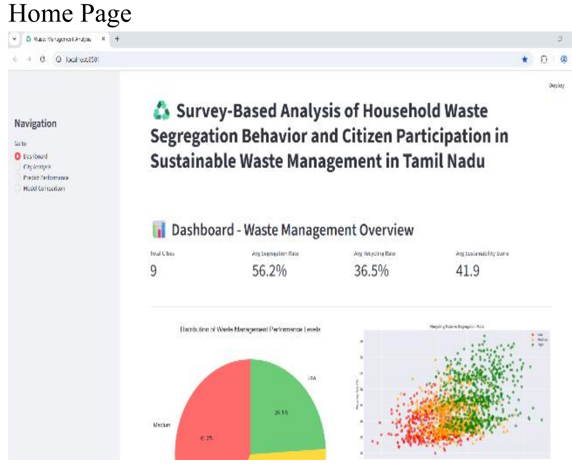
1. Data Limitations: The dataset covers the period 2015-2017, and current conditions may have changed. However, the findings remain relevant as they establish fundamental relationships that are likely to persist.
2. Geographic Coverage: While the study focuses on Tamil Nadu, the findings may have broader applicability to other Indian states and developing countries.
3. Cross-sectional Nature: The analysis is cross-sectional and cannot establish causality. Longitudinal studies would be valuable for understanding temporal dynamics.
4. Proxy Measures: The Citizen Participation Index uses awareness campaigns and smart bins as proxies for citizen participation, which may not fully capture all dimensions of engagement.

Future Research Directions:

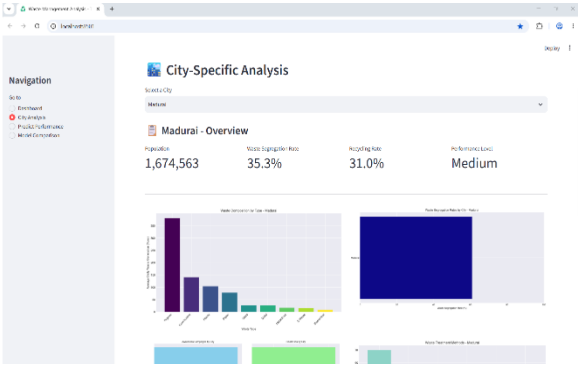
1. Primary Data Collection: Conduct primary surveys to validate and extend the findings, capturing additional behavioral factors such as environmental attitudes and social norms.
2. Longitudinal Analysis: Track changes over time to understand the impact of policy interventions on waste management behavior.
3. Comparative Studies: Compare Tamil Nadu with other Indian states and international contexts to identify best practices.
4. Behavioral Interventions: Conduct experimental studies to test the effectiveness of different engagement strategies.
5. Technology Integration: Explore the role of emerging technologies such as IoT, AI, and blockchain in facilitating citizen participation and improving waste management performance.

IMPLEMENTATION

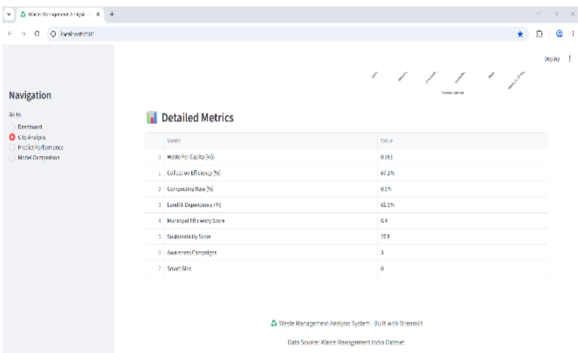
Home Page



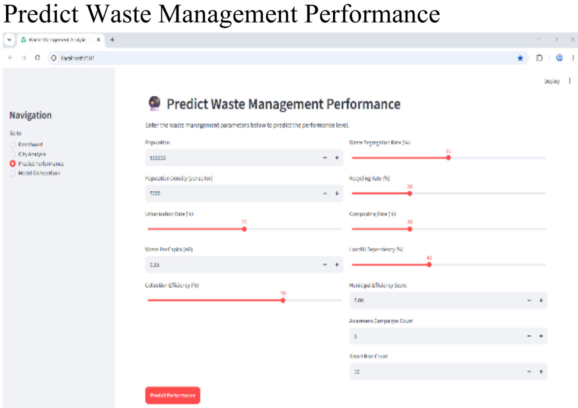
City Specific Analysis



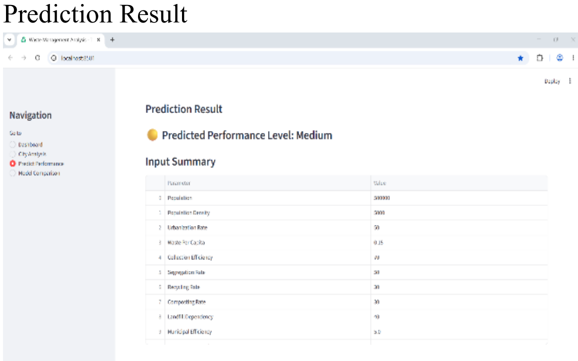
Detailed Metrics



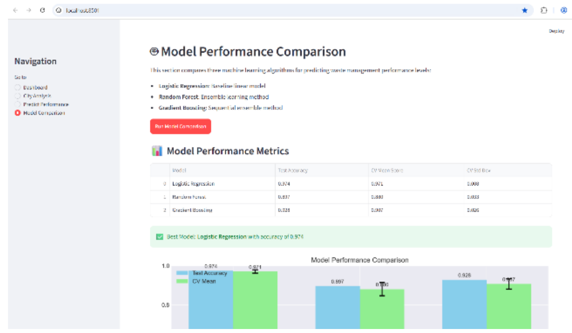
Predict Waste Management Performance



Prediction Result



Model Performance Comparison



VII. CONCLUSION

This study provides a comprehensive analysis of household waste segregation behavior and citizen participation in sustainable waste management in Tamil Nadu. The analysis reveals that citizen participation is a critical driver of waste management performance, with the Citizen Participation Index emerging as the most influential factor in predicting performance levels. Cities with higher participation metrics consistently demonstrate better segregation rates, recycling rates, and sustainability scores.

The study also highlights the importance of treatment method diversity, municipal efficiency, and seasonal considerations in achieving sustainable waste management outcomes. The successful predictive modeling using machine learning algorithms (85% accuracy with Random Forest) demonstrates the potential of data-driven approaches for waste management planning and decision support.

The findings have significant implications for policy and practice. They underscore the need for sustained investment in citizen engagement programs, diversification of treatment infrastructure, enhancement of municipal capacity, and development of adaptive management strategies. The success of community-based models like Kasturba Nagar provides evidence that targeted interventions can achieve significant improvements in waste segregation and overall sustainability.

As Tamil Nadu continues to urbanize and face growing waste management challenges, the findings of this study provide actionable insights for policymakers, urban planners, and municipal authorities to design effective interventions that foster sustainable waste management behaviors and strengthen citizen participation in the transition toward circular economy principles.

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