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# INFORMAL RECYCLING AND INCLUSIVE SOLID WASTE MANAGEMENT IN ASIAN ECONOMIES: A MATERIAL FLOW AND SOCIAL EXCLUSION PERSPECTIVE

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**Abstract:** Solid waste management (SWM) remains a critical challenge across Asian nations, where diverse socio-economic contexts influence the adoption of sustainable practices. While advanced economies such as Japan and South Korea prioritize "zero waste" and "zero landfilling" strategies through heavy investment in 3R (reduce, reuse, recycle) technologies, resource-constrained countries like India face structural and financial limitations. This study employs the material flow method to evaluate the contribution of informal recycling within India's SWM system, emphasizing both its advantages and inherent drawbacks. Although informal recyclers enhance collection efficiency and resource recovery, their integration into formal frameworks presents significant policy dilemmas. Using ANOVA t-test analysis, this research highlights the tension between improving system efficiency and safeguarding the livelihoods of low-income waste pickers. To address these complexities, the study applies the concepts of capital forms and the normative theory of social exclusion, proposing pathways toward inclusive SWM models that balance sustainability goals with social equity.

**KEYWORDS:** Solid waste management, recycling, landfilling, India, sustainability management

## 1. Introduction

Solid waste management, or SWM, is becoming more and more popular on a local and national level. To address SWM, local governments and regulatory agencies are taking into account strategies including recycling programmes, source reduction campaigns, and alternative waste processing options. Each community's distinct objectives are defined by the issues and conditions specific to the location. For instance, a municipality with limited landfill capacity may choose to reduce the amount of garbage disposed of there and investigate volume reduction techniques, such as the production of energy from waste, source reduction, and waste diversion via recycling. The optimal choice for SWM is frequently unknown, though. Building a waste-to-energy factory, for instance, might not be the best solution if the community is already recovering the majority of the combustible waste materials as recyclable material, or a recycling programme might not be as cost-effective if the market prices of recyclable materials are low.

Furthermore, it's not obvious if the overall environmental advantages of a SWM strategy outweigh the environmental costs associated with additional collection efforts and the energy consumed by waste recovery facilities related to recycling. The goal of solid waste management is to address the negative effects of improper waste streams disposal on the environment, economy, resources, aesthetics, and health. These issues continue to worry the international community, nations, cities, companies, and people. Systems analyses, which use engineering models, analytical platforms, and evaluation tools to monitor and optimise current SWM systems and provide decision-supporting aids for planning processes, have been employed by SWM agencies in industrialised nations since the 1960s. Today's society places a high priority on solid waste management, and growing environmental consciousness has prompted the development of pollution control technologies as well as more stringent waste handling and disposal regulations. New laws, the nation's steadily increasing solid waste generation, and frequent landfill closures have all pushed for the implementation of incineration and recycling programmes in Italy. When establishing such programmes, integration of social, technical, environmental, and economic elements must be taken into account.

The management of sustainable waste (SWM) is a multifaceted problem with aspects related to economics, technology, and regulations. Industrialised countries have mostly embraced the "Waste Management Hierarchy" concept while developing SWM management plans. Research on creating economic-based optimisation models for SWM flow allocation has been concentrated over the last 20 years. A recent model that takes energy and material recovery requirements into consideration aims to minimise total cost as a constrained non-linear optimisation problem. Treatment, transportation, servicing, reuse, and possible advantages for the sale of electric energy are all included in this model. It does not, however, always result in the best structure for the SWM management system.

A further approach to managing SWM flows takes into account the composition, rates, and adverse impacts on the environment. This model minimises a linear cost function to find the optimal SWM flows to various treatment plant typologies under the assumption that flows are independent variables. It is necessary to fully comprehend and look into possible garbage component treatment methods to build an extensive model of SWM management systems. Depending on different strategies for treating solid waste and the availability of particular treatment plants, the total volume of treated waste streams may vary. The number of recycling activities and the accessibility of treatment facilities are directly related. To make a choice that takes everything into account, a precise system model needs to be made. This model has to show SWM fluxes and their chemical and physical properties, as well as evaluate the relative benefits of recovery vs disposal for each material. In order to evaluate the possible recovery of material and energy from them, modelling properties such as humidity and heating value are required.

Controlling human activity, maintaining public health, and safeguarding the environment are enabled by integrated environmental management systems such as solid waste management (Yoshida 2020). Technology interventions, collaboration, and societal consensus are vital for system improvement. In least developed countries, per capita waste averages 0.56 kg/day, dominated by organics (52%) and recyclables (26%), yet inadequate collection, minimal recycling, and poor landfill practices persist due to limited finance, infrastructure, and policy (Bundhoo 2018).

Sustainable solid waste management emphasizes the 3R principle (reduce, reuse, recycle), supported by life cycle assessment and modelling tools (Das et al. 2019). Viewing waste as a secondary resource can boost industrial economies, create jobs, and improve livelihoods (Godfrey et al. 2019). China's system improvements (2004–2019) show progress in source reduction, recycling, and harmless treatment, aided by investments in pollution control (Guo et al. 2021).

Invisible SWM factors, identified via PESTLE analysis, influence regional behaviors and sustainability outcomes (Mukhtar et al. 2018). Integrating energy efficiency with waste processing enhances sustainability (Vertakova and Plotnikov 2019). In China's eastern provinces, waste generation trends vary regionally, highlighting policy and infrastructure disparities (Khan et al. 2022). In Johannesburg, poor waste management harms health, the environment, and productivity (Kubanza and Simatele 2020). In Nigeria, monopolized state systems struggle with organic waste disposal, requiring stronger policies and databases (Ike et al. 2018). In rapidly urbanizing Thailand, stakeholder-driven solutions are essential for scalable systems (Yukalang et al. 2018). Compliance in rural villages depends on community participation and local enforcement (Wang et al. 2018).

Adopting global best practices, such as German household waste separation systems, can enhance urban management in developing nations (Azevedo et al. 2021). Prioritizing waste segregation in developing Asia strengthens downstream recycling efficiency (Hondo et al. n.d.). Advanced technologies like PSO-CNN can optimize biomedical waste handling (Madeshwaren et al 2025). Hybrid deep learning approaches such as EnU-Net-DNN-BMWC improve waste classification accuracy (Madeshwaren et al 2024).

## 2. Simulation Analysis

### 2.1 Data Collection

The study was carried out in India, a country spanning 13,213 hectares of different areas in different states of India, which is displayed in Table 1. Over 22 million people were projected to live there in 2021. The specific region of India was examined in this study in order to examine solid waste management. There were 3053 responders in the unorganised sector, representing different departments. There were 57 public replies from SWM, both male and female.

**Table 1: Data Collection**

| City | Overall, solid waste feasibility | Total of waste (million tons) | Area | Waste depth (m) | |
|---|---|---|---|---|---|
| | | | | Minimum | Maximum |
| Delhi | yes | 6,50,000 | 44 | 10 | 20 |
| Mumbai | Yes | 6,27,546 | 8 | | |
| Hyderabad | No | 1,15,00,000 | 112 | 4 | 14 |
| Pondicherry | No | 15,00,000 | 35 | 15.6 | |
| Pune | No | 13,56,000 | 17.4 | 4 | 10 |
| Chennai | Yes | 4,73,542 | 1 | 5 | 11.6 |
| Agra | No | 2,54,689 | 3 | 18.2 | |
| Coimbatore | No | 4,26,581 | 2.68 | 12.9 | |
| Trichy | No | 2,65,98,100 | 3.5 | 54 | |
| Madurai | Yes | 2,10,000 | 52 | 8.4 | |

## 3. MATERIAL RECOVERY OF SWM

### 3.1 Typical system for solid waste management

India is renowned for having a diverse range of cultures in terms of terrain, cuisine, climate, and economy. SWM systems take this into account. Several factors, such as the population's concentration in urban areas, governmental actions, the introduction of newer technology, and growing public awareness of the value of sanitation and hygiene, are contributing to the significance of SWM. In Figure 1, a typical SWM system is displayed.

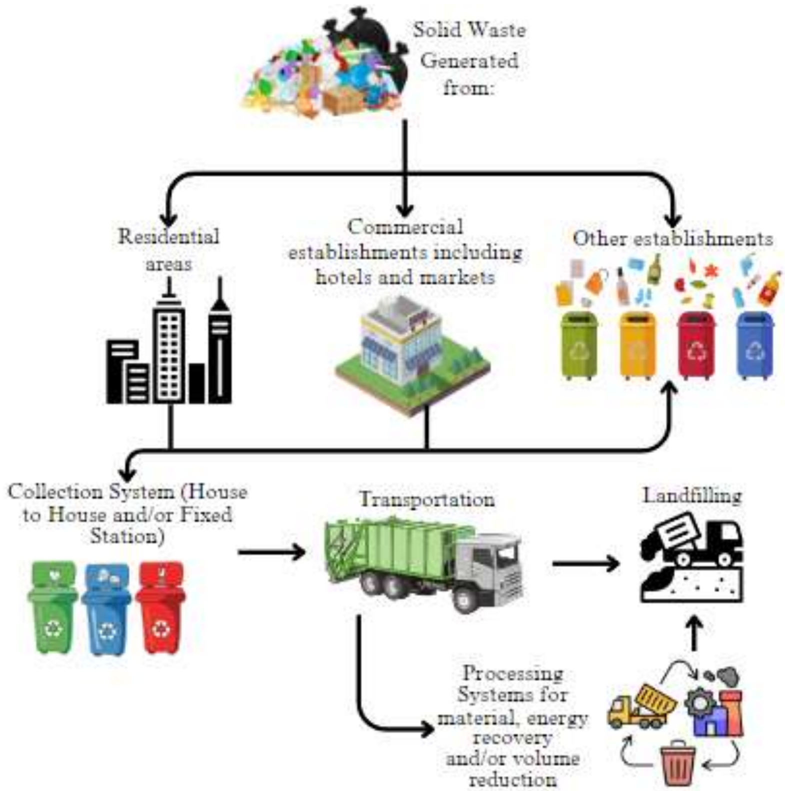


**Figure 1. Solid Waste Management typical system**

### 3.2 Recycling

The best strategies to stop trash from being produced are reduction and reuse. The greatest option for handling wastes once they are produced and gathered is recycling, in which the materials often go through a chemical change. Reusing can occasionally occur after collection, when unofficial vendors gather useless things from homes, repurpose or fix them, and then sell them at consignment stores. Recycling is the process of using garbage as a raw resource to create new items, as opposed to reusing a used material. Thus, recycling balances the need for virgin raw resources. Up to 95% of a product's environmental impact is known to occur before it is disposed of, with the majority occurring during the manufacturing process and the extraction of virgin raw materials. Recycling is therefore essential to minimising a material's total life cycle effects on the ecosystem and the public's well-being. Nevertheless, recycling necessitates a separate stream of garbage, whether it be separated at the source or afterwards (after collection).

### 3.3 Energy Recovery

Energy recovery from garbage is a superior option for meeting a community's energy needs than landfilling, at least to some extent. One way to recover the chemical energy in MSW is through energy recovery. A portion of the energy used to create those components as inputs is stored as chemical energy in wastes. Energy recovery is ranked lower on the waste management hierarchy than material recovery because of the disparity in resources (materials/energy) that may be recovered.

### 3.4 Processing and resource recovery

Solid waste is treated to minimise its volume and potential for pollution in landfills, as well as for recycling purposes. The cost-effectiveness of a recycling industry is a determinant of its sustainability, which is mostly influenced by a society's economic standing. Certain recyclables, such as paper, glass, and metal, have a structured mechanism for collection and processing that involves both governmental and private involvement in developed countries. In emerging economies, where recyclable fractions such as glass, metals, and paper make up a smaller percentage of the total, tiny industries have been responsible for recovering and recycling these materials in an unorganised way. One recognised thermal processing technique for the combustible portions of solid waste is incineration. Recovering the heat produced during combustion and minimising the amount of waste that needs to be disposed of at the end are the goals. Additionally, there are a number of initiatives underway to establish composting as a significant processing technology for the majority of the degradable organic fractions. This is a strategy that would lower the amount of organic waste that ends up in landfills while also providing compost to the agricultural sector as a soil conditioner.

**3.5 Waste-To-Energy Combustion (WTE)**

The process of controlling combustion to convert combustible solid waste into an ash residue with little to no combustible material and generate steam, electricity, or other energy is known as waste-to-energy combustion (WTE). This is done using an enclosed unit. WTE combustion aims to treat SWM to decrease its volume, even if both Refuse Derived Fuel (RDF) and WTE combustion combust SWM. Producing electricity and energy simply enhances this process.

**3.6 Ultimate disposal by landfilling**

Sanitary landfilling is the last method of disposing of solid wastes that cannot be treated any other way, as well as residues and other materials that are thrown after processing. Aggressive preventive procedures separate the deposited waste from the environment in affluent economies. Nevertheless, these procedures lead to sanitary landfilling procedures that are extremely costly and technologically advanced. Even while open dumping is prevalent in underdeveloped nations, it is recognised that this is insufficient. To reduce environmental contamination, efforts are being made to regulate tipping or to adopt sanitary landfilling.

**3.7Air Emissions during SWM**

Millions of urban Indians are directly exposed to these emissions every day as a result of SWM being burned on the streets. Although MSW burning in landfills occurs in less populated areas, the process releases pollutants into the lower atmosphere, where there is a very low dispersion of pollutants, increasing the likelihood of being exposed to these dangerous emissions.

**Table 2: Inventory of Air Emissions from Open Burning and Other Combustion in Selected Indian Areas**

| Source of emission | Emissions (tons/year) | | | | | |
|---|---|---|---|---|---|---|
| | PM | SO2 | Nox | CO | HC | Total |
| Commercial food sector | 1,542,8 | 12,254.10 | 13654 | 265 | 3265 | 25,698 |
| open burning | 256.8 | 19,254.00 | 21,254 | 21,654 | 548621 | 3,66,548 |
| Crematoria | 3651 | 215.14 | 16,548 | 2,354 | 54326 | 21,654 |
| Domestic sector | 260.2 | 65248 | 5,654 | 65248 | 215468 | 5,486 |
| Central&Western Railway | 54.1 | 21549 | 3,986 | 32468 | 21365 | 3,596 |
| Aircraft&Marine Vessels | 65.8 | 2164.5 | 42,568 | 630 | 6584 | 2,156 |
| Road Transportation | 1,562.80 | 2,541,2 | 24,891 | 3365 | 2015 | 2,003 |
| Industrial | 5,264.80 | 25,241,6 | 3,254 | 6500 | 254 | 65,596 |
| Power plant | 542.7 | 524.7 | 65,214 | 7580 | 2489 | 29,458 |

The report notes that in order to improve Mumbai's air quality, open burning of SWM on roadways and dump sites must be promptly discontinued. (Table 2)It also emphasises the necessity for reliable solutions to this issue. According to the report, among many other measures, a 50% decrease in open burning and a 100% decrease in landfill fires are needed to reduce PM pollution in India by 98%.

**3.8 Problematic management of solid waste in Indian urban areas**

Indians living in cities find improper SWM to be a daily annoyance. Uncollected waste streams on the streets serve as a haven for stray animals, street dogs, and other disease-carrying agents. Indians living in urban areas have to deal with the smell of open garbage bins and MSW dumps every day, as well as the odour on the streets as soon as they leave their houses. Many urban Indians encounter the unpleasant task of having to walk through ankle-deep puddles contaminated with decaying municipal solid waste (MSW) during the rainy season. During his study trips to India, the author saw dry solid garbage flying in the wind. Living in such settings with children exacerbates the trauma experienced by adults whose children are exposed to similar conditions, which is in Figure 2. They create a negative perception of themselves in the eyes of the public as a result of these traumatic and painful experiences. Conditions like this have the potential to negatively affect people's feelings of community and to make people less receptive to actions that could improve the situation over time.

**Figure 2** Indians living in cities find improper SWM to be a daily nuisance.

**4. ANOVA**

Examining differences between the means (or averages) of multiple groups is done statistically using an approach known as Analysis of Variance (ANOVA). It is employed in a range of contexts to ascertain whether the means of different groups differ in any way. This ANOVA result is known as the 'F statistic'. This ratio produces a Figure 3 that can be used to determine whether the null hypothesis is accepted or rejected by highlighting the differences between within-group and between-group variance. There are two sections to the decision-maker questionnaire. It also has to do with the respondents' backgrounds and their involvement in SWM decision-making. It displays the respondent's personal ranking and degree of agreement with each of the four scenarios, each of which was assessed on a five-point Likert scale ranging from very good to very poor or agree to disagree. The scenarios are

**Scenario 1-** household composting and community composting to a sanitary landfill
**Scenario 2-** Open dumping to sanitary landfill (informal sector)
**Scenario 3 -** waste to energy (WTE) ( composting)
**Scenario 4-** waste to energy (WTE) (informal sector)

If there is a significant difference between the classes and the null hypothesis is not supported, the F-ratio will be larger. Although it could seem like different factions have different means, this could just be the consequence of random errors rather than a direct effect of the independent component on the dependent factor. If sampling error was the cause of the gap between the group averages, it makes no difference. Finding out if the variance in average scores is statistically significant is made easier with the help of ANOVA.

## 5. Results And Discussion

### 5.1 An integrated strategy for managing solid waste in a sustainable manner

Solid waste management, or SWM, can be compared to a massive materials management system that is dispersed across a metropolis to collect solid waste and then transport it to the periphery to be processed and disposed of. In addition, the system offers services to the general public, employs a substantial workforce, and needs a substantial amount of resources in several forms. With time, it has become clear that designing a combined system as a whole is more important than choosing discrete component subsystems that might not function well together. Integrated SWM is becoming a more widely accepted idea. In this paradigm, every component system is chosen at the same time to enable sensible planning and efficient implementation. The final system configuration guarantees the interoperability of the parts, enhancing overall performance. The selection and implementation of appropriate techniques, technologies, and management systems to accomplish particular objectives and goals is another definition of integrated solid waste management. The author does, however, believe that SWM management is more than merely a technology system that makes processing and disposing of SWM easier. Numerous other aspects, including the operating environment, socioeconomic conditions, and local government acts, are also involved in SWM management. Many topics about sustainable SWM were covered in this area. All of those kinds of problems have to be taken into account while designing each component of the system. In order to accomplish this, it is required to integrate numerous components that control system performance in order to streamline functionality (Figure. 3), which will be covered in more detail below.

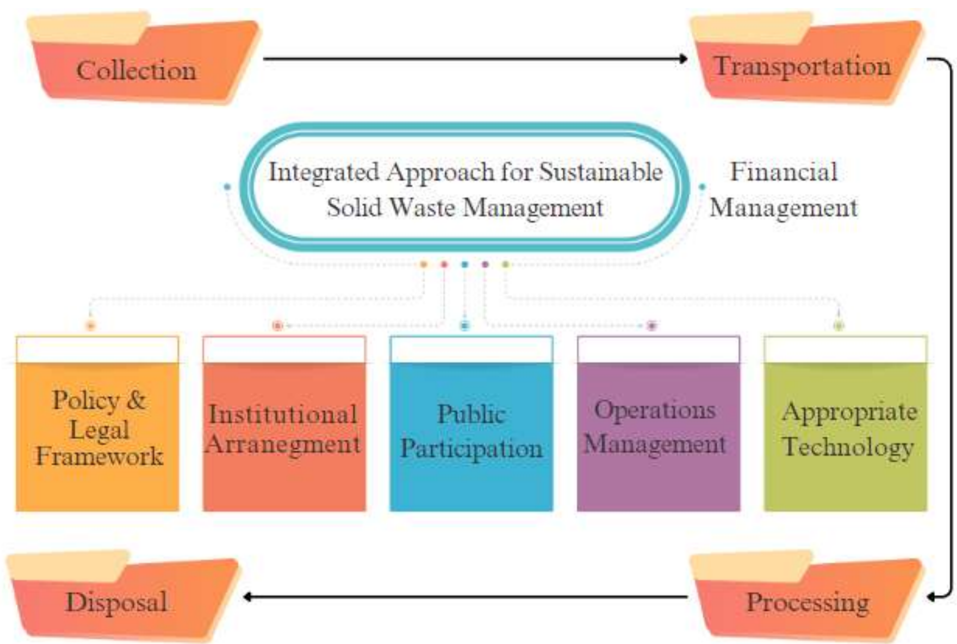


**Figure. 3 Integrated sustainable solid waste management system**

### 5.1 Role of the informal sector in SWM

In India, informal recycling refers to the recovery of materials from waste and is primarily carried out by waste pickers or scavengers. While some Indian municipal solid trash collection teams get extra money by salvaging materials from waste streams, most informal recycling is done by scavengers. Waste is seen by scavengers as a resource for making money. Scavengers' low social standing is reinforced when they are associated with waste streams, a low-status material. Hence, scavengers or garbage pickers are characterised in this research as an unofficial SWM system that relies on recovering waste rather than disposing of it, and that is associated with stigma due to their line of work. Because the informal industry is unregistered, it might be difficult to identify the movements of recyclable materials. With a few exceptions, the majority of unregistered informal recycling operations are carried out by large-scale businesses, intermediaries, and manufacturers. As a result, it may only be possible to estimate the entire population. However, model prediction yields an approximation of its contribution. In 2021, it was projected that at least some individuals in the SWM in India were employed in the unorganised sector (Table 3).

**Table 3: Estimation of the number of employees in SWM's informal sector.**

| Actor | Scavenger IPS | Scavenger IPA | Itinerant buyers | Dealer | Enterprises (small) | Enterprises (large) | Total |
|---|---|---|---|---|---|---|---|
| Total number of facilities/enterprises | 134 | 2 | 55 | 16 | 22 | 240 | |
| Number of workers' | 15 | 500 | 2 | 5 | 42 | 46 | |
| Worker in the informal sector | 2453 | 500 | 54 | 72 | 146 | $2 | 3053 |

**5.2 Respondents result about SWM**

Table 4 displays the respondents' gender distribution. For decision-making, 50 males and 13 females were surveyed regarding solid waste management. Everyone was from different fields, such as politicians, government sector employees, academia, and NGOs

**Table 4 Gender distribution of respondents**

| Type of decision makers | | Politician | Government | Academia | NGOs | Total |
|---|---|---|---|---|---|---|
| Gender of decision makers | Male | 4 | 30 | 4 | 15 | 50 |
| | Female | 2 | 20 | 6 | 3 | 13 |
| | Total | 5 | 40 | 7 | 13 | 57 |

Based on the independent sample t-test, comparing the mean scores of scenarios 1 and 2 shows a significant difference between their ranks (the significance of 0.001 is less than 0.05, see also Table 4). Therefore, statistically decision makers significantly preferred integrating the composting to integrating the informal sector. Figure. 4 shows a descriptive figure of each group's perspectives regarding the scenarios.

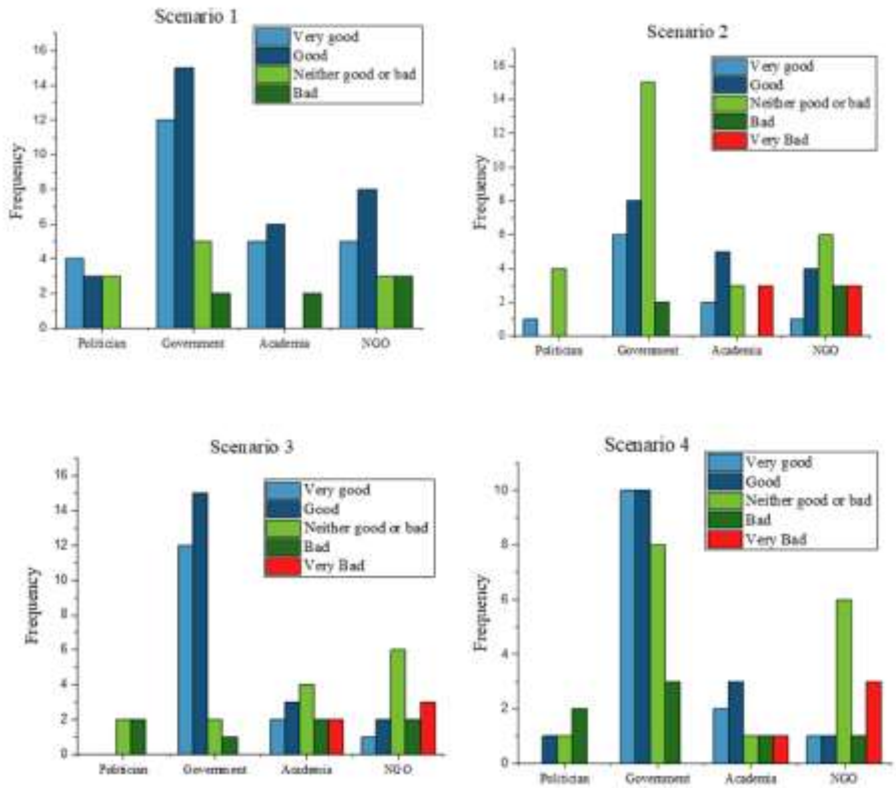


**Figure. 4. Opinion of each group toward scenarios**

### 5.3 SWM Materials Disposal

Nevertheless, more investigation revealed that the respondent lacked adequate recycling understanding. Only two types of recyclable materials were found to be recycled, according to the investigation of how they handled their waste. Figure 5 illustrates how recycling processing techniques differ depending on the type of material, which is in contrast to the earlier finding. The outcome shows that the respondents' degree of recycling knowledge and comprehension is in line with the low level of execution. Over 50% of basic recyclable materials, such as newspapers, magazines, used clothing, and other papers, were collected. The current state of affairs, in which few materials are sold to door-to-door collectors, is the reason for this response. Private collectors or non-governmental organisations (NGOs) use a range of methods, particularly trucks or vans, to collect items door to door. However, the majority of homes throw all of their waste—including plastics, glass, food scraps, and polystyrene—into the trash can without sorting it first. However, the results also show that recycling rates for PET, plastic, and aluminium bottles are acceptable (40% to 48%).

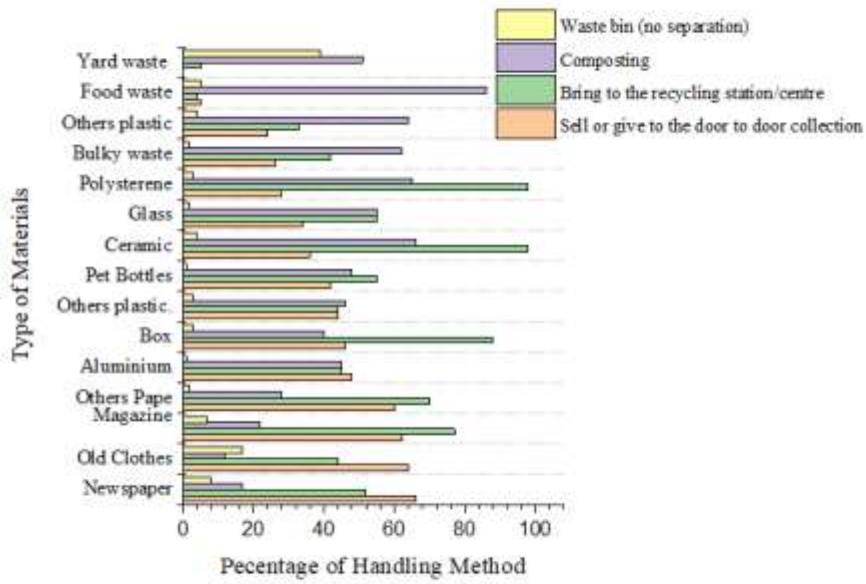


**Figure 5 Handling methods of SWM by materials.**

### 5.4 Mean analysis for 4 scenarios

The structure should also make it easier to plan and run the system. For example, the definition of "solid waste" should do more than just assign blame; it should also include data that could help address technological concerns related to the choice of waste management systems. Provisions in the legal framework that enable efficient enforcement of the regulations are necessary. The scenario with the lowest mean score, which involves integrating composting from homes and communities and moving from open dumping to sanitary landfills, was determined to be the most favoured option. The scenario with the lowest mean score is the one that is favoured above the others. Every country ought to have an integrated sustainable solid waste management (ISSWM) policy that addresses issues like hygienic practices, upholding public health standards, protecting the environment, and continuing financial support. Regarding the availability of landfill area for upcoming generations, the policy ought to consider sustainability. The mean, median, variance, valid was evaluated for the 4 scenarios in this research. The median was common in all the scenarios 1, 2, 3 (the value is 3) expect scenario 4 (the value is 3.4). The mean value was high in scenario 3, which was 3.73, and low in scenario 1 (2.24). The valid point was 56 for all the 4 scenarios. The variance was high in scenario 3 (2.582) and low in scenario 1 (1.413). These are all explained in Table 5.

**Table 5: Based on respondents' assessments of the mean score, the mean, median, and final ranking of the scenarios**

| | | | | |
|---|---|---|---|---|
| Ranking | 1 | 2 | 3 | 4 |
| Median | 3 | 3 | 3 | 3.4 |
| Variance | 1.413 | 2.511 | 2.582 | 2.263 |
| Valid | 56 | 56 | 56 | 56 |
| Mean | 2.24 | 3.35 | 3.73 | 3.65 |
| Scenario | 1 | 2 | 3 | 4 |

### 5.5 Scenario analysis

Scenario 1, with the lowest mean score, which involves integrating composting from homes and communities and moving from open dumping to sanitary landfills, was determined to be the most favoured option. The scenario with the lowest mean score is the one that is favoured above the others. For all scenarios, including the inclusion of the unorganised sector (scenario 2), there was no statistically significant difference between the responses from male and female participants. The study employed one-way ANOVA analysis to examine the scenario rank (as the dependent variable) and gender mean (as a factor). According to the data, gender differences had no statistically significant effect on scenario rank (Table 6). The significant value was less than 2.021. In the F-test, the maximum and minimum values were reached in scenarios 1 and 2. The Figure 6 was 1.573 and 2.847. In scenario 4, the significance value of 1.987 was reached at its highest. In scenario 2, a minimal significance value of 1.234 was obtained. An independent sample t-test comparing scenarios 3 and 4 reveals no statistically significant change in mean scores. This is not the same as the t-test that compares situations 1 and 2. Put another way, by including the WTE facility in the scenario, there is statistically no difference between incorporating the informal sector and composting. The explanation can be the severe disapproval of WTE facilities held by all Indian stakeholders.

**Table 6 independent t-test to check for mean equality**

| Scenario | F | Significance |
|---|---|---|
| 1 | 1.573 | 1.342 |
| 2 | 2.847 | 1.234 |
| 3 | 1.879 | 1.452 |
| 4 | 1.673 | 1.987 |

Operational systems comprise the handling of materials and treatment procedures that are used to regularly collect, transport, process, and dispose of waste produced from various sources. There must be integrated mechanisms for tracking and managing operations, as well as clearly defined processes and standards for every part system.

**5.6 Understanding Sustainable Solid Waste Management: Raising Public Awareness and Participation**

In order to forecast recycling behaviour, knowledge is crucial. Increasing information will essentially cause behaviour to alter. Understanding home recycling involves knowing what, where, when, and how to do it in real life. The results for individuals who selected "Yes" on the list of recycling-related knowledge are displayed in Figure 6. The findings indicated that the majority of responders had some recycling expertise. 96% of respondents thought they knew what kind of materials could be recycled. The majority of respondents—85%—admitted that they were aware of how to separate waste from their homes.

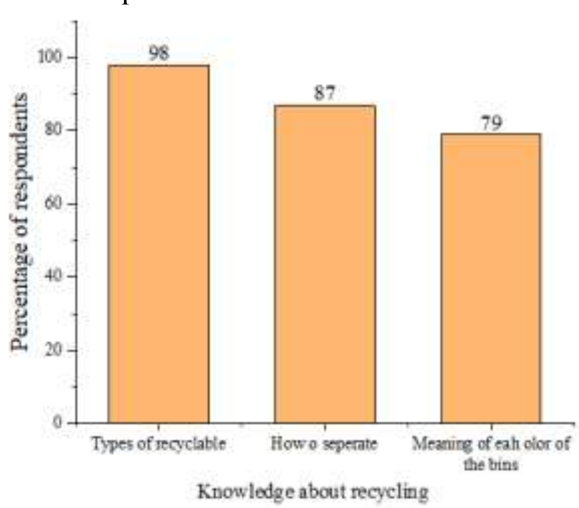


**Figure 6 Knowledge about recycling.**

### 5.7 Technological aspects of SWM

The design of an ISSWM must take into account the types and amounts of waste that are present, as well as the current operating environment. Different types of handling equipment, such as vehicles, processing gear, and disposal equipment, need to be properly constructed based on the characteristics of the waste. To establish policy in this area, it is insufficient to understand how the informal sector helps divert recyclables from the waste stream. Persuading legislators and authorities is a difficult task. Public policies at the moment tend to be unfavourable to the unorganised sector. It makes sense why the majority of SWM policies are unfavourable when one considers how deep learning, artificial intelligence, and machine learning were used to create them. Historically, they have been motivated by the need to regulate public health and the negative effects of insufficient SWM on the environment. The debate that follows demonstrates how decision-makers in SWM view and feel about the unorganised sector.

## 6. Conclusion

Everyone uses the phrase sustainability in one way or another, from producers of commodities and service providers to international policy makers. It's uncertain whether these parties have the same definition of what "sustainable development" means. According to estimates, the rate at which resources are extracted now is 10,000 times higher than the rate at which they are created. There's a slim probability that this ratio will alter dramatically in the near future. Furthermore, it's not apparent if SWM can make a significant contribution. Therefore, developing sustainable SWM as opposed to SWM for a sustainable society would be preferable. The SWM method ought to work with a society's available funds as well as the assimilation potential of the surrounding area. One important factor in removing recyclables from garbage is the informal sector. The SWM analysis in Indian City includes 57 public from both genders and 5073 informal sector workers in the business sector. The informal sector collected at least 13% (by weight) of the waste streams created in the city of Bandung. To determine the better findings, an ANOVA technique was used to analyse the test data. However, decision makers' perceptions of the informal sector have not changed as a direct result of this material flow information. The F-test was maximum in scenario 2, which is 2.847, and significance was achieved higher value in scenario 4 (1.987). The minimum value of f-test and significance was in scenario 1 and scenario 2

### 6.1 Future enhancement

The least desirable scenario for integrating the informal sector indicates that the informal sector is not well-liked by decision makers. The authors contend that there is still a significant obstacle in persuading decision makers, using four distinct scenarios, to shift from bias to constructive involvement, such as the merger of the informal sector into the formal sector. In order to fully comprehend the ramifications of the reorganisation of the financial, social, and economic, and environmental gains from the informal recycling, it is advised that this topic be properly researched. It's not simple to include the unorganised sector in SWM. The integration of the informal economy presents challenges for decision makers. On the one hand, the unorganised sector supported SWM, but it still needs social rights and basic services. However, as technology and collection improve, the informal sector's participation will decrease.

## REFERENCE

1. Yoshida, M. Social development and the environment—a view from solid waste management. *International Development and the Environment: Social Consensus and Cooperative Measures for Sustainability*, (2020): 27–43.
2. Bundhoo, Z. M. Solid waste management in least developed countries: current status and challenges faced. *Journal of Material Cycles and Waste Management*, 20 (2018): 1867–1877.

3. Das, S., Lee, S. H., Kumar, P., Kim, K. H., Lee, S. S., and Bhattacharya, S. S. Solid waste management: scope and the challenge of sustainability. *Journal of Cleaner Production*, 228 (2019): 658–678.
4. Godfrey, L., Ahmed, M. T., Gebremedhin, K. G., Katima, J. H., Oelofse, S., Osibanjo, O., and Yonli, A. H. Solid waste management in Africa: governance failure or development opportunity. *Regional Development in Africa*, 235 (2019).
5. Guo, W., Xi, B., Huang, C., Li, J., Tang, Z., Li, W., and Wu, W. Solid waste management in China: policy and driving factors in 2004–2019. *Resources, Conservation and Recycling*, 173 (2021): 105727.
6. Mukhtar, E. M., Williams, I., and Shaw, P. Visibility of fundamental solid waste management factors in developing countries. *Detritus*, 1 (2018): 162–173.
7. Vertakova, Y. V., and Plotnikov, V. A. The integrated approach to sustainable development: the case of energy efficiency and solid waste management. *International Journal of Energy Economics and Policy*, 9(4) (2019): 194–201.
8. Khan, S., Anjum, R., Raza, S. T., Bazai, N. A., and Ihtisham, M. Technologies for municipal solid waste management: current status, challenges, and future perspectives. *Chemosphere*, 288 (2022): 132403.
9. Kubanza, N. S., and Simatele, M. D. Sustainable solid waste management in developing countries: a study of institutional strengthening for solid waste management in Johannesburg, South Africa. *Journal of Environmental Planning and Management*, 63(2) (2020): 175–188.
10. Ike, C. C., Ezeibe, C. C., Anijiofor, S. C., and Daud, N. N. Solid waste management in Nigeria: problems, prospects, and policies. *Journal of Solid Waste Technology and Management*, 44(2) (2018): 163–172.
11. Yukalang, N., Clarke, B., and Ross, K. Solid waste management solutions for a rapidly urbanizing area in Thailand: recommendations based on stakeholder input. *International Journal of Environmental Research and Public Health*, 15(7) (2018): 1302.
12. Wang, F., Cheng, Z., Reisner, A., and Liu, Y. Compliance with household solid waste management in rural villages in developing countries. *Journal of Cleaner Production*, 202 (2018): 293–298.
13. Azevedo, B. D., Scavarda, L. F., Caiado, R. G. G., and Fuss, M. Improving urban household solid waste management in developing countries based on the German experience. *Waste Management*, 120 (2021): 772–783.
14. Hondo, D., Arthur, L., and Gamaralalage, P. J. D. Solid waste management in developing Asia: prioritizing waste separation. (Year not specified).
15. Madeshwaren, V., Veerabathran, S., and Kunal, K. Ecowaste framework leveraging PSO-CNN for precise and sustainable biomedical waste management in cities. *Global Nest Journal*, 27(1) (2025).
16. Madeshwaren, V., Gandhimathi, R. S., and Kunal, K. Efficient biomedical waste management: optimizing segmentation and classification with EnU-Net-DNN-BMWC. *Global Nest Journal*, 26(10) (2024).
17. Madeshwaren, V., Gunasekaran, U., and Sankaranarayanan, B. Analysing the barriers to effective segregation and recycling in biomedical waste management: a fuzzy DEMATEL analysis. *Journal of Environmental Protection and Ecology*, 25(6) (2024): 1846–1853.