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# Landfill Reduction In The Context Of Sustainable Waste Management: A Case Study Of Bengaluru

**Sangeetha Kulala K[1*] and Prof. S. Manasi[2]**
[1]Ph.D. Scholar, Centre for Research in Urban Affairs, Institute for Social and Economic Change, Nagarabavi, Bengaluru, India
[2]Professor, Centre for Research in Urban Affairs, Institute for Social and Economic Change, Nagarabavi, Bengaluru, India

***Abstract***
*Municipal solid waste generation is the fundamental problem for Bruhat Bengaluru Mahanagara Palike (BBMP) in Bengaluru due to urbanization and an expansion of population. The main objective of the study is to examine the key stakeholders' waste management practices across Bengaluru city. This study is completely based on the qualitative research method. The key stakeholders of this study are Resident Welfare Associations (RWAs), non-governmental organizations (NGOs), corporate offices, Information Technology (IT) parks, educational institutions, BBMP, temples, and markets. The stakeholders are involved in waste segregation, composting, recycling, and waste-to-energy initiatives. Hence, 39.39% of the city waste is diverted from landfills, and 21.82% of the waste is diverted with the help of windrow composting plants. Additionally, the study recommended that public awareness, participation in waste management activities, enforcement of the various government policies, waste-to-energy projects, and technological interventions in waste management activities are essential to reduce the landfill burden in the city.*
***Keywords:*** *Solid Waste Management, Circular Economy, Waste Diversion, landfill, Sustainability, and Bengaluru.*

## 1. INTRODUCTION

Solid waste management is a major problem for almost all developing countries in the world, including India. Bengaluru is one of the most popular metropolitan cities and generates 5500TPD of waste. Hence, it is a major challenge for BBMP to manage the waste systematically due to urbanization, population expansion, changing consumption patterns, and economic growth. Under a linear economy, waste completely depends on landfills without any waste management initiatives. But in recent years, various stakeholders have been taking a lot of initiatives to shift from the linear economy to the circular economy approach, which emphasizes more on reduce, reuse, recycle, and sustainable waste processing methods.
The solid waste management system in Bengaluru city highly depends on various stakeholders, including government agencies like the Bruhat Bengaluru Mahanagara Palike (BBMP), private institutions, NGOs, RWAs, environmental activists, and community-based initiatives. Leaf, lane, vermicomposting method, windrow composting, and bio-methanation or waste-to-energy project initiatives have collectively contributed to the waste diversion from the landfill. However, despite these initiatives, most of the city waste is still ending up in the landfill due to a lack of awareness about 3R's(reduce, reuse, and recycle) and a lack of segregation of the waste at ground level, an inefficient waste collection and treatment system and poor implementation of waste management policies.
The main objectives of the study are to identify the waste diversion strategies from a circular economy perspective and to determine the key stakeholders' initiatives to manage the waste across Bengaluru city. This study incorporated the key stakeholders to manage the waste, which include members of Resident Welfare Associations (RWAs), non-governmental organizations (NGOs), corporate offices, IT parks, educational institutions, shopping malls, temples, and markets.

## 2. REVIEW OF LITERATURE

Urbanisation, population growth, and an overabundance of resource demand in cities have resulted in significant waste-related environmental and socioeconomic problems. Many countries throughout the world have completely embraced CE principles and abandoned the use of outdated waste management procedures and regulations (Mathews & Tan, 2011). When low- and middle-income nations adopt CE

policies and practices, they face a number of challenges, including a lack of information and a lack of expertise about the implementation procedures (Su et al., 2013)

Local government is mainly responsible for managing the waste in the city. They are involved in spreading awareness among the public about waste segregation, disposal, and treatment at the household level. However, in recent years, they have been facing the problem of a lack of finance and support from the organization to manage the waste systematically in the city (Yukalang et al., 2017). A few years ago, economic expansion was highly dependent on the linear economic system (Millar et al., 2019). According to Shanks et al., 2016, state that the current linear manufacturing model completely depends on the production process, including product design and framework, raw material extraction, manufacturing, consumption, and final disposal (Shanks, 2016). However, waste has been dumped in landfills regularly due to inadequate waste management and the linear economic system (Widomski et al., 2017).

In order to enhance the scientific waste management process in the urban city, this study emphasised more on sustainable waste management activity through the circular economy system. The CE main intention is to divert the waste from the landfill and convert the waste into a resource with the help of the economic cycles of resource flows (Haas et al., 2015). Now, it is very significant to inculcate the circular economy principles into the sustainable waste management system. Further, it helps to improve the ecosystem, health, and quality of life of the public, improve the sustainability of the environment and community in the city, creation of jobs, enhance economic growth and development (Elsheekh et al., 2021).

There are two categories for solid garbage: dry waste and moist trash. The city's NGOs Hasirudala and DWCC pick up the dry waste every two weeks. Additionally, they transfer the material to the recycling centre after separating it into various streams. The city of Bengaluru produced the most organic trash (61% daily) (Schneider, 2017). Because of this, BBMP, NGOs, SHGs, households, and people are more concerned with recycling organic waste through the use of vermicomposting, windrow composting, leaf composting, lane composting, aerobic and anaerobic composting, and other techniques (Naveen & Sivapullaiah, 2020). In order to turn biodegradable trash into compost and electricity, BBMP has set up facilities for wet waste processing and biomethanation. garbage management is crucial for developing solutions for reuse that add economic value in addition to reducing the amount of garbage that ends up in landfills. Moving from a linear economy to a circular economy presents challenges for waste management in this setting (Amoah & Kosoe, 2014). Environmental deterioration is exacerbated when waste builds up in landfills and disposal sites, contaminating groundwater and releasing greenhouse gases. Additionally, diseases like respiratory and vector-borne disorders are spread by inappropriate trash disposal (Mainul, 2019). There are social, economic and environmental consequences affecting the overall well-being and quality of life.

The inefficient management of solid waste has led to several environmental problems. Poor disposal practices and insufficient waste treatment contribute to pollution of air, water, and soil, causing harm to ecosystems and human health (Mohan and Joseph, 2021). Accumulation of waste in landfills and dumping sites emits greenhouse gases and contaminates groundwater, worsening environmental degradation. Additionally, improper waste disposal contributes to the spread of diseases, including vector-borne and respiratory illnesses (Mainul, 2019). The consequences are not only environmental but also social and economic, affecting the overall well-being and quality of life

Numerous environmental issues have resulted from the ineffective management of solid waste. Ecosystems and human health are harmed by air, water, and soil pollution brought on by improper disposal methods and inadequate waste management.

## 3. METHODOLOGY

This research Is based on the qualitative research method and a review of the literature. The data collection was done by interview of 36 participants including officials/members of RWAs(7), NGOs(5), Educational institutions(4), BBMP officials (5), Corporate Offices(4), IT parks officials (4), temple Managers (4) and Market management team members (2). The duration of the interview for each participant was 45 minutes to 1 hour. The data was collected during the period from June 2022 to February 2024. Participants were selected by a non-probability sample method under which a purposive

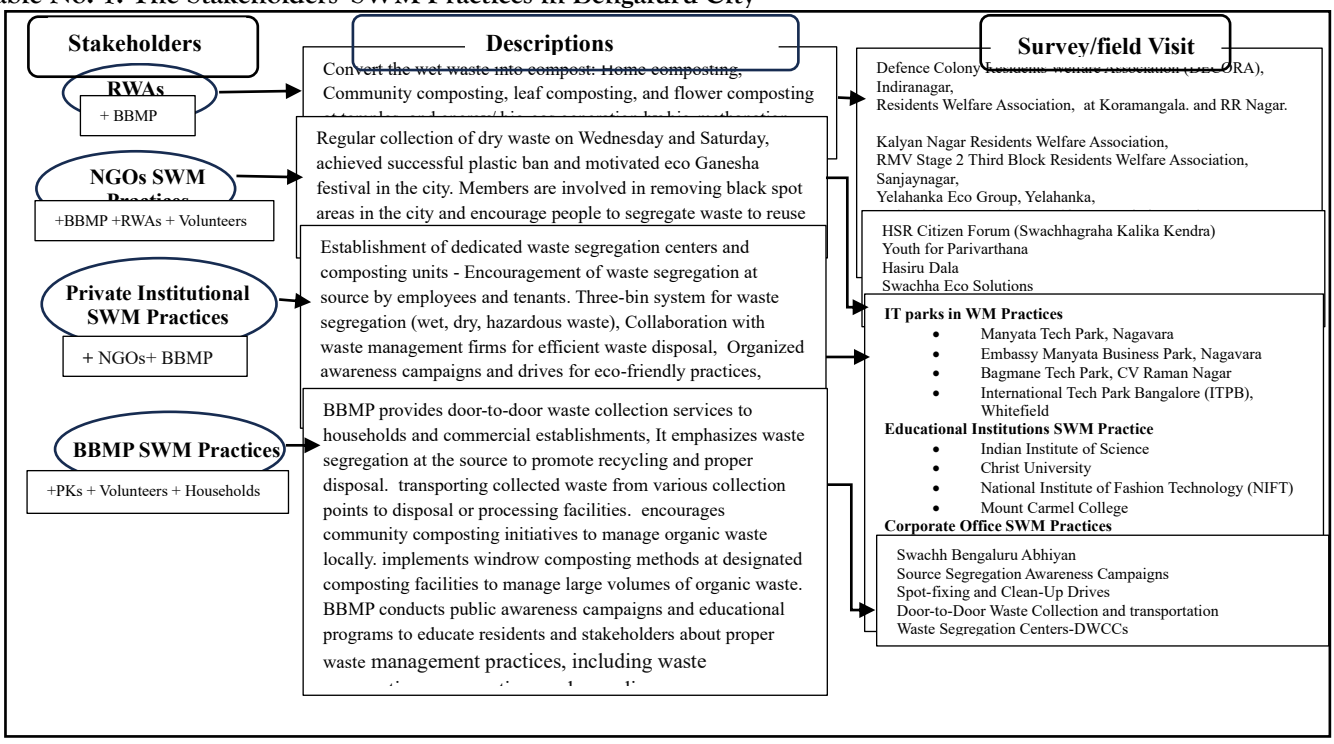
and snowball sampling technique were employed. Further, various secondary sources of data, such as official documents, e-newspapers, articles, and peer-reviewed journals, were used. This research was conducted in Bengaluru city, Karnataka, India.

## 4. RESULTS AND DISCUSSION

### 4.1 Waste Diversion Strategies in Bengaluru City

In this study, waste diversion strategies are classified into 2 ways: 1. Stakeholders' participation in SWM (Table No.1) and 2. Other SWM practices (Table No. 2).

**Table No. 1: The Stakeholders' SWM Practices in Bengaluru City**




Source: Survey/Field Visit

#### 4.1.A. Stakeholders' participation in SWM

##### 4.1.A.1. RWAs SWM practices

Resident Welfare Associations (RWAs) have played a significant role in managing waste in the city by spreading awareness about segregation, as well as home, lane, and leaf/flower composting initiatives among households. Furthermore, with the assistance of volunteers and NGOs, RWAs have taken the initiative to remove the black spots and create a cleaner environment in the Bangalore city.

For instance, Ward No. 80, the Defence Colony Residents Welfare Association (DECORA) in Indiranagar has been implementing waste management initiatives since 1990. Initially, 800 households and 500 registered members have taken the initiative in composting and waste segregation activities. Similarly, Ward No. 151, the Koramangala Block 1 Residents Welfare Association, emphasized maintaining cleanliness and eliminating the black spots are the main priority to manage the waste systematically. There are 400 households in the ward. Ward No. 27, The Kalyan Nagar Residents Welfare Association, Banaswadi initially took support from the BBMP until 2019, after that, they have taken independent initiatives to ensure a cleaner neighbourhood.

RWAs in RMV Stage 2 Third Block, Sanjaynagar, are not satisfied with the waste management activities of BBMP. Hence, they have taken the initiatives to maintain the cleanliness and remove the black spots in the city. Ward No. 58, Tippasandra, The HAL Stage 3, Tax Payers Residents Association and Wards No. 1-11 Yelahanka Eco Group have given priority to spread the awareness among the households and active participation in the waste management activity to achieve the sustainable waste management. Ward No. 35, Sadashivnagar, Residents Welfare Association has taken the initiative to inculcate the home, leaf,

lane, and flower composting methods to achieve the circular economy and sustainable waste management system in the city.

Further, Ward No. 160, the Rajarajeshwari Nagar I Care Residents Welfare Association given priority in lake rejuvenation programs and aims to enhance the environmental conditions in the region. Under a decentralized waste management system, these RWAs have played a pivotal role in diverting waste from the landfill with the help of composting and community-driven sustainability initiatives. These initiatives emphasised the significance of public participation in managing waste in the city, and they also became a lesson for other residential communities to implement sustainable waste management practices.

**4.1.A.2. NGOs SWM practices**

In Bengaluru, NGOs have played a pivotal role in managing the waste systematically with the help of 3 R s'(reduce, reuse, and recycle). In the HSR layout, the HSR Citizen Forum has taken the initiative to spread awareness among the households about segregation, composting, as a result, 0.5 TPD of the waste is diverted from the landfill. Youth for Parivarthana has 5,000+ volunteers and is actively involved in a clean-up drive, recycling program, and motivating the public to celebrate the eco-friendly festival to achieve the circular economy in the city. In Bengaluru, there are a total of 164 dry waste collection centres. In which 33 dry waste collection centres are managed by Hasiru Dala. With the help of Hasiru dala initiatives, 88.35 TPD of the waste is diverted from the landfill. Swachha Eco Solutions has given services to a total of 392,000 households in the city. They have given the main priority for recycling, composting, and protecting the safety of the waste workers. Adamya Chetana has given main emphasis on reducing waste with the help of Reusable Plates and Cutlery Banks, a Zero Garbage Kitchen, and a Fossil-Free Fuel Kitchen. These initiatives help to divert 300kg of waste per day from the landfill. These NGOs collectively support the public in sustainable waste management and generate employment opportunities for waste pickers/workers in the city. These NGOs' initiatives help multiple stakeholders in the circular economy waste management process and make the city a role model for other cities in the country.

**4.1.A.3. Private Institutional SWM Practices**

**4.1.A.3.a. IT Parks in WM Practices**

The IT parks have taken the circular economy initiatives to manage the waste in the city. They have given a greater contribution to reducing the environmental footprint. Manyata Tech Park has been able to divert 11.11 TPD of the waste with the help of segregation, vermicomposting, and awareness campaigns. Embassy Manyata Business Park has diverted 69.66 TPD of waste using waste bins, composting, and a biodigester. Bagmane Tech Park inculcated the recycling and sustainable waste management practices. International Tech Park Bangalore (ITPB) has received support from waste management agencies to ensure the proper segregation and disposal of the waste, along with the concept of diverting the waste from the landfill.

**4.1.A.3.b. Educational Institutions' SWM Practice**

This study examined several educational institutions, including the Indian Institute of Science (IISc), Christ University, National Institute of Fashion Technology (NIFT), and Mount Carmel College. These institutions are actively involved in raising awareness about waste management among students and teachers. They are incorporating sustainable waste segregation, recycling, and composting practices into their premises. In recent years, they have collaborated with non-governmental organizations (NGOs) to enhance the efficiency of their sustainable waste management activities within their limits.

IISc has initiated the conversion of green waste into biogas with the help of a bio-methanation plant. As a result, this institution has diverted 0.7 tons per day (TPD) of waste from the landfill. Christ University has diverted 0.675 TPD of waste from the landfill with the help of segregation, bio-gas generation, reuse, and recycling practices. NIFT Institute has collaborated with NGOs to manage waste systematically. However, they have diverted 0.32 TPD of waste from the landfill with the help of an upcycling and recycling program.

These institutions promote sustainability and environmental responsibility. Mount Carmel College has diverted 0.15 TPD of waste from landfills due to the student-led eco-club initiatives, such as spreading awareness about segregation, composting, and recycling practices among the students, faculty members with the help of NGO collaborations.

These educational institutions have been supporting the enhancement of sustainability and environmental practices. They collectively support waste segregation, reduction, reuse, recycling, resource conservation, and the inculcation of circular economy principles in their premises. Their designed framework of waste management programs is essential to divert waste from the landfill, along with achieving a cleaner and greener city.

**4.1.A.3.c. Corporate Office Waste Management Practices in Bengaluru**

This study evaluated the major corporate offices such as Infosys, Wipro, Accenture, and IBM in Bengaluru. These institutions have incorporated various waste management practices, i.e., segregation, reduction, reuse, recycling, composting, and banning plastics on their premises to enhance sustainable waste management practices. These institutions have collaborated with NGOs, along with the waste vendor, pourakarmikas, and employees, to enhance resource conservation and protect the environment.

Infosys has taken the initiative to achieve the circular economy principles across its campuses. Hence, they have processed 100% of their wet waste with the help of nine automated biogas systems and eight organic waste converter composting bins. This bio-gas system has an annual capacity of 3,700 tons and can convert the wet waste into biogas, which they use for the campus kitchen. The composting bin can convert the waste into organic compost. Additionally, they have taken the initiative to reduce single-use plastic consumption by 91% since 2018 to achieve their sustainability goals. The company has incorporated 17 biogas and composting units across its Indian campuses to enhance circular economy practices.

Wipro has incorporated sustainable waste management initiatives such as installing waste segregation bins, enhancing recycling programs for paper, plastic, and e-waste across its campus. Further, they have taken measures to reduce paper waste and improve disposal, and they have adopted digitalization to reduce physical documentation with electronic records.

The company has conducted several training programs to maintain sustainable solid waste management practices across the campus. Wipro has been able to divert waste from the landfill, with 80% of the inorganic waste is diverted from the recycling process through approved partners, and the remaining 20% of the wet waste is sent to animal feed.

Accenture India has taken major initiatives to reduce the waste that goes into the landfill. They are mainly focused on waste segregation, recycling, and reducing food waste. During 2022, 99% of the e-waste was reduced and recycled, along with the concept of avoiding single-use plastics across its campus. Further, employees have collectively taken the initiative to spread awareness about segregation, waste reduction, recycling, and environmental protection programs to achieve sustainable waste management on the campus.

Like these companies, IBM India follows similar sustainable waste management practices. The company has given priority to conducting various training programs relevant to adopting the circular economy principles, along with enhancing energy consumption efficiency. During 2019, 35,700 metric tons of non-hazardous waste were diverted from the landfills. Hence, 88.8% of the waste was successfully recycled with the help of waste management initiatives. As per the company records, 1.08 million metric tons of product waste are collected and processed. It has successfully reduced 39.7% of carbon emissions.

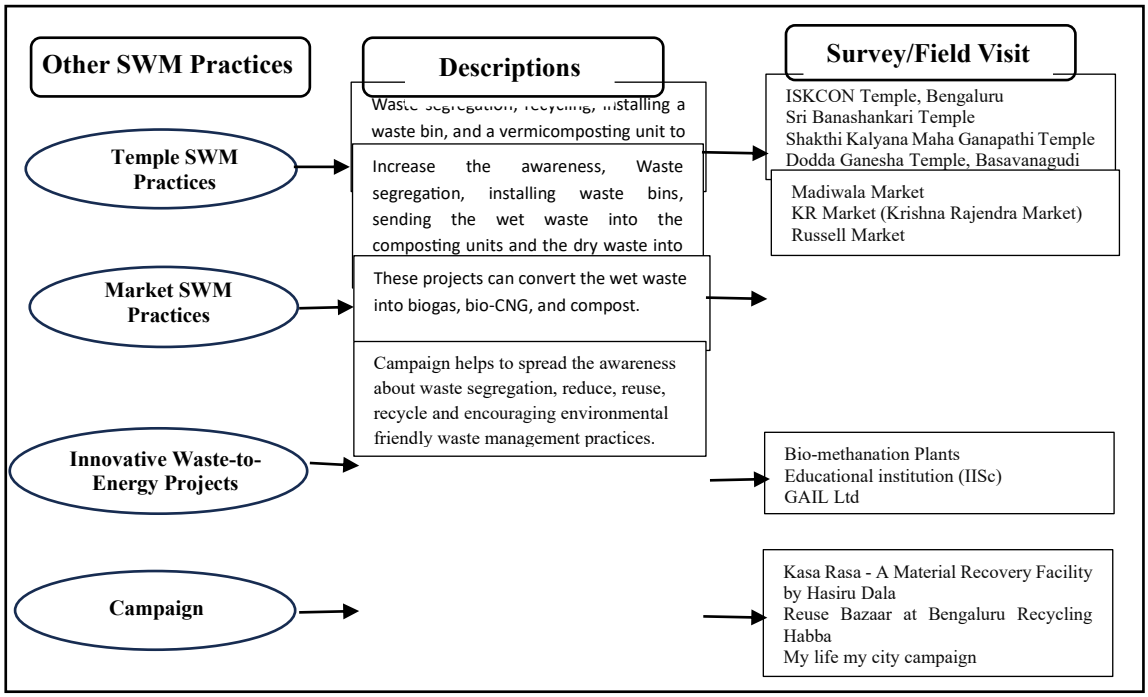
Therefore, these corporate offices' sustainable waste management practices can reduce waste from the landfill, along with reducing the carbon footprint, improving the recycling process, converting waste into energy, and compost initiatives. They are given more priority to achieve a sustainable urban ecosystem.

**4.1.A.6. BBMP's SWM practices**

The Bruhat Bengaluru Mahanagara Palike (BBMP) has been facing a lot of challenges in managing waste systematically. Hence, in recent years, BBMP has taken various initiatives such as a focus on waste segregation at the source, community engagement, cleanliness drives, and infrastructure development. Furthermore, it has been implementing various government policies along with the Swachh Bharat Abhiyan. This initiative encourages waste segregation and public awareness to reduce waste and maintain a clean and green environment in the city. BBMP has been conducting a waste management awareness campaign to educate the public about waste segregation and the disposal system. Additionally, with the help of NGOs, Resident Welfare Associations (RWAs), community leaders, and environmental activists, BBMP has been able to tackle illegal dumping and public space cleanliness, spot-fixing, and clean-up

drives. It has improved the door-to-door waste collection services to maintain hygiene across the city. BBMP has collaborated with NGOs like Hasirudala and has been able to establish 164 dry waste collection centres to encourage waste segregation, recycling, and resource recovery across Bengaluru. Furthermore, it has incorporated windrow composting and bio-methanation units to convert wet waste into compost and energy. With the help of these initiatives, BBMP has been able to enhance energy generation and sustainable agricultural practices. These initiatives of BBMP have been able to divert 1,200 metric tons of organic waste per day (TPD) from landfills.

**Table No. 2: Other SWM Practices in Bengaluru City**




### 4.1.B. Other SWM Practices in Bengaluru City

#### 4.1.B.1. Temple SWM Practices

This study examines the major temples like ISKCON, Sri Banashankari Temple, Shakthi Kalyana Maha Ganapathi Temple, and Dodda Ganesha Temple. These temples have taken the initiative to convert the wet waste into compost within the premises, and dry waste generated in the premises is sent to the recycling facilities. ISKCON Temple has taken the initiative to spread awareness about waste segregation, installed different types of waste bins and a composting plant, and recyclable items generated from the temple go to the recycling units. Like the ISKCON Temple, Sri Banashankari and Shakthi Kalyana Mahaganapathi Temples have been implementing almost similar waste management initiatives. Dodda Ganesha Temple has adopted the principle of circular economy. Hence, they reduced the single-use plastic items and containers, and motivated the devotees to bring their containers for prasadam. These sustainable waste management practices help to divert the temple waste from the landfill and maintain a cleaner and more hygienic environment in the city.

#### 4.1.B.2 Market - SWM practices

This study mainly incorporated the KR Market, Madiwala Market, and Russell Market. In these three markets, various stakeholders, including NGOs, RWAs, BBMP, vendors, environmental activists, and pourakarmikas, have taken the initiative to divert waste from the landfill. Hence, they are involved in spreading awareness among the public about waste segregation, recycling, and composting. Further, they have taken the initiative to convert wet waste into biogas. The KR market has diverted 1.67 TPD of waste from landfills, and Russell Market has diverted 1.33 TPD of waste with the help of various sustainable waste management practices.

**4.1.B.3 Innovative Waste-to-Energy Projects**

This study has highlighted waste-to-energy projects in Yelahanka, Koramangala, and GAIL Ltd. because most of the wet waste generated from the city is sent to the biogas plant. In these plants, they can divert organic waste into biogas, CNG, and compost. Each bio-methanation plant has a capacity of 5.56 TPD and diverts 1.66 TPD of waste from landfill. GAIL Ltd.'s bio-methanation plant has collaborated with the BBMP and treated 300 TPD of wet waste. As a result, it has been able to produce 10.7 tons of bio-CNG daily. These waste-to-energy projects can produce bio-CNG, which is used by BMTC buses, streetlights, and parks. These sustainable waste management practices and energy generation initiatives help Bengaluru to achieve a cleaner and greener environment in the city.

**4.1.B.4 Campaign**

BBMP has been taking many initiatives to achieve the circular economy principles in the city. The My Life My City campaign has motivated the public to reduce, reuse, and recycle (3Rs) of the waste, which indirectly helps to divert the waste from the landfill. Kasa rasa initiatives by the Hasirudala have diverted the 300 TPD of waste from the landfill. Further, 40 tonnes of waste were diverted from an exchange of reusable items by the Reuse Bazaar at Bengaluru Recycling Habba. These initiatives help to spread environmental awareness, reduce the landfill dependency, enhance the stakeholders' participation, and achieve sustainable waste management practices in the city.

Table No. 3 indicates the stakeholders' participation in solid waste management (SWM) across the stages in Bengaluru. RWAs, NGOs, IT parks, corporate offices, educational institutions, BBMP, temples, and markets are actively involved in waste generation, segregation, and treatment practices. But the collection and transportation of the waste is the complete responsibility of the BBMP and NGOs in the city. However, BBMP is the primary stakeholder to manage the waste in the city with the help of door-to-door collection efficiency, treatment, and waste disposal. Ultimately, these stakeholders actively participate in the sustainable waste management practices to reduce the landfill dependency in Bengaluru.

**Table No. 3: Various SWM Practices Across the Stages in Bengaluru City**

| **Stakeholders/ WM Practices** | **Generation** | **Segregation** | **Collection** | **Transportation** | **Treatment/Processing (Reduce, Reuse, Recycle)** | **Disposal/Lan** |
|---|---|---|---|---|---|---|
| RWAs | √ | √ | X | X | √ | X |
| **NGOs** | X | √ | √ | √ | √ | √ |
| IT Parks | √ | √ | X | X | √ | X |
| Educational | √ | √ | √ | X | √ | X |
| Corporate Office | √ | √ | X | X | √ | X |
| **BBMP** | | √ | √ | √ | √ | √ |
| Temple Waste | √ | √ | X | X | √ | X |
| Market Waste | √ | √ | √ | X | √ | X |
| **Other Initiatives** | √ | √ | X | X | √ | X |

Source: Study estimation by the author. Note: "√" indicates various practices present in the Waste Management Process; "X" indicates various practices not present in the Waste Management Process

**Table No.4: Estimated Volume and Percentage of Waste Diverted from Various SWM Practices**

| **Stakeholders/ SWM Practices** | **Estimated volume of waste diverted from landfill (TPD)** | **Estimated percentage of waste diverted from landfill** |
|---|---|---|
| RWAs | 3 | 0.05% |
| NGOs | 92.51 | 1.68% |
| IT Parks | 81.77 | 1.49% |

| | | |
|---|---|---|
| Educational | 1.845 | 0.03% |
| Corporate Office | 139.04 | 2.53% |
| BBMP | 1200 | 21.82% |
| Temple Waste | 0.34 | 0.01% |
| Market Waste | 3 | 0.05% |
| Other Initiatives | 644.98 | 11.73% |
| **Overall waste diverted from the landfill** | **2166.485** | **39.39%** |

Source: Author estimation based on the study

Table No. 4 shows that 2166.485 TPD of waste is diverted from landfills in Bengaluru, accounting for 39.39 % of the total waste. BBMP leads the efforts (21.82%), followed by corporate offices (2.53%), NGOs (1.68%), and IT parks (1.49%). RWAs, educational institutions, temples, and markets contribute minimally (<1%), indicating the need for improved waste management practices. 11.73% of the waste is diverted from other initiatives such as innovative waste-to-energy projects and reduce, reuse, and recycling campaigns. Expanding segregation, recycling, and composting initiatives across all sectors can further enhance waste diversion and sustainability efforts in the city.

## 5. CONCLUSION

Bengaluru's solid waste management system has been transitioned from a linear economy system to a circular economy system. But this is a challenging task for the BBMP to manage the waste from the CE perspective in the city. This study found that approximately 39.39% of the waste was diverted from the landfill due to the various stakeholders' initiatives in waste management activities such as BBMP (21.82%), corporate offices (2.53%), NGOs (1.68%), IT parks (1.49%), 11.73% of the waste is diverted from innovative waste-to-energy projects and reduce, reuse, and recycling campaigns and other stakeholders. BBMP has been facing several challenges in achieving the circular economy principles in the city. They are a lack of finance, inefficient infrastructure, inconsistent waste segregation, a lack of public awareness, and a lack of implementation of solid waste management policies. There is a need to enhance the solid waste management practices with the help of the collaboration of various stakeholders. These stakeholders actively participated in conducting awareness campaigns and installing the waste-to-energy projects and compost units in the city.

To achieve the circular economy principles, BBMP needs to focus on implementing effective policies in sustainable waste management, enhancing the investment in waste management infrastructure, technology, and transportation, improving the awareness campaigns, installing waste-to-energy projects, and windrow composting are essential to achieve zero waste in Bengaluru city.

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