A Multidimensional Analysis of Economic, Environmental, And Social Implications of Transitioning from Landfill-Based Waste Disposal to A Zero-Landfill Model

Tanaz S. Tamboli [1], Nikhil Vaiude [2], Harshad Raisoni [3]

[1] Researcher, Department of Planning, MITSOA, MIT-ADT University, Pune, India.

[2]Associate Professor, Department of Planning, MITSOA, MIT-ADT University, Pune, India.

[3]Associate Professor, Department of Planning, MITSOA, MIT-ADT University, Pune, India.

Corresponding Author: ttnz1904@gmail.com

Abstract: - A major challenge is posed by the growing issue of waste generation and its effects on the environment, the economy, and society. Landfills are overburdened due to rising populations and consumption habits, which pose a threat to the environment in the form of air and water pollution, greenhouse gas emissions, and health problems. The zero-landfill approach, which prioritizes waste reduction, recycling, composting, and other measures to reduce landfill-bound trash, has emerged as a possible remedy to this problem. With this paradigm, a shift to a circular economy is necessary, where waste is seen as a valuable resource that may be recycled, reused, or put to other uses. In addition to its positive effects on the environment, the zero-landfill model also has positive effects on the economy, including the development of jobs in the recycling and waste management industries, cost savings from lower waste disposal costs, and improved public health results owing to less pollution. A complete strategy encompassing policy reforms, infrastructure development, and individual behavioral improvements is necessary to implement a zero-landfill paradigm, nevertheless. It is critical to overcome obstacles like scarce resources and a lack of knowledge and instruction about trash reduction and recycling practices. Collaboration between organizations, enterprises, and people is essential for reducing waste creation and promoting sustainable patterns of consumption and production. The zero-landfill model is a pressing problem that necessitates group effort to reduce the negative effects of waste while promoting a more resilient and sustainable future.

Key Words: — ***Waste generation, Landfills, Zero landfill approach, Circular economy, Sustainable consumption, and production.***

I. INTRODUCTION

Due to its huge environmental and socioeconomic ramifications, waste management has recently taken on a more urgent worldwide significance. The conventional method of dumping waste in landfills has proven to be unsustainable, resulting in negative impacts like pollution, resource depletion, and poor health.

Manuscript revised September 22, 2023; accepted September 23, 2023. Date of publication September 24, 2023.

This paper available online at www.ijprse.com

ISSN (Online): 2582-7898; SJIF: 5.59

The idea of zero waste to landfill has gained popularity as a substitute and more sustainable waste management strategy in response to this dilemma. The zero waste-to-landfill models prioritizes waste reduction, recycling, composting, and other practices to reduce or eliminate the quantity of trash transported to landfills. It promotes a transition to a circular economy, in which waste is viewed as a useful resource that can be recycled, reused, or put to other uses.

This study aims to investigate the justification for the zero-waste-to-landfill model and to assess both its possible advantages and disadvantages. The goal of our thorough analysis is to highlight the benefits of this strategy from an environmental, economic, and social standpoint. We will also look into the several plans, laws, and tools that can help us move closer to zero waste to landfill. Environmental science, economics, and social science theories will all be used in this

multidisciplinary study. We will evaluate the reductions in the environmental impact brought about by waste diversion from landfills using a combination of literature research, case studies, and data analysis.

We will also examine the financial effects of adopting zero waste practices, such as cost savings, the creation of jobs, and resource efficiency. Finally, we will look at the social elements, looking at measures to engage the community, raise public awareness, and modify behavior that is essential for successful implementation. This study seeks to give policymakers, companies, and people looking to implement sustainable waste management methods useful insights on the significance and promise of zero waste to landfill. We anticipate that the results of this study will help shape sensible regulations and practices that will lead us toward a time when waste production is reduced, resources are saved, and societal and environmental well-being are given top priority.

II. Topic Overview / BACKGROUND Study / Literature Review

Solid waste management is a pressing global issue stemming from population growth, urbanization, and industrialization, leading to increased solid waste generation. Insufficient waste segregation exacerbates economic and environmental consequences. Effective solutions necessitate source segregation, comprehensive planning, and localized waste analysis. Global urbanization intensifies the waste crisis, with disparities in waste disposal practices across regions. Only 19% of waste is recycled globally, while 40% ends up in landfills. Low-income countries experience 93% open dumping, while high-income nations see 2%. Developing comprehensive waste management systems promoting segregation, recycling, and environmentally friendly disposal, alongside awareness and education, is paramount. Responsible waste management practices will mitigate environmental impact, conserve resources, and foster sustainability for future generations. (Namoun et al., 2022)

India, following China and the US, holds the position of being the third-largest producer of solid waste globally. However, India faces substantial challenges in garbage collection, transportation, treatment, and disposal. The rapid growth of India's urban population and average income has led to significant changes in urban consumption patterns, overwhelming urban local bodies (ULBs) with the escalating waste volume. Inadequate waste segregation and doorstep collection, inefficient treatment technologies, and indiscriminate waste dumping are among the major issues plaguing India's solid waste management (SWM) system. The generation of solid waste in India varies due to several factors, including population growth, increasing affluence, and evolving food habits. The impact of population expansion on waste generation is particularly pronounced in urban areas. (Singh, 2020).

The United Nations Development Programme (UNDP) has launched the Zero Waste Campaign to advance waste management and reduction strategies, with the ultimate objective of achieving zero waste to landfills and incineration by 2030. This campaign aims to foster the adoption of sustainable waste management practices across all sectors, including households, businesses, and governments, while promoting the principles of the circular economy, such as waste reduction, recycling, composting, and waste-to-energy conversion. Key areas of focus include advocacy and awareness-raising, capacity-building and knowledge-sharing, partnership-building, and the promotion of innovation and technology. By raising awareness, building capacity, fostering partnerships, and embracing innovation, The Zero Waste Campaign aims to encourage sustainable waste management practices and facilitate the transition to a circular economy. This initiative by the UNDP plays a vital role in promoting the significance of circular economy principles and establishing partnerships to realize the goal of zero waste to landfills and incineration by 2030. (UNDP Zero Waste Offer, n.d.).

Zero waste to landfills has several advantages, such as lowering greenhouse gas emissions, protecting natural resources, generating new business ventures and employment opportunities in the waste management and related sectors, fostering sustainability and social responsibility, enhancing public health and wellbeing, and preserving resources by extending the life of materials through recycling, reuse, and repurposing.

According to World Bank, in low-income countries over 90% of waste is not disposed of correctly. And in India, 77% of waste is disposed of in open dumps. And as per SDG 12.5 targets substantially Reduce Waste Generation, by 2030 through prevention, reduction, recycling & Reuse. According to CPCB 47,415, TPD is landfilled and a maximum number of landfill sites have been identified in Maharashtra with 382. Pernod Ricard, India’s fast-growing multinational alcohol beverage company, states that by 2050, India will need a landfill the size of New Delhi.

Implementing a comprehensive waste management system that puts waste reduction, reuse, and recycling ahead of waste-to-

energy or alternative disposal options is important to reach zero waste-to-landfill. This strategy calls for a mindset change away from the linear, "take-make-dispose" paradigm and towards a circular one that aims to increase the useful life of materials.

Overall, the zero-waste-to-landfill approach promotes a circular economy and a more sustainable future by reducing waste, conserving resources, and creating new economic opportunities. The primary objective is the proper segregation of organic & inorganic waste. Organic material is used in the biogas plant which eliminates transportation costs to landfill. Process all the waste at the ward level itself thereby reducing transportation and labor costs and subsequently eliminating the need for landfills. Landfill sites are partially responsible for global warming as they release methane gas & CO2 that cause climate change and an increase in the planet's temperature.

The concept of a circular economy holds significant potential for enhancing solid waste management (SWM) practices and achieving sustainable development goals. By prioritizing resource conservation, recycling, and the regeneration of natural systems, a circular economy approach can contribute to reducing waste generation and optimizing resource utilization in SWM. Incorporating circular economy principles into SWM can be accomplished through various strategies:

Waste prevention: Emphasizing waste reduction and encouraging reuse can effectively minimize the volume of waste generated. Measures such as promoting the use of refillable containers and implementing packaging waste reduction strategies can significantly contribute to waste prevention.

Recycling and material recovery: Establishing efficient recycling systems and promoting material recovery from waste streams can divert waste from landfills and preserve the value of recyclable materials. Recycling paper, plastic, and metal, among other materials, reduces the need for virgin resources and reduces environmental impacts associated with extraction and processing.

Waste-to-energy conversion: Harnessing the energy potential of waste through advanced waste-to-energy technologies offers an opportunity to generate renewable energy sources while minimizing reliance on fossil fuels. This approach can help mitigate greenhouse gas emissions and contribute to a more sustainable energy mix. By integrating circular economy principles into SWM practices, we can transition towards a more sustainable and resource-efficient waste management system. This approach not only addresses waste management challenges but also fosters environmental protection, resource conservation, and a greener, more resilient future.

2.1 Case Study 1 - Ambikapur, Chhattisgarh

Ambikapur, located in the state of Chhattisgarh, has become a shining example of effective solid waste management (SWM) in India. With a population of over 2 lakhs, the city has successfully implemented a comprehensive SWM system that has not only improved the environment but also created employment opportunities for the local community. Previously, Ambikapur struggled with poor waste management practices, including overflowing bins and indiscriminate dumping leading to a poorly managed landfill with hazardous emissions. However, in 2015, the district administration collaborated with stakeholders to develop an action plan for sustainable waste management. This involved training and forming Self-Help Groups (SHGs), implementing user charges and plastic bans, and establishing by-laws for waste management.

The SHGs joined forces to create the 'Swachh Ambikapur Mission Sahakari Samiti Maryadit, Ambikapur' to effectively manage waste. The town adopted the 'Garbage Clinic' model, with 17 Solid and Liquid Resource Management (SLRM) centers established. These centers collect source-segregated waste from different wards using pedal rickshaws and e-rickshaws. At the SLRM centers, waste is further segregated into non-biodegradable and recyclable categories. Recyclables are sent to recycling plants, while non-recyclables are baled, packed, and transported to reclaimed land for tertiary segregation into 156 categories. To support the SWM efforts, by-laws were introduced for solid waste, plastic, construction and demolition, and e-waste management. Non-recyclable waste is compressed into cubes and sold as fuel to cement plants. The success of the Garbage Clinic model can be attributed to the diligent work of the SHG workers, who raised awareness, and collected and segregated waste. During the COVID-19 pandemic, these workers even established a start-up unit to manufacture masks and sanitizers, addressing the town's shortage of these essential items.

The impressive achievements of the Ambikapur SWM system demonstrate the power of community engagement, awareness, and efficient waste segregation practices. By adopting innovative approaches and involving local stakeholders, Ambikapur has transformed its waste management landscape, showcasing a sustainable model for other cities in India and beyond to emulate.

2.1.1 Lessons learned

Ambikapur's successful waste management model highlights the significance of information, education, and communication (IEC) activities in creating awareness and engaging the public.

Regular follow-ups, penalties for non-compliance, and identification of littering spots have also played a crucial role. Continuous interaction with Self-Help Group (SHG) members and an ICT-based monitoring system have been instrumental in the city's waste management success. The key lesson learned is that waste should be viewed as a resource to be reduced, reused, or recycled rather than a liability. A decentralized approach involving the community is essential for sustainable waste management, promoting community participation, accountability, and a sense of responsibility. The government's efforts can be complemented by community initiatives for more efficient and sustainable results, emphasizing the need to merge both approaches.

2.2 Case Study 2 - Chandrapur, Maharashtra

Chandrapur, a city in Maharashtra, India, has faced environmental challenges due to rapid urbanization and industrialization. In the past, waste management practices were inadequate, with mixed waste being dumped in landfills and open burning being prevalent. However, since the inception of the Swachh Bharat initiative in 2016, significant improvements have been made. The city now segregates waste into three categories and implements a recycling and recovery process, resulting in 95% of waste being processed and recycled, with minimal landfill waste. Additionally, around 800 households have embraced home composting, reducing organic waste burden. To support these efforts, the Chandrapur Municipal Council has redesigned waste collection routes, introduced a two-bin-one-bag system for segregation, and established common community bins for e-waste. Waste collection is efficiently carried out using tricycles and auto tippers with GPS tracking. Public places are equipped with over three hundred compartmentalized bins, and an app called 'Recycle-U' facilitates waste collection. The council actively promotes composting at home by providing composters and offering to purchase the produced compost. Awareness programs, workshops, and fines for non-compliance have been instrumental in building capacity and encouraging waste segregation. The council has also introduced the "Adarsh Ward Competition" to promote effective waste segregation practices. At the landfill facility, specialized units handle different types of waste, including non-biodegradable waste processed into sub-categories, biodegradable waste treated through windrow composting, and hazardous waste managed by third-party vendors as per regulations. The scientific landfill unit serves as the final destination for waste that cannot be processed by other units. Overall, Chandrapur's comprehensive waste management infrastructure and community engagement have significantly improved the city's environmental sustainability.

2.2.1 Lessons learned

The waste management system implemented by the Chandrapur Municipal Council (CMC) highlights valuable lessons. One key lesson is recognizing waste as a valuable resource and implementing practices that transform it from a liability to a revenue source. Building appropriate infrastructure, including the landfill and necessary equipment, is essential for efficient waste management. Incorporating the existing informal workforce, such as former rag pickers, proves advantageous as they possess valuable traditional knowledge and skills, eliminating the need for extensive training. Offering stable employment opportunities to waste workers enables upward social mobility and fosters a sense of ownership in the waste management program.

III. RESEARCH METHODOLOGY

- The first step in the research process involves reading broad literature reports, books, and articles like "What a Waste 2.0," "CPCB report," and SDG goals to identify the need for the study. This step helps me to understand the current scenario of waste management and the challenges faced by different countries in achieving sustainable waste management.
- The second step involves studying detailed literature on types of waste, what is zero waste, zero waste policy, why to adopt a zero-waste approach, and identifying technologies for decentralized treatment. This step provides me with a better understanding of the concepts and technologies related to zero waste management.
- The third step involves studying case study models of Ambikapur, Chandrapur, and Taliparamba to achieve the first objective. These case studies help me to identify successful models of zero waste management and the strategies adopted by different cities to achieve their goals.
- The fourth step involves conducting primary and secondary surveys to achieve the second objective. The primary survey involves geo-mapping the city, photo documenting, and conducting household and stakeholder interviews. The secondary survey involves studying the DPR and assessing the existing situation. These surveys provided me with a

comprehensive understanding of the waste management system in the study area and the challenges faced by stakeholders.

- The fifth step involves data processing and analysis to identify areas of improvement with correct waste handling using technology. This step helps me to identify the gaps in the current waste management system and to come up with a waste diversion and minimization strategy.
- Finally, the last step involves applying the waste diversion and minimization strategy in Saswad City for validation. This step helps me to validate the effectiveness of the proposed strategy in a real-world scenario.

Saswad, located in the Pune district of Maharashtra, India, is a town known for its scenic beauty and rich cultural heritage. Situated alongside the Karha River and surrounded by lush green hills, Saswad offers a picturesque environment. The town enjoys good connectivity to Pune and other parts of the state through a well-connected highway. With a history dating back several centuries, Saswad holds significance as a historical and cultural hub. It has been ruled by notable Maratha leaders and served as an important center of the Maratha Empire. The town boasts several renowned historical sites, including Purandar Fort, Rameshwar Temple, and Jadhavwadi Dam. Agriculture and allied industries form the backbone of Saswad's economy. The town is known for its agricultural produce, including vegetables, wheat, and sugarcane. Additionally, small-scale industries, such as food processing and textile production, contribute to the local economy. In recent years, Saswad has witnessed significant development, leading to an increase in residential and commercial properties. The town is gradually gaining popularity as a tourist destination, resulting in the expansion of hotels and resorts in the vicinity.

Saswad Municipal Council has been taking steps to improve its solid waste management (SWM) practices. The presence of a landfill on the proposed airport boundary was a crucial factor in the decision-making process for selecting Saswad as a city. One of the key initiatives taken by the council is the Swachh Saswad Abhiyan, which is a cleanliness drive aimed at promoting awareness among the residents of Saswad about the importance of proper waste management. The council has also set up several waste segregation centers in the town where residents can segregate their waste into recyclable and non-recyclable categories. In the latest survey conducted in 2021, Saswad's ranking dropped to 82nd in the same category. Despite the drop in ranking, the council has implemented several measures such as setting up waste segregation centers, introducing door-to-door collection of waste, and setting up composting and recycling plants. These efforts are commendable and will undoubtedly contribute towards improving Saswad's ranking in future Swachh Survekshan surveys.

Efficient waste management in Saswad City requires household waste segregation, which is currently lacking. Without proper separation, waste collection and processing are affected. Although the waste processing centers have the capacity to handle 19TPD, only a fraction is processed, and the remaining mixed waste is disposed of. To effectively manage current and future waste generation, Saswad Municipal Council must enhance the existing system, including collection, transportation, treatment, and disposal.

IV. Results/ Findings & Discussions

Table.1. Proposed Waste Minimization and Diversion Strategy for Zero Landfill City Model

Output	Tasks
 100% Door To Door Collection	Conduct a thorough survey and mapping of the target area to identify all households and residential units. Divide the area into manageable zones or sectors for efficient collection. Develop a fixed collection schedule specifying the days and time slots for waste collection in each zone. Establish a MRF center where the collected waste can be consolidated. Arrange for suitable collection vehicles to transport the waste from each household to the MRF center. Educate residents on proper waste segregation methods, such as separating recyclables, organic waste, and non-recyclables. Encourage residents to segregate waste at the source and provide them with separate bins or bags for each category.
 Treatment and Disposal Infrastructure	Evaluate current usage, capacity, functionality, and human resources Set up adequate storage facilities such as transfer stations or material recovery facilities (MRFs) to temporarily store and sort the collected waste. Establish appropriate treatment facilities based on the waste characteristics and available technologies (landfill, composting, recycling, waste-to-energy plants, etc.). Develop recycling centers or MRFs to process and recover valuable materials from the waste stream. Support the establishment of small-scale enterprises or cooperatives for recycling and upcycling activities. Collaborate with relevant stakeholders, including the informal sector, to enhance recycling efforts and create market linkages for recyclable materials.
 Bulk Waste Generators Manage their Own Waste	Assist bulk waste generators in conducting waste assessments to determine the quantity, composition, and characteristics of the waste generated. Classify and categorize the waste streams based on their potential for reuse, recycling, or disposal. Assist bulk waste generators in establishing on-site recycling facilities or partnering with recycling companies to manage recyclable waste streams effectively. Provide information on local recycling options, technologies, and best practices for maximizing resource recovery.
 Capacity Building	Establish ward and community committees to participate in planning, implementation, and monitoring Use various channels such as social media, local newspapers, community meetings, and flyers to raise awareness. Clearly communicate the collection schedule, types of waste accepted, and any specific guidelines. Conduct training programs to build the knowledge and skills of bulk waste generator employees involved in waste management. Offer workshops and seminars on waste segregation, handling, storage, and other relevant topics.
 Circular Economy	Map the flow of waste to identify opportunities for circularity and areas for improvement. Establish or support recycling facilities to recover valuable materials from waste streams. Encourage the use of recycled materials in manufacturing processes through procurement policies and incentives. Engage farmers, urban gardeners, and horticulturists to take compost, Encourage neighborhood repair services, swaps and exchanges

4.1 Future problems for Saswad in the absence of my proposal

The presence of a landfill on the airport boundary in Saswad without implementing a zero-landfill city initiative can lead to various future problems. These include environmental risks

such as water and air pollution. The proximity of the landfill to the proposed airport raises concerns about air pollution due to the discharge of methane and other hazardous gases, potentially impacting air quality and the health of nearby residents.

As the population grows and waste generation increases, existing landfills may quickly reach capacity and overflow. This can result in environmental hazards, groundwater contamination, and unpleasant odors, negatively affecting the well-being of residents. Ineffective recycling and waste reduction efforts can also lead to the wastage of valuable resources embedded in waste, causing resource depletion and a greater reliance on raw materials for industrial processes.

Without a zero-landfill city approach, the potential economic opportunities associated with recycling and waste management industries may be missed. These industries can generate employment and contribute to the local economy. Ineffective waste management practices, such as unnecessary transportation to distant landfills, can increase expenses related to garbage collection and disposal, placing a financial burden on municipal authorities and taxpayers.

Addressing these challenges through a zero-landfill city approach can mitigate future problems associated with waste management. It promotes environmental sustainability, resource conservation, and a healthier living environment for the residents of Saswad while also creating economic opportunities.

V. CONCLUSIONS

In conclusion, the case study on planning a zero-landfill city model in Saswad City demonstrates the effectiveness of utilizing technology and comprehensive planning to address waste management challenges. The model emphasizes sustainable practices, resource recovery, and energy generation. Through public participation and awareness programs, responsible waste disposal habits can be fostered. Despite initial costs, the economic and environmental benefits of the model make it a viable long-term solution. The success of Saswad City serves as a source of inspiration for other cities, highlighting the significance of stakeholder collaboration and community engagement. Overall, the study showcases the potential for sustainable waste management in urban areas through innovative approaches and collective efforts.

Recommendations for future research in waste management:

- Technological Innovations: Study and develop innovative solutions for waste management, such as better waste segregation procedures, effective recycling strategies, and waste-to-energy conversion systems. To improve waste management procedures and increase resource recovery, look into cutting-edge technology like automation, machine learning, and artificial intelligence.
- Approaches to the circular economy Make investigations on the application of circular economy ideas in a zero-landfill city model. Investigate strategies for promoting resource conservation, recyclable product design, and the implementation of closed-loop systems that reduce waste generation and maximize material reuse.
- Assessments of the Economic and Environmental Impact: Evaluate the economic and environmental impacts of zero landfill city models. Analyse the financial viability, economic efficiency, and environmental effects of waste management solutions, including the potential for job creation, the monetization of waste materials, and greenhouse gas emission reductions.
- Schedule for Waste Collection: Develop an app that provides personalized timetables for waste collection based on the user's location. Users can sign up to receive notifications about upcoming collection dates, ensuring they never miss a collection and encouraging prompt disposal.
- Implement a map-based function in the app called "bin locator" that enables users to find the closest disposal bins for different types of garbage. By pointing users to nearby composting facilities, recycling facilities, and hazardous waste drop-off locations, this service makes garbage disposal easier.

REFERENCES

[1]. Digitalcommons@usu, D., & Mcallister, J. (2015). Factors Influencing Solid-Waste Management in the Developing Factors Influencing Solid-Waste Management in the Developing World World.

[2]. Kaza, S., Yao, L., Bhada-Tata, P., & Woerden, F. van. (n.d.). WHAT A WASTE 2.0 A Global Snapshot of Solid Waste Management to 2050 OVERVIEW.

[3]. Namoun, A., Tufail, A., Khan, M. Y., Alrehaili, A., Syed, T. A., & BenRhouma, O. (2022). Solid Waste Generation and Disposal Using Machine Learning Approaches: A Survey of Solutions and Challenges. In Sustainability (Switzerland) (Vol. 14, Issue 20). MDPI.

[4]. Singh, S. (2020). Solid Waste Management in Urban India: Imperatives for Improvement.

[5]. WASTE-WISE CITIES Best practices in municipal solid waste management NITI Aayog. (n.d.).
[6]. Nandan, A., Yadav, B. P., Bose, D., & Baksi, S. (2017). Recent Scenario of Solid Waste Management in India. World Scientific News, 66, 56–74.
[7]. Banerjee, P., Hazra, A., Ghosh, P., Ganguly, A., Murmu, N. C., & Chatterjee, P. K. (2019). Solid Waste Management in India: A Brief Review. In Waste Management and Resource Efficiency (pp. 1027–1049). Springer Singapore.
[8]. Tiwari, A., Mishra, A. R., Mishra, S. A., & Tiwari, A. v. (2014). SOLID WASTE MANAGEMENT-CASE STUDY. International Journal of Research in Advent Technology, 2(1).
[9]. Nandan, A., Yadav, B. P., Bose, D., & Baksi, S. (2017). Recent Scenario of Solid Waste Management in India. World Scientific News, 66, 56–74.
[10]. Mundhe, N., Jaybhaye, R., & Dorik, B. (2014). Assessment of Municipal Solid Waste Management of Pune City using Geospatial Tools. International Journal of Computer Applications, 100(10), 24–32.
[11]. UNDP Zero Waste Offer. (n.d.).
[12]. Arya, M. A. (n.d.). Advanced Chemistry Cell Battery Reuse and Recycling Market in India.