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Review Article

Trash Talk: A Review of Evolving Waste Management Paradigms

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Abstract:

This review traces the evolution of waste management, from basic disposal to advanced integrated systems that treat waste as a resource. It emphasizes the significance of waste management in achieving the Sustainable Development Goals (SDGs) and the shift toward integrated approaches that address environmental, economic, and social dimensions. A comparative analysis of centralized and decentralized waste management systems highlights the growing significance of community-driven models, particularly in developing countries, where localized solutions can better address socio-environmental challenges. The review also examines Integrated Solid Waste Management (ISWM) and Integrated Sustainable Waste Management (ISWM) principles, focusing on their potential to reduce waste, conserve resources, and mitigate environmental degradation while creating green jobs. Challenges like technical gaps, financial constraints, and stakeholder coordination are also discussed, stressing the need for systemic reforms. The role of local self-governments, social capital, and community participation in decentralized waste management is highlighted, with emphasis on inclusivity, public health improvement, and environmental stewardship. Participatory governance, institutional support, and policy alignment are identified as key factors for scaling these systems. The review concludes by underscoring the need to incorporate sustainable waste management into broader development frameworks, positioning waste management as a cornerstone of sustainable urban and rural development.

1. Introduction

The management of solid waste has evolved into one of the most pressing global challenges, shaped by growing environmental concerns and public health imperatives. As societies have advanced, so too has the complexity of waste management, reflecting humanity's increasing awareness of the intricate links between waste, resource use, and sustainability. Historically, the Industrial Revolution marked a turning point in waste generation. The rapid pace of urbanization and industrialization led to unprecedented amounts of waste, necessitating more organized disposal methods. Early solutions, such as the widespread adoption of sanitary landfills and incineration in the early 20th century, provided temporary relief but also introduced new environmental and health risks [1,2]. By the 1970s, the environmental movement brought a paradigm shift, emphasizing the need for integrated approaches that prioritized waste reduction, recycling, and resource recovery [3]. This shift aligned with the broader concept of sustainable development, as articulated in the Brundtland Report. The report underscored the importance of producing "more from less"—a principle advocating for efficient resource utilization and waste minimization to ensure the well-being of both present and future generations. As it aptly states, "Sustainable development could only be attained if society in general, and industry in particular, master the art of producing 'more from less'; more goods and services from fewer resources, including energy, while generating less pollution and waste" [4]. Building on this foundation, the late 20th century and early 21st century witnessed the emergence of innovative approaches to waste management. Concepts like "zero waste" and extended producer

responsibility sought to address the root causes of waste generation, while technological advancements revolutionized waste treatment and recycling [5]. In the digital age, smart technologies have further transformed the sector, optimizing collection routes, improving sorting efficiencies, and enhancing resource recovery [6]. These developments have culminated in the adoption of circular economy principles, which aim to minimize waste and maximize resource efficiency across the entire lifecycle of products [7]. To overcome socio-economic issues such as unemployment and environmental damage, it is necessary to establish a sustainable economy by re-evaluating current patterns of production and consumption [8]. This can be accomplished through dematerialization, remanufacturing, and recycling—key CE practices that promote sustainable waste management [9]. In the Netherlands, this approach is exemplified through various strategies such as prioritizing regenerative resources (ensuring renewable, reusable, non-toxic materials are used for energy and production), treating waste as a resource (recovering and recycling waste streams for reuse), extending product life through sustenance, repair, and upgrades, and leveraging digital technology to optimize resource use and enhance connections within the supply chain [10] .Today, solid waste management is recognized as a critical contributor to global sustainability. Its effective implementation directly supports multiple Sustainable Development Goals (SDGs), including those related to health, climate action, and sustainable cities [11]. The journey of waste management—shaped by historical lessons, technological advancements, and sustainability imperatives—highlights the importance of integrated approaches that address environmental challenges while fostering community participation and social equity.

2. Material and Methods

2.1 Search Strategy

This review utilized databases such as Google Scholar and Scopus to identify relevant literature on waste management and its associated themes. A broad range of keywords was employed to capture diverse perspectives, including waste management, solid waste management, sustainable waste management, integrated sustainable waste management, centralized and decentralized waste management, local self-government, community participation, and social capital etc. The majority of the studies included in this review are highly cited, ensuring the incorporation of authoritative and impactful research. This paper adopts a narrative review approach rather than a systematic review. The narrative approach was chosen to allow flexibility in synthesizing insights from both qualitative and quantitative studies, facilitating a broader exploration of interconnected themes and diverse methodologies in waste management research.

2.2 Solid Waste Management and its Evolution

Throughout history, the management of waste has evolved significantly, shaped by the changing needs and innovations of society. In ancient civilizations, waste management was rudimentary, often involving the disposal of refuse in open streets or pits [12]. This system, while functional for small, agrarian communities, began to show its limitations as urbanization took root. The Industrial Revolution, with its massive scale of urbanization and mass production, brought forth a dramatic increase in waste generation. Cities became crowded, and waste accumulation reached unprecedented levels. It was during this period that the need for more formalized waste management systems became evident [1]. To address this growing issue, sanitary landfills and incineration became widespread in the early 20th century, marking a significant development in waste disposal practices [2]. However, as the 20th century progressed, a wave of environmental consciousness began to sweep across the globe. The 1970s sparked a shift in how society viewed waste, leading to the introduction of more sustainable practices. The concept of integrated waste management emerged, emphasizing not just disposal, but the need to reduce waste generation, recycle, and recover valuable resources [3]. This shift laid the groundwork for what we now know as zero waste management. Zero waste management is an ambitious approach designed to eliminate waste altogether. By focusing on product design and resource conservation, it encourages systems that reduce waste generation and prioritize the reuse, recycling, and composting of materials. The goal is clear: create a circular economy where materials are continuously repurposed, and waste is diverted from landfills and incineration [13]. This approach has gained momentum in recent decades, signalling a transformative shift in how we think about waste management. A key aspect of this transformation is Extended Producer Responsibility (EPR), a policy principle that extends the responsibility of producers to include the post-consumer phase of a product's lifecycle. This means that producers must take responsibility for the collection, recycling, and proper disposal of their products, helping to reduce environmental impacts at the source [14]. As we move further into the 21st century, digital

technologies have also begun to play a pivotal role in waste management. The advent of smart technologies has optimized collection routes, improved sorting efficiencies, and enhanced the overall effectiveness of waste management systems [6]. These technological innovations are further propelling the transition towards circular economy principles, which focus on minimizing waste and optimizing resource use throughout the lifecycle of products [7]. In today's world, waste management is no longer seen merely as a service to manage refuse; it is viewed as an essential component of achieving broader sustainable development goals (SDGs). Efficient waste management practices can directly impact goals related to health, climate action, and the development of sustainable cities [7]. As we continue to embrace these modern approaches, we are not only reshaping how we manage waste but also fostering a more sustainable and circular future for generations to come.

2.3 Sustainable development

Imagine a world where the environment, society, and economy all work in harmony, creating a future where progress doesn't come at the cost of our planet or its people. This vision of sustainable development, a concept deeply rooted in the balance of these three pillars, is fundamental to ensuring that we can thrive today while securing the well-being of future generations [12]. At the heart of sustainable development are two crucial ideas. The first emphasizes the "needs" of the world's most vulnerable populations. It insists that these basic needs should take precedence above all else, highlighting the moral imperative to ensure that no one is left behind in the quest for a better life. The second idea revolves around the constraints placed on the environment. Our planet has a finite capacity to meet the demands of a growing global population, and this capacity is limited by both the state of our technology and our social structures. Together, these principles serve as a reminder that while we strive for progress, we must do so within the bounds of what our planet can sustainably provide [15]. To help visualize this intricate balance, sustainability is often depicted as three overlapping circles, representing social, economic, and environmental elements, with the essence of sustainability sitting at the centre. This simple yet powerful design helps to illustrate how each of these elements is interconnected, reinforcing the idea that true sustainability can only be achieved when all three aspects are considered in equal measure [16]. As we delve deeper into this concept, sustainable development calls for enhancing our production capabilities while acknowledging the ecological limits we face. It is about fostering innovation and adopting technologies that allow for economic growth, but without compromising the integrity of our environment [17].

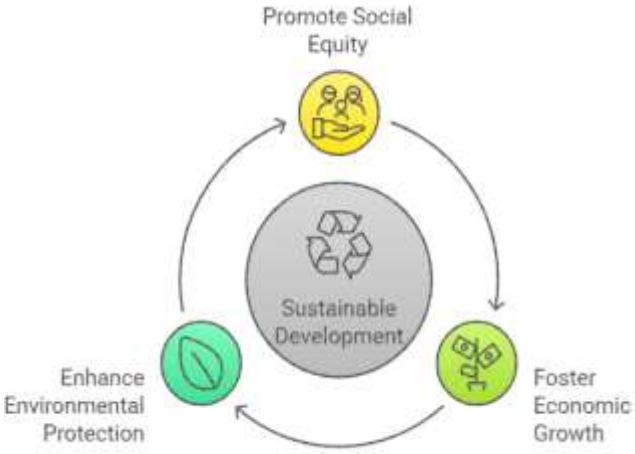

Figure 1. *Cycle of Sustainable Development*

However, no plan for sustainable development would be complete without recognizing the human element at its core. Human capacities such as consciousness, skill, and knowledge are vital for driving meaningful change. Education, in particular, plays a pivotal role in cultivating these qualities. By equipping people with the tools to understand and tackle sustainability challenges, we empower a generation capable of making informed decisions and implementing sustainable practices across all sectors of society [18]. In this way, sustainable development is not just an abstract concept but a call to action—a call to nurture the planet, support its people, and create systems that work for both the environment and the economy. With each step, we move closer to a world where the future is not just a dream, but a reality we can shape together. Figure 1 shows cycle of sustainable development.

2.4 Sustainable Waste management

The United Nations' Sustainable Development Goals (SDGs) point out the importance of sustainable waste management as a key driver in achieving a balanced approach to sustainability. Waste management, when done correctly, touches upon all three pillars of sustainability: the environment, the economy, and society [19,20,21]. However, the path to sustainability is not straightforward. It involves the integration of multiple dimensions—technical, economic, and social—and requires careful consideration of how these aspects work together. At the core of sustainable waste management is the need for systems that are not only environmentally

Figure 2. *Waste Management Hierarchy: A Sustainable Approach*

effective but also economically feasible and socially acceptable. Environmentally, the goal is clear: waste management systems must reduce harm to the planet. This includes minimizing emissions of pollutants like carbon dioxide (CO2), methane (CH4), and heavy metals, which can contaminate air, water, and soil. However, environmental goals alone are insufficient. The system must also be affordable—its costs should be manageable for communities, especially those with limited infrastructure and financial resources. To balance these factors, the system must make use of existing resources while ensuring long-term cost-effectiveness. But perhaps most crucially, the system must be socially acceptable. Building trust and fostering open dialogue within the community are essential to gaining their support, making the system more likely to succeed in the long run [4]. This is where the true challenge lies: creating waste management systems that align with the unique needs of each city or community. The solution? Sustainable solid waste management (SWM), a dynamic approach that involves integrating technical, environmental, economic, and cultural factors. SWM is not just a matter of policy—it's about understanding the intricate demands of urban spaces and tailoring systems that respond to those needs. It also emphasizes the engagement of all stakeholders—from the general public and non-governmental organizations to informal recyclers and women as heads of households [19,21]. In essence, successful waste management requires more than just the right policies; it requires collective effort and active participation. For waste management to be truly sustainable, it must encompass multiple steps, from collection and transportation to processing and final disposal. It also requires urban planning that divides cities into manageable zones to streamline operations and ensure more effective waste handling [22]. Yet, these technical procedures are not enough if they do not also address the environmental and public health risks associated with waste. In many cities across the Global South, inefficient waste management practices—like unregulated dumping, open-air incineration, and mixing hazardous waste with general refuse—are causing lasting harm to both the environment and vulnerable communities. These practices not only pollute air, water, and land but also exacerbate the impacts of climate change [23]. This underscores the urgency of shifting toward more sustainable practices that prioritize the protection of both people and the planet. At the heart of these practices lies the concept of the 3Rs—reduce, reuse, and recycle—which serve as the foundation for sustainable waste management. By adopting these principles, we can reduce the amount of waste generated and promote the recycling and repurposing of materials, thereby reducing environmental impact.

The concept of zero waste has emerged as a crucial strategy in this regard, emphasizing that the ultimate goal should be to prevent waste from being created in the first place. This philosophy supports a circular economy, where materials are perpetually reused and repurposed, minimizing waste and conserving resources [24,25,26,27,28]. But implementing these sustainable practices is not merely a technical challenge—it is a global imperative. This approach is not just about logistics; it is about safeguarding the future for all generations, ensuring that resources are preserved, and that the negative impacts of waste mismanagement are minimized [29]. A truly sustainable waste management system must also address the social dimensions of waste management. Too often, economic and environmental concerns overshadow the social impacts. However, sustainable systems must ensure that they are socially acceptable and equitable. This means taking into account the effects on communities, particularly marginalized groups, and ensuring that waste management systems are inclusive and fair. Engaging local communities, promoting equity, and prioritizing public health are all integral to making waste management truly sustainable [30]. As we move toward more sustainable systems, the role of social engagement becomes even clearer. By prioritizing equity and community involvement, waste management systems gain the support they need to be effective and long-lasting. Incorporating strategies like waste segregation, circularity, and waste-to-energy technologies ensures that the environmental, economic, and social aspects are addressed in unison, creating a system that works for everyone [26,28,30]. Ultimately, the goal of sustainable waste management is simple yet

profound: to minimize the quantity of waste exposed to the environment and society, to protect our resources, and to reduce harmful consequences on both human health and the planet. Through collaboration, innovative strategies, and community involvement, we can build systems that not only meet today's needs but also safeguard the future for generations to come. Figure 2 is the waste management hierarchy.

2.5 Municipal Solid Waste Management in Sustainable Development Goal

Building on the principles of sustainable waste management, the classification of waste plays a pivotal role in designing efficient systems that prioritize resource recovery and minimize environmental impact. By systematically grouping waste according to origin, physical characteristics, chemical composition, and disposal methods, management strategies can be better tailored to address specific challenges and opportunities. For example, within the organic fraction, waste can be categorized as mineral waste (low organic content), organic-mineral waste (moderate organic matter), and organic waste (primarily biodegradable materials). Similarly, municipal waste includes diverse categories such as household waste (e.g., food scraps, packaging), street litter, construction debris, and seasonal waste. These classifications not only facilitate effective waste handling but also enable targeted recovery strategies that reduce environmental harm while maximizing the reuse of valuable resources [31]. SDGs have defined waste as any material that is not the primary product (i.e., the products which are created for market) for the producer, has no further usage for production transformation or consumption, and which they dispose of or intend or are required to discard [32]. Solid waste management systems are increasingly intertwined with the United Nations Sustainable Development Goals (SDGs). Waste-to-energy technologies, such as anaerobic digestion and landfill gas recovery, exemplify this connection by contributing to SDG 3 (Good Health and Well-being), SDG 7 (Affordable and Clean Energy), and SDG 11 (Sustainable Cities and Communities). Additionally, waste charging schemes like unit pricing promote waste segregation and reduction, advancing SDG 12 (Responsible Consumption and Production) [33]. Furthermore, sustainable waste management also supports SDG 6 (Clean Water and Sanitation) [34] by preventing waste-related water pollution and ensuring safe disposal methods. Effective management of hazardous and non-biodegradable waste contributes to protecting water sources and promoting sustainable sanitation. Similarly, well-designed systems reduce land degradation and pollution, supporting SDG 15 (Life on Land) by protecting terrestrial ecosystems and promoting sustainable land use practices.

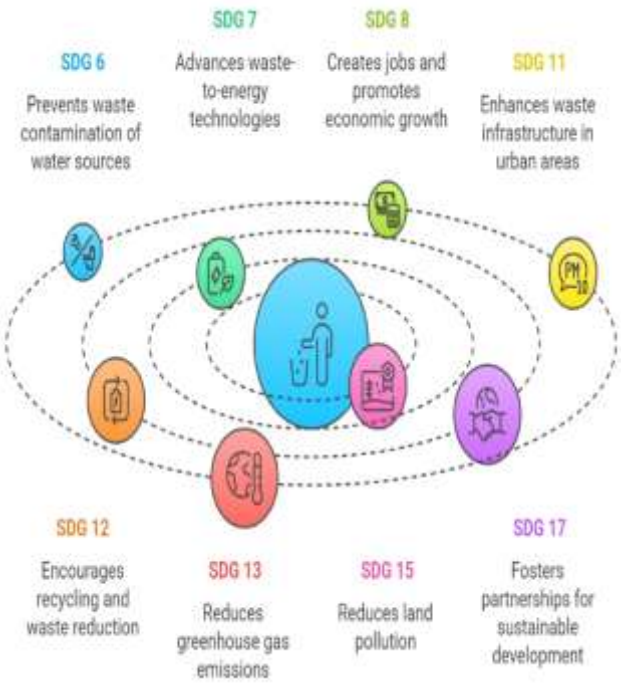

***Figure 3**. Sustainable Waste Management to Achieving Sustainable development*

Figure 3 shows sustainable waste management to achieving sustainable development. In many developing nations, waste management systems face significant barriers, including unsystematic disposal practices, inadequate infrastructure, and low public awareness. These challenges highlight the need for greater investment in eco-cultural education and community engagement to foster sustainable waste practices [28]. Specifically, SDG 4: Quality Education calls for the provision of inclusive and equitable education [35], and promoting eco-cultural education is an essential step in addressing waste management challenges. By integrating waste segregation, recycling, and circular economy principles into everyday life, communities can be educated on the importance of sustainable practices, empowering individuals with the knowledge and skills to reduce waste generation and enhance resource recovery [28]. Communities near poorly managed waste disposal sites often bear disproportionate environmental and social burdens, facing issues like polluted air, contaminated water, and health risks. To counter these effects, sustainable waste management strategies must go beyond technical solutions and incorporate inclusive approaches that address social equity, public health, and active community participation [36]. By

addressing these interconnected challenges, sustainable solid waste management can contribute to achieving multiple SDGs, creating a healthier, more equitable, and environmentally resilient future for all.

3. Results and Discussions

3.1 Centralised v/s Decentralised Waste Management Approaches

As waste management practices have evolved, different frameworks have emerged to address the growing challenges. Centralized and decentralized waste management are two structural models adopted by nations to tackle these challenges. A centralized system accumulates, shifts, and processes garbage in a single, large facility. In contrast, decentralized waste management handles waste at smaller, regional facilities [37,38]. These models describe how waste is physically handled and managed within a system. While Zero Waste and Extended Producer Responsibility (EPR) focus on waste prevention and producer accountability, centralized and decentralized systems address the logistical question of where and how waste processing occurs.

Characteristics of centralized waste management

Centralized solid waste management (SWM) systems operate on a model where decision-making power is concentrated among a few key individuals. This concentration results in the establishment of a limited number of large-scale SWM facilities, typically located in select areas, with the government assuming full accountability for service delivery and any related shortcomings [39]. The allure of centralized systems lies in their ability to reduce total system costs and produce a wide range of bio-based products [40]. Large facilities in these systems benefit from economies of scale, making pollution control and waste-to-energy transformation more efficient. However, this efficiency comes at a cost. Centralized systems are often criticized for their diminished resilience, the long travel distances they necessitate—clogging roads and increasing carbon footprints—and the societal divide they create. Those who benefit from these systems often do so at the expense of others. Moreover, centralized facilities can erode civic engagement. Citizens are reduced to passive consumers of waste services, with little incentive to reduce waste or participate in its management. This lack of ownership can stifle efforts to build a waste-conscious society [41]. While centralized systems remain profitable and appealing due to their large-scale efficiency, they are not without flaws. High investment and operating costs, coupled with inefficiencies, outdated practices, and unscientific approaches, have often resulted in poor service delivery and insanitary living conditions in urban areas [42]. Despite their advantages, the limitations of centralized SWM systems highlight the need for innovative and inclusive approaches that address both environmental and societal concerns.

Characteristics of decentralised waste management

Decentralized waste management offers an alternative and complementary approach to the conventional centralized waste treatment processes. By leveraging decentralized technologies, this model aims to manage solid waste in a more effective, reliable, and community-driven manner [37]. Unlike centralized systems, decentralized waste management distributes decision-making power among multiple governing bodies, resulting in a network of smaller SWM facilities spread across regions. This shift places subnational governments in charge, granting them the authority and responsibility to regulate waste management, thereby reducing the direct oversight of national governments [41]. At its core, decentralized waste management emphasizes three key dimensions: political, financial, and administrative [43]. It views waste as a resource and seeks to address solid waste issues by actively involving communities. The focus is on source segregation, recycling, and composting, which reduce waste disposal and promote cleaner environments. This localized approach empowers communities to recycle or compost waste on-site, transforming it into valuable resources and fostering a mindset that perceives waste not as a burden but as an opportunity. The impact of decentralized waste management is evident in various settings, from urban neighbourhoods to educational institutions. Successful implementations have demonstrated its potential to conserve the environment, reduce costs, and enhance soil fertility [44]. For instance, food waste can be converted into compost, creating a closed-loop system that benefits agricultural production while addressing the substantial portion of municipal solid waste that is organic [45,46,47]. This sustainable strategy not only minimizes waste sent to landfills but also sustains cleaner neighbourhoods, contributing to healthier, more sustainable cities [45,46,47]. Moreover, decentralized systems have proven particularly effective in contexts where centralized systems are impractical. Remote locations, sparsely populated regions, and areas lacking robust infrastructure have benefited greatly from this flexible and cost-effective approach [48,49]. These systems cater to the unique needs of such regions, turning logistical

challenges into opportunities for localized innovation.

However, decentralized waste management is not without its challenges. Despite its adaptability, the system often faces economic and logistical hurdles. High operational costs, stringent regulatory requirements, and difficulties in monitoring waste flows have been reported in urbanized settings such as Tokyo, Japan [41]. Insufficient support from local authorities has also led to planning delays and inefficiencies. Many local governments focus more on waste collection than treatment, resulting in segmented and short-term solutions. Capacity constraints, institutional weaknesses, and financial limitations further exacerbate these issues, especially in developing nations [50,51]. Additionally, questions remain about the optimal level of waste treatment achievable through decentralization [48]. In conclusion, the choice between centralized and decentralized waste management systems depends on factors such as cost, efficiency, environmental impact, and the specific needs of a community or region. Each system has its strengths and limitations, and selecting the appropriate model requires a careful assessment of the unique characteristics and resources available [40].

3.2 Integrated Approaches: Integrated Solid Waste Management and Integrated Sustainable Waste Management

Integrated Waste Management (IWM) is a comprehensive approach that views waste management as an interconnected system of operations and functions. Originating from W.R. Lynn's systems approach in 1962, it evolved through key milestones, including the Solid Waste Authority of Palm Beach County's 1975 mission and R.M. Clark's 1978 observation on the need for flexible methods [52]. By 1991, the concept was expanded to encompass all types of waste and various treatment technologies, as defined by the Economic Commission for Europe. The United Nations Environmental Programme further recognized IWM in 1996 as a framework for designing, implementing, and optimizing waste management systems, highlighting its role in ensuring effective and adaptable waste management practices [4].

There are significant differences in solid waste management approaches between industrialized and developing countries. Successful waste management requires addressing both technical and governance challenges. While developed nations often prioritize technical aspects like collection, disposal, and recycling, developing nations are increasingly adopting Integrated Solid Waste Management (ISWM), which combines both elements to enhance sustainability and strengthen institutions. The contrast in approaches is evident in the systems employed by different nations. In industrialized nations, they are following sophisticated system analysis and engineering models to develop integrated waste management systems, driven by various factors such as public health concerns and environmental footprints. On the other hand, developing nations follow very different solid waste management practices, often dictated by resource constraints and rapid urbanization [53].

To illustrate these differences:

1. Waste Generation and Collection: In high-income countries, the average per capita waste generation is 2.1 kg per day, while in low-income countries, it's 0.6 kg per day [54]. Waste collection rates in high-income countries typically exceed 90%, while in low-income countries, they can be as low as 30-60% [55].
2. Waste Treatment Methods: In many developed countries, a significant portion of municipal waste is recycled or composted. For instance, some European countries achieve recycling rates over 50% [56]. In contrast, in low-income countries, about 90% of waste is often dumped in unregulated sites or openly burned [54].
3. Technological Approaches: Industrialized nations often employ advanced technologies such as mechanical biological treatment (MBT) plants, waste-to-energy facilities, and automated sorting systems [57]. Developing countries, due to resource constraints, often rely on manual sorting, open dumping, and basic composting methods [58].
4. Governance and Policy: Many developed countries have comprehensive waste management policies and regulations, with clear targets for recycling and recovery [55]. Developing countries often lack comprehensive policies or struggle with enforcement, facing significant governance challenges in implementing sustainable waste management practices [11].
5. Financial Resources: High-income countries typically spend significantly more per capita on waste management compared to low-income countries, with differences often exceeding tenfold [54].
6. Integrated Approaches: While developed countries focus on technological solutions, many developing countries are adopting ISWM approaches, integrating informal waste pickers and implementing community-based recycling programs [59].

In developing and less developed nations, there is limited household waste segregation, often relying

on informal waste picking, which impedes long-term planning for solid waste management (SWM). These countries frequently lack the equipment needed for effective garbage segregation. In contrast, developed countries have robust awareness programs, adequate equipment, and thorough waste flow data crucial for strategic SWM. Collection methods in developing countries typically include roadside and door-to-door waste collection by community organizations, with varying frequencies [60]. These disparities highlight the need for a more comprehensive approach to waste management. Nevertheless, developing countries face specific challenges, including rapid urbanization and scarcity of resources, which lead to vague waste management paradigms and often worsen inequality. To address these issues, integrated solid waste management needs to be effectively implemented in developing countries [53].

Integrated solid waste management refers to a comprehensive approach that encompasses various strategies to efficiently handle solid waste while considering environmental, social, economic, and technological factors. This approach involves the integration of different waste management practices such as waste generation, collection, disposal, and recycling to minimize environmental impacts and optimize resource utilization. Building upon this concept, there is another approach called integrated sustainable waste management, which is a key concept in addressing the issues of waste disposal and environmental sustainability [61,62,63].

Sustainable waste management is vital for attaining environmental, economic, and social sustainability goals, specifically in the context of global concerns over solid waste management and the pressing necessity for integrated approaches incorporating all stakeholders [64]. Integrated sustainable waste management emphasizes optimizing waste management processes from generation to disposal, involving all stakeholders for efficient operations [65]. It is designed in a way to meet local community needs, maintain and improve existing jobs, and create new opportunities for those with deprived socioeconomic status [61]. With the aim of optimizing waste allocation, treatment, and disposal options while reducing expenses and environmental impacts via innovative models and optimization processes, integrated solid waste management and integrated sustainable waste management are holistic approaches that take into consideration environmental, social, economic, and technological components in waste handling [66,67]. Integrated Solid Waste Management and Integrated Sustainable Waste Management (S-ISWM) are closely tied, as both maximize procedures while taking social, economic, and environmental aspects into account [68]. As urbanization and consumption tendencies vary and waste streams become more diverse, this integration encompasses the thorough care of all waste streams, including organic waste [69].

The benefits of these integrated approaches are manifold. By combining waste management with sustainable methods, it is possible to achieve a better environment, enhance health and safety, improve economic growth, and promote social well-being [70]. The objective of integrated sustainable waste management is to set up a system that takes note of social, economic, and environmental considerations along with process optimization for long-term sustainability. With this strategy, waste is distributed among treatment options in an efficient manner, reducing costs, and the environmental impact is assessed using Life Cycle Assessment techniques [71]. Integrated sustainable waste management involves inclusive planning to ensure equitable involvement of stakeholders, including private service providers. Active participation of NGOs, women's unions, and community representatives promotes transparency and accountability, fostering community engagement and enhancing the sustainability of waste management initiatives [72]. Thus, Integrated Sustainable Waste Management, ensuring a high level of waste collection coverage and regulated disposal, is viewed as best practice [3]. Some of the strategies used by integrated sustainable waste management systems consist of composting, vermicomposting, and high-temperature incineration. These methods have proven effective for managing solid waste in a sustainable way, such as cutting down on landfill volumes and improving soil fertility [73]. However, integrated sustainable waste management demands effective governance mechanisms to address the complex challenges of solid waste disposal and resource recovery, emphasizing the crucial role of governance in waste management [74]. For effective recycling of organic waste, composting is used as one of the technologies in sustainable waste management. Through this method, valuable fertilizer is generated as the end product, simultaneously lowering operational costs and reducing environmental degradation [61]. Social acceptance is an important factor in the accomplishment of integrated sustainable waste management solutions, and education is an essential instrument for advancing sustainable waste management [75]. Furthermore, to improve the efficacy of waste management, Sustainable Materials Management (SMM) techniques spotlight the necessity of tracking and documenting individual materials generated and disposed of [76]. The Multi-Criteria Generic Evaluation Sustainable Approach (MCGESA) proposes strategies for waste

management systems that boost product quality, encourage eco-friendly behaviour, and reduce their negative impact on the environment. In order to facilitate sustainable waste management practices, these integrated approaches emphasize the significance of public participation, well-informed decision-making, and thorough assessment [77].

Despite the benefits, challenges remain. This approach encounters barriers including lack of sufficient budget and inefficient governance in underdeveloped nations. Advancement of legislation, public-private collaborations, and energy recovery are instances of success factors [78]. Additionally, consumer perception of garbage generation, collection, and disposal is pivotal for effective Integrated Sustainable Waste Management. Educating and engaging the public is crucial for the success of these integrated approaches [79].Thus, it highlights the urgent need for a well-balanced mix of community-led projects and top-down legal interventions to ensure sustainable waste management systems that are economical and carbon-friendly in nature [67].These systems should aim to reduce environmental impact, optimize utilization of resources, and ensure economic feasibility through methods like composting and cleaner technologies [61].

In conclusion, while challenges persist, especially in developing nations, the integrated approaches to waste management offer a comprehensive and sustainable solution to the global waste crisis. By addressing technical, social, economic, and environmental factors simultaneously, these strategies pave the way for more efficient and sustainable waste management practices worldwide [56].

3.3 Decentralised Solid Waste Management Through Local Self-Government

To build on the principles of Integrated Sustainable Waste Management (ISWM), local self-governments play a determining role in ensuring that waste management systems are not only efficient but also aligned with sustainability goals. By focusing on community-driven solutions, decentralization, and local-level governance, these entities contribute significantly to the broader vision of waste management that is environmentally, socially, and economically sustainable. Positioned at the heart of local communities, local governments are uniquely capable of understanding and addressing the specific waste management needs of their constituents. This proximity enables them to design and implement solutions tailored to the unique challenges of their areas [80]. The growing recognition of their potential has led to a wave of innovation, with local governments adopting best practices that aim not only to improve waste management but also to boost the capacity and effectiveness of local government employees. Recent studies have highlighted how local authorities are embracing creative strategies to contribute meaningfully to the SDGs, demonstrating their commitment to sustainable development [81]. A key element in this approach has been the decentralization of waste management from central governments to municipal and urban local bodies, a trend seen across many nations. This shift has allowed for more localized and efficient solutions that cater to the specific needs of communities [82]. Local self-government plays a critical role in sustainable development, with a focus on spatial planning, environmental conservation, property governance, and the management of waste disposal. These responsibilities underscore the multifaceted role local governments play in sustainability, with waste management being particularly significant. The outcome of waste management systems directly impacts the credibility of these governments, emphasizing the need for efficient waste management practices [83,84]. In many countries, local self-governments have taken the lead in decentralized solid waste management. This localized approach allows for more effective decision-making and control over waste management processes, which is crucial for addressing the growing demands of urbanization [82]. Local governments are also playing a vital role in early waste segregation and composting initiatives. By encouraging households to separate their waste, municipalities free up capacity for other critical functions and reduce the volume of waste that needs to be transported. Decentralized recycling programs foster more sustainable and efficient waste management systems, benefiting both the environment and local economies [85].

Moreover, local self-governments often collaborate with communities to ensure the success of their waste management strategies. This is exemplified by the UN Sustainable Cities Programme (SCP), which introduced the concept of community engagement in municipal waste management in the early 1990s. This initiative aimed to empower local governments in developing countries, whose resources were overwhelmed by rapid urbanization, to manage waste more effectively. By prioritizing community involvement, the SCP demonstrated the significant role local populations play in the success of waste management initiatives [86]. Despite these promising advancements, local self-governments face several barriers that hinder their efficiency in waste management. A lack of adequate facilities, insufficient financial resources, and low public willingness to pay for services are significant

challenges. Moreover, local governments often struggle with garbage collection in impoverished areas, where access to waste management services is limited. Perhaps most critical is the issue of transferring power to local governments without providing the necessary funding, which further exacerbates the challenges they face. These barriers showcase the need for a more comprehensive approach that includes increased support and resources for local governments to effectively manage waste and contribute to the achievement of SDGs [84,86,87].

3.4 Social Capital and Community Participation in Waste Management

As mentioned above, community participation has an integral role in the success of sustainable waste management systems. Community participation in waste management is deeply rooted in social capital theory, which emphasizes the importance of trust, networks, and social norms in fostering sustainable waste management practices [88,89]. The willingness of residents to engage in government-led waste management programs is a key form of social capital, facilitating the transformation of waste into valuable agricultural products [90]. Social capital plays a crucial role in strengthening community collaboration, particularly through initiatives like waste banks, where trust and networking among community members contribute significantly to waste reduction and recycling [91]. Studies have shown that social capital enhances waste-separation behaviour by fostering social learning and reinforcing reputation effects, especially among women, more educated individuals, and political party members [92]. When combined with human capital, social capital has a positive impact on waste recycling, alleviating challenges such as waste separation [93]. Furthermore, social capital facilitates information-sharing and coordination among community members, leading to reduced environmental harm, particularly in areas with less reliance on waste-releasing industries [94,95]. Motivational factors for community participation in waste management include the desire to improve environmental quality, a sense of responsibility for proper waste management, and the influence of observing others in the community [96]. Studies suggest that environmental norms are activated when individuals believe their actions have adverse environmental consequences and when they feel personally accountable for the ecological crisis [97]. Economic incentives and public awareness campaigns further motivate participation, with more educated individuals tending to be more conscious of waste management processes [92,98]. Community-based waste management (CBSWM) methods, such as waste banks and waste segregation programs, provide financial incentives to encourage participation and engage communities at various levels—ranging from communal waste projects to household-level waste management [99]. Despite challenges such as poor communication between stakeholders, CBSWM can enhance participation, address financial strain, and incorporate informal sector activities for sustainability [100]. Examples from regions like sub-Saharan Africa and Bali Province demonstrate the practical success of such initiatives, with government support playing a key role in the effective management of waste [101,102].

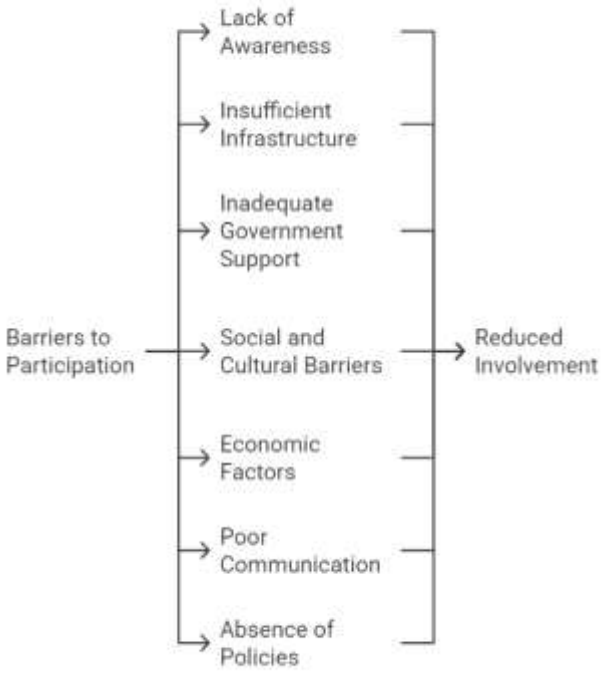

Figure 4. *Barriers to Community Participation in waste Management*

Figure 4. is the barriers to community participation in waste management. To improve waste management outcomes, comprehensive approaches that include community engagement, strong policy frameworks, infrastructure development, and private sector involvement are essential. Financial mechanisms, technological advancement, and formalizing the informal sector are also critical to addressing challenges and ensuring sustainable waste management [101,102]. Collaboration among various stakeholders, including female-headed households, NGOs, the informal recycling sector, and both public and private sectors, is crucial for successful CBSWM, [103]. In high-density, low-income neighbourhoods, fostering collaborative participation among all stakeholders is especially

important for efficient waste management [93]. Lastly, incentivizing waste reduction through systems like volume-based charges has shown success in certain regions, although political resistance can arise if issues like illegal dumping are not adequately addressed [4]. Sustainable Development is studied and reported in the literature [104-107].

4. Conclusions

To sum up, this review highlights how crucial sustainable waste management is to solving environmental challenges worldwide and fulfilling sustainable development objectives. While both centralized and decentralized systems offer exceptional strengths, the shift towards decentralized, community-based approaches seem particularly promising, especially in developing nations. The role of local self-governments and community participation, underpinned by social capital, emerges as vital in implementing effective and sustainable waste management practices. However, major obstacles remain, including inadequate infrastructure, limited resources, and the need for greater public awareness and engagement. Moving forward, successful waste management will entail a balanced approach that integrates technological innovations, policy frameworks, and community involvement, tailored to local contexts and needs. By incorporating these integrated, sustainable approaches, societies can transform waste management from a liability into an opportunity for environmental protection, resource conservation, and sustainable urban development.

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