

Review

# Waste Management, Waste Indicators and the Relationship with Sustainable Development Goals (SDGs): A Systematic Literature Review

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**Abstract:** Waste management plays an important role in sustainable development. The innovative management of waste results in minimizing the adverse effects of climate change, and social and economic sustainability. The creation of Sustainable Development Goals (SDGs) by the United Nations in 2015 was an important step toward environmental sustainability, whereby the 17 goals focus on strengthening the means of implementing and revitalizing the Global Partnership for Sustainable Development. This research paper applies a systematic literature review using the PRISMA methodology to analyze different published research papers and research reports mainly focused on waste management and its relationship with the SDGs. This paper extensively discusses the context of waste management, SDGs, waste indicators in SDGs, and the relationship between SDGs and waste management. This paper also widely discusses the aspects of waste management regarding SDGs. The results are further divided into two sub-categories, including descriptive results, which elaborate the different approaches that are used to review the literature for this paper, and thematic results, which include the key results and discussions of different aspects of this paper. The analysis of different published research papers and research reports mainly focuses on waste management and its relationship with the SDGs. This study presents a discussion of (1) the detailed context of waste management about SDGs, (2) the waste indicators in SDGs and (3) the relationship between waste management and SDGs. This study suggests future possible areas of research by extending the regional boundaries, increasing the number of papers, focusing on more specific SDG goals and targets and studying case studies based on the specific targets and indicators.

**Keywords:** waste management; SDGs; waste indicators; solid waste; sustainable waste management



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## 1. Introduction

In the second decade of this century, many problems have arisen, and climate change is one of the problems that has a greater impact both nationally and internationally [1]. Waste management and climate change have a close relationship. Waste is commonly referred to as garbage, trash, junk or rubbish. Waste can be in any form, such as a liquid, solid or gas; it can even be in the form of waste heat. Therefore, there are many types of waste. The production and incineration of inorganic waste consumes natural resources like fuel, water, timber, and metal in the production process and results in greenhouse gas emissions, mainly carbon dioxide and other pollutants. On the other hand, plastic waste also produces greenhouse gas emissions at each stage of decomposition [2].

There are different international, regional, and national policies that deal with waste management. The 2030 Agenda for Sustainable Development, also called the SDGs (SDGs), were launched by the United Nations in 2015 [3]. The SDGs can be used to measure the well-being of people, challenges in terms of economic development and the creation of a better environment, as well as focus on how such changes can be included [3]. The 17 goals of the

SDGs focus on how to “Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development”. In addition, there are specific goals that focus on waste management, for example, Goal 6, “ensuring the access to water and sanitation to all”; Goal 11, “making cities and human settlements inclusive, safe, resilient and sustainable”; and Goal 12, “ensuring sustainable consumption and production patterns” by the year 2030. In this context, the goals further focus on the sound management of chemicals and water concerning both the environment and globally agreed frameworks, while also focusing on reducing the release of these chemicals into water, soil and the air in order to reduce the negative impacts that they would have on human beings [4]. The overall aim of these specific goals of waste management focuses on reducing waste generation by the year 2030 by preventing, reducing and recycling or reusing waste [4]. At the same time, the key principles of the circular economy are underpinned by three key factors, commonly known as the 3Rs: reduce, reuse and recycle. In essence, the SDGs are significant drivers behind the development of sustainable waste management activities as well as other current issues, such as environmental concerns, public health and enhancing the value of resources, with involvement in inclusivity and climate change [5].

This research paper has applied a systematic literature review using the PRISMA method and analyzed different published research papers and research reports with a specific focus on waste management and its relationship with the SDGs. In this paper, the context of solid waste management and SDGs, and the indicators of waste management in SDGs are extensively discussed. The results are further divided into two sub-categories, including descriptive results, which elaborate the different approaches to review the literature used for this paper and the thematic results, which include the key results and discussions of different aspects of this paper. This paper found that there was a gap in previous studies, especially in terms of discussing the relationship between the SDGs and waste management, as well as a gap in terms of discussing the aspects of waste management relating to the SDGs. It was found through this review that there are different studies on the SDGs or waste management, but studies that discuss these topics in detail are lacking; therefore, this review aimed to analyze the available published material from various regions and areas of the world within its limited scope.

Various research articles were studied and analyzed for this literature review. Most of the research articles mainly focus specifically on the areas of understanding waste management, waste management practices, recycling, solid waste, waste management procedures, policies of waste management, municipal waste and the context of waste management relating to the waste indicators of the SDGs. The overall general focus in analyzing the literature was on the important aspects of understanding waste management, waste management in general and SDGs as well as the context of waste management.

## 2. Scope of Review and Methodological Approach

A systematic literature review was applied using the PRISMA method. The literature review focused on the concepts, contexts, disciplines and different files in the available literature. The main contributions of this literature review may be in shaping the current knowledge and evaluating the progress of this knowledge; additionally, future contributions could include a performance analysis.

This literature review studied various sources of the available literature. The sources of the literature review include published articles in journals and published research. This systematic literature review was applied on studies from the years 2007 to 2024. This review also considered the context of waste management before the launch of the SDGs, as the goals were launched in 2016. Nevertheless, this review has included context since 2007 because the earlier reviews provided the perspectives of waste management before the launch of these goals. The review of earlier years also helped us to determine the policies and practices of waste management that already existed prior to the SDGs, and those may help in achieving the larger context of the goals. It was interesting to comprehend the general context of waste management and existing policies and procedures of waste management

before the launch of the SDGs from the available literature since 2007. Considering the earlier publications helped us to know the context of waste management, practices, and achievements before the launch of the SDGs and is also helpful in knowing the foundations of solid associations between waste management and the SDGs.

One of the interesting facts we found in the most recent publications in the area of this review was that most of the published scientific articles from recent years have been in the areas of waste management and SDGs. This review has applied the below steps to search, study, and analyze the literature to present the results of the literature review.

### *2.1. Identification and Screening*

To compile the literature on waste management concerning solid waste, waste indicators, and sustainable development goals (SDGs), a systematic exploration was conducted on Google Scholar as the primary database. The major keywords that were used for the search include “Waste Management”, “Solid Waste”, “Sustainable Development Goals”, and “Waste Indicators in SDGs”. These keywords were chosen because they provide a detailed view of the chosen topic to find relevant studies. The search was limited to 130 publications initially. Following that, the duplicate entries were removed and irrelevant articles were also excluded based on their titles and abstracts. A total number of 100 publications were considered relevant for further review. After screening the abstracts, full texts of a total of 30 publications were selected for detailed analysis.

### *2.2. Eligibility*

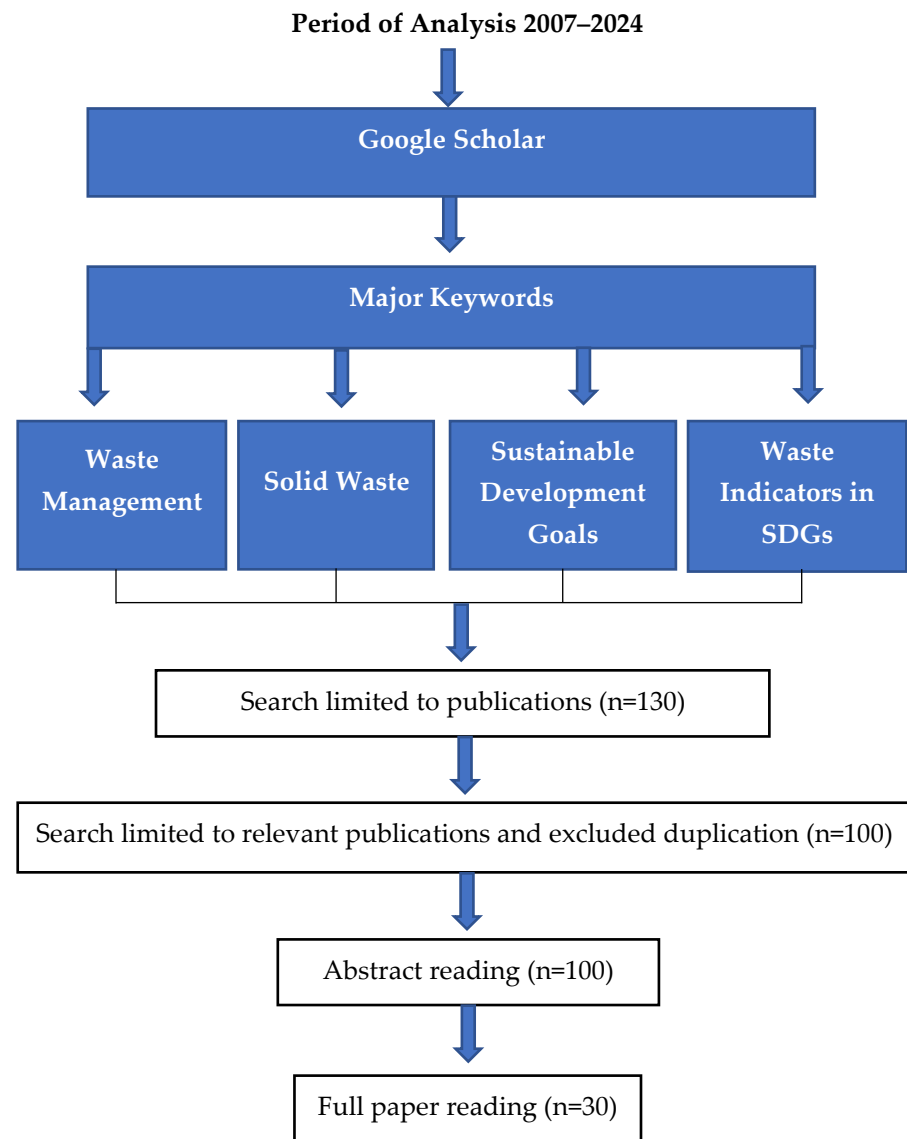
The criteria for the inclusion of these chosen studies are as follows: (a) publications that discuss the practices of waste management; (b) studies on solid waste; (c) studies that explore the sustainable development goals in regard to waste management; and (d) publications which are available in full-text format. The selected publications were in English language but no restriction was imposed on geographical regions.

The criteria for excluding the studies include (a) papers that did not focus on waste management, (b) papers that did not focus on waste management and relationship with sustainable development goals, (c) publications related to methodological issues, and (d) publications with a lack of empirical data.

### *2.3. Inclusion*

The extraction of data was carried out using the MS Excel (Version 2408) sheet for documenting important details from each study, including the names of authors, title, publication year, journal name, keywords, abstract and type of publication. The data were arranged, and a descriptive analysis was conducted to present the figures for each important detail.

Figure 1 mentions the search inclusion and exclusion strategy/step followed for the search.



**Figure 1.** Search inclusion and exclusion strategy/step followed for search.

### 3. Descriptive Analysis of the Review

This literature review is based on analyzing the existing literature to identify and present insights from existing work. The literature has helped to increase the understanding of the topic specifically and find out the gaps in existing research studies to work on the specific research areas. The studies, including refs. [6,7], used a similar analysis for the descriptive results. This paper analyzed data and found different results, as shown below.

#### 3.1. Distribution of Papers by Years

The related studies from various years have been studied and analyzed for this literature review. Figure 2 below shows that most of the papers reviewed are from 2022, while 2021 stands at second, and 2020 and 2018 stand as the third major year in terms of distribution of papers per year. This review has generally reviewed the papers from the year 2007 to 2024.

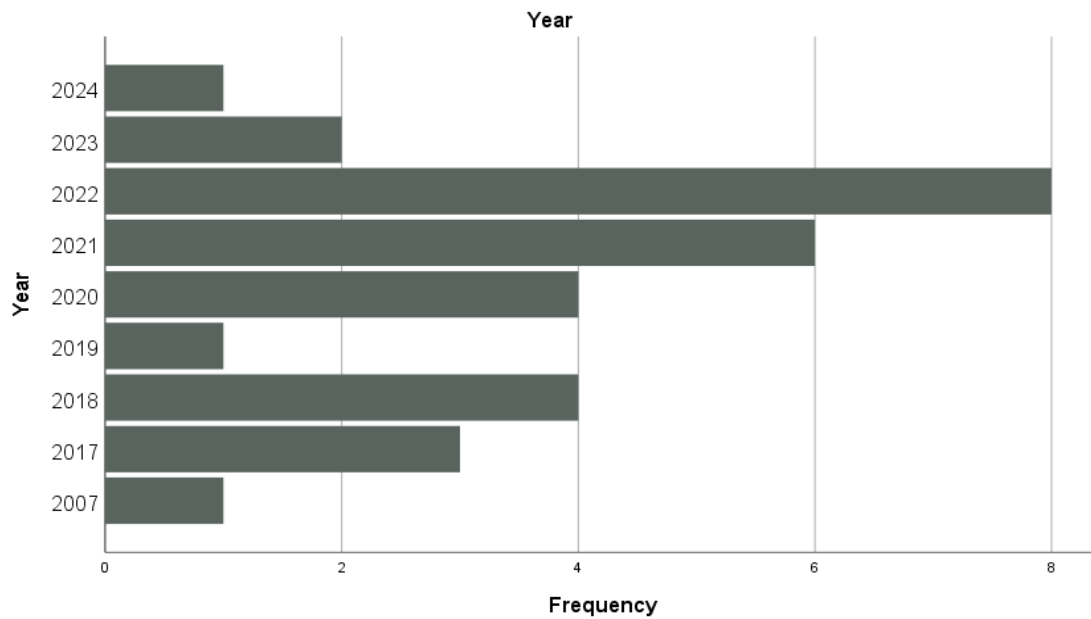


Figure 2. Distribution of papers by years.

### 3.2. Distribution of Research Journals

This literature review reviewed articles from different research journals. The search process was already defined in the above part. There are journals that were searched, reviewed, and cited presented in this paper. The journals are from the Scopus-indexed journals, and reviewed papers are available as online access or, in other cases, are available on Google Scholar. Figure 3 below mentions the key research journals.

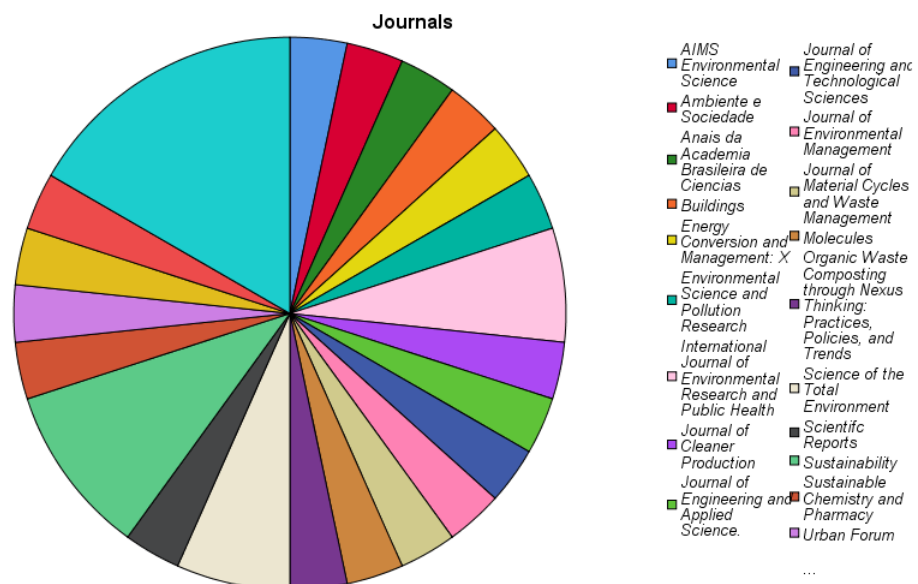
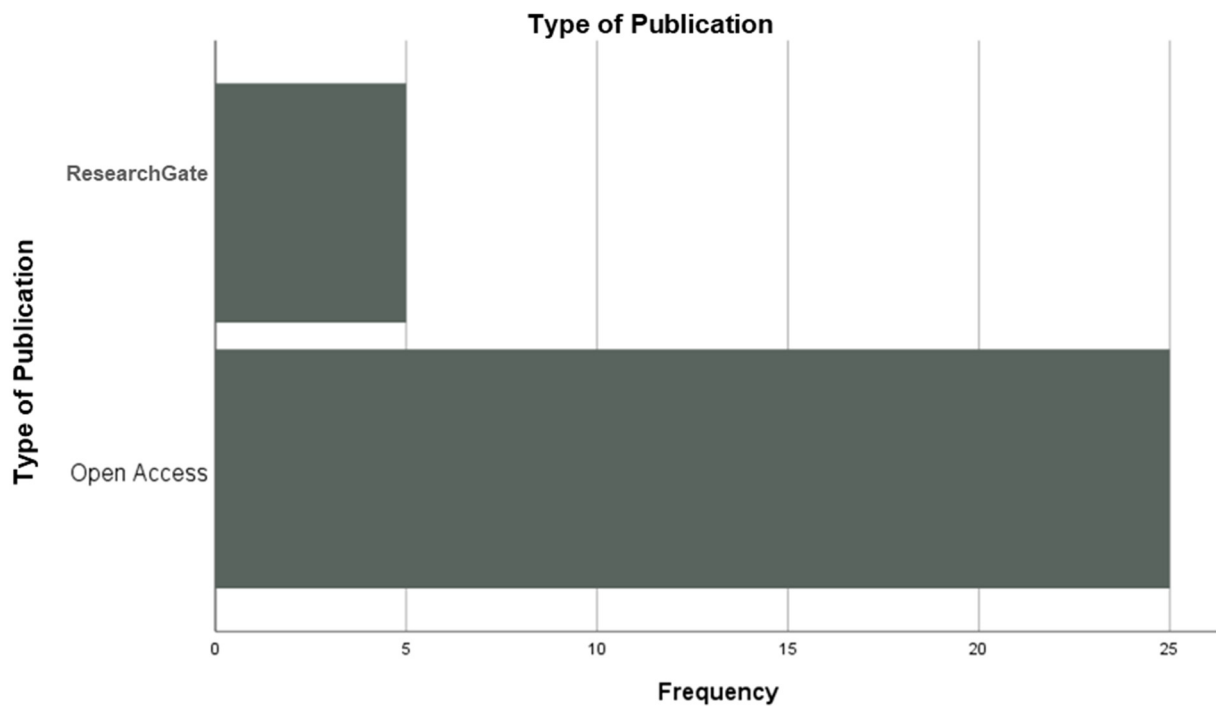


Figure 3. Distribution by research journals.

### 3.3. Distribution by Type of Publications

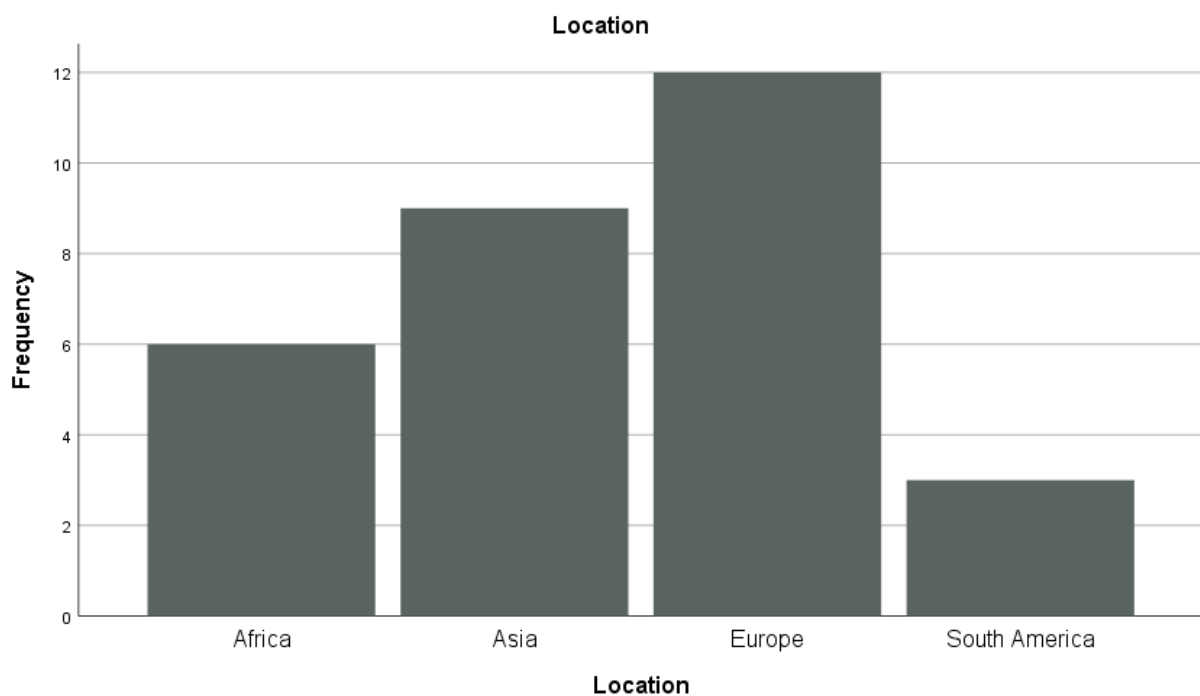
This literature review reviewed publications of two different kinds. The literature review reviewed research articles available as open access publications and papers not available as open access but full access on ResearchGate. There were 30 research papers reviewed for the literature review; 25 were available as open access while 5 were not available in open access, which were available on ResearchGate as full papers. Figure 4 presents the publication type by open access or full access on ResearchGate (Berlin, Germany).



**Figure 4.** Distribution by type of publication.

#### 3.4. Distribution by Geographical Location

This review also reviewed important sources of data from various countries. The review aimed to focus on most of the areas to cover a larger geographical area. The reviewed papers were mainly from countries in Asia, Europe, Africa and South America. The division of geographical location was divided by focusing on different regions by merging the countries into those regions. Below, Figure 5 shows the division of areas like Asia, Europe, Africa and South America.



**Figure 5.** Distribution of papers by geographical location.

## 4. Thematic Analysis of the Review

### 4.1. Context of Solid Waste Management and SDGs

Waste management or disposal includes the processes and actions essential to managing waste from production to final treatment [8]. The comprehensive process of waste management includes collecting, transporting, treating and disposing of it. It also means keeping an eye on and controlling waste management actions, enforcing laws about waste using technologies and applying economic strategies. The waste comes in different forms, for example, the waste coming in the form of liquid, solid or gas, which therefore needs different methods of management. Waste management involves dealing with a wide range of waste varieties, like biological, household and municipal organic radioactive waste, to ensure thorough and efficient waste disposal and regulation across different sectors [8].

Waste can pose a threat to human health in some cases [9]. Biological-infectious waste like bio-hazardous waste, infectious waste and pathological waste present as a more significant threat to human health than regular waste [10]. The whole process of management has strong connections with human health issues. Health issues might arise directly or indirectly from the handling of solid waste or by consuming the waste in terms of soil or food. The extraction and processing of raw materials also generate waste from human activities [8]. The management of waste intends to reduce the negative effects of waste on human health, the overall environment, aesthetics and resources on the planet. Waste management has a crucial role in protecting the environment and human health by reducing the effects of waste. The larger proportion of waste management deals with municipal solid waste that mainly comes from commercial and household sources. The strategies for managing waste differ between developing nations as well as between rural and urban regions and various sectors like residential and industrial. Each of these settings poses challenges that require tailored solutions for waste management [11].

Solid waste management is a cross-cutting theme to influence various surfaces of growth in every domain of sustainability, including the environment, society and economy [12]. The core values that form the foundation of the SDGs closely align with the changing approaches in managing waste. These values can be broadly classified based on their significance to SDGs, such as health (SDG 3), “Ensure healthy lives and promote well-being for all at all ages”; safeguarding the environment (SDG 6), “Ensure access to water and sanitation for all”; SDG 11, “Sustainable cities and communities”; and SDG 13, “Take urgent action to combat climate change and its impacts”. Recent efforts also highlight the pressing need to tackle climate change within the framework of waste management strategies [5]. For example, SDG 12.3 emphasizes the share of global food loss and waste, further focusing at the retailer and consumer levels, and SDG 14 focuses on conservation and sustainable usage of the seas, oceans and resources from marine life, further spreading that the indiscriminating use and disposing of plastic waste results in marine litter and concerns over microplastics. These are all not possible without achieving the targets of the sustainable management of waste. The waste that is not collected as well as poor disposal of the waste have resulted in adverse effects on human health and the environment (SDG 6 and 13). The overall costs for addressing such impacts at different times are higher than the real costs to develop and operate easily accessible and adequate waste management systems [13]. Solid waste management can be mainly linked to 12 out of 17 SDGs of the UN as essential utility systems that, currently, more than two billion people are lacking [12].

Global waste is predicted to increase to 3.4 billion tons by the year 2050 from the recent figures of waste of 2.01 billion tons. The emissions concerning solid waste management are estimated to grow to 2.38 billion tons of CO<sub>2</sub> per year by 2050 if no advances are implemented in this specific area [13]. Thus, it is crucial to change our approach from the economy “producer–consumer model” to the circular economy of the “reduce, reuse, recover, recycle, and redesign remarket” model. This shift is needed because the circular economy is more focused on regeneration and restoration, and it can significantly contribute to making progress toward fulfilling the SDGs. The practice of the circular economy helps to reduce waste to a minimum by extending the life cycle of the products [14]. The

achievements on specific SDGs also help in this regard; for example, SDG 1 calls to eradicate poverty in all ways; SDG 3 focuses on ensuring healthy lives and promoting the well-being of everyone; SDG 6 focuses on providing access to water and sanitation to everyone; SDG 7 focuses on modern energy to all (which must be affordable, sustainable and reliable); SDG 8 promotes the inclusivity and sustainable growth of the economy, employment and opportunity of work for all; SDG 9 focuses on building resilient infrastructure, promoting industrialization which is sustainable and inclusive, as well as fostering innovation; SDG 11 emphasizes on making safe, inclusive, sustainable and resilient human settlements and cities; SDG 13 calls for the urgent actions for combating climate change issues and impacts; SDG 14 focuses on conservation and sustainable usage of the seas, oceans and resources from marine; and SDG 15 calls for the protection, restoration and promotion of the sustainable usage of terrestrial ecosystems, as well as managing forests in sustainable ways, combating desertification, and halting reservation, land degradation and biodiversity loss. A structural change is reflected by the circular economy, which creates stability in the long run and increases the use and flow of resources, nutrients, and commodities (SDG 12). At the same time, it also provides economic, social, and environmental profits (SDGs 1, 2, 9, 13–15), which supports the private and public sectors for addressing not only the short-term objectives, but also advancements to the long-term SDGs' objectives [15]. The concept of the circular economy hinges on the management of waste materials, playing a role in promoting social equity, safeguarding the environment and fostering economic progress [16].

Solid waste management plays an important part in development and affects the economy, environment and society. It influences sanitation, living standards, public health, ecosystems, job opportunities and resource conservation. As a result, effective waste management is directly connected to most of the goals outlined in the UN's 2030 agenda for development. Therefore, among the 17 goals in the UN 2030 agenda for sustainable development, there are at least 12 goals and targets of those goals that are directly linked with solid waste management [12]. The United Nations Environment Programme (UNEP) believes that waste management's broad impact on the 12 Development Goals (SDGs) warrants increased political attention and recognition of its significance in contrast to the opposing viewpoint [17].

It results from all the sources that waste management includes a range of actions and processes which focus on effectively handling the waste from its point of generation to the final disposal. It involves activities like waste collection, transportation, treatment and regulation, with different methods employed for various types of waste, including solid, liquid and gaseous forms. The literature review shows that it is very important that waste management should be properly addressed because of the different risks to the health of humans that can arise from indirect exposure or direct handling of waste. Waste generation primarily results from human activities like raw material extraction and processing. The key goal of waste management is mitigating the harmful effects of waste on human health, natural resources and the environment; it is very important in managing municipal solid waste management, which originates from commercial, residential or industrial sources. The waste management practices may differ from country to country, region to region or sector to sector, showing different approaches for handling the waste. Solid waste management intersects with multiple SDGs (SDGs) proposed by the United Nations, including those concerning public health, environmental concerns, climate change, resource sustainability and the overall well-being of societies. However, global waste is projected to increase substantially, contributing to escalating CO<sub>2</sub> emissions if improvements in waste management are not implemented. Thus, the transaction process from the linear "production, consumption, and dispose of" model toward the framework of the circular economy that emphasizes the reduction, reuse, recovery, recycling and redesign of waste is very important to achieve the SDGs. The approach of the circular economy not only fosters stability in the long term but also helps in yielding the environmental, social and economic benefits linked with various SDGs. Solid waste management is an integral

component of the circular economy, promoting social inclusion, environmental protection and economic development. The UN's SDGs, launched in 2015, address various aspects of sustainable waste management, highlighting the need for environmentally sound practices, the reduction in and prevention of waste generation, and sustainable water and chemical management. Solid waste management has wide-ranging implications for sustainable development, affecting areas like sanitation, public health, ecosystems, job opportunities and responsible usage of natural resources.

#### 4.2. Waste Indicators of SDGs

The world is facing larger threats due to the climate change crisis. The emissions of carbon are harming nature every day. Industrial and daily life habits cause horrific damage to the atmosphere [18]. There is a daily rise in the amount of waste production because of increased economic development, rise in industrial activities and growth of populations [19]. Urban sustainability has been challenged in terms of worsening problems of the environment because of the rapid development of industrialization and urbanization. It calls for smart strategies for monitoring their dynamics around various regions [20]. Previous studies have estimated that the production of municipal solid waste may reach 2.6 billion ton per year by the year 2025 [21]. There is therefore a need for a robust strategy in addressing waste management issues [22].

The sustainability concept plays a vital role, especially for the manufacturers, local government and citizens who are trying to reduce the volume of waste. There is greater attention paid to industrial waste because of its negative environmental impacts and consequences on human health. It is believed that different sectors and industries can benefit from applying sustainable waste management practices. Sustainable waste management mainly involves transitioning from the traditional models of make–use–dispose to a more circular economy approach. In this kind of approach, the waste returns to the production cycle either in the shape of new raw materials, as energy, or even as a new product. Currently, ongoing popular waste management techniques include landfills, waste incineration plants, and biological cycling such as composting and recycling glass, plastics and aluminum. It is relatively easy to propose ongoing waste management strategies with an eye for sustainability [23]. Decisions regarding the right technique for sustainable waste management will depend on the kind of waste material, industry and legislative requirements [23].

Sustainable waste management can only ensure the everlasting protection of the biosphere and the prevention of irreversible global damage by decreasing the number of toxic wastes and environmental pollution and conserving the natural resources and ecosystem. Given the important value of sustainable waste management, it is still concerning to see that the amount of its application is still very low [18]. The launch of SDGs has brought important attention to environmental sustainability as an important foundation for sustainable development [20].

The 2030 Agenda for the Sustainable Development was launched and implemented by 193 countries in 2015 with the key goal of evaluating the world development and improving the life quality of all people. The SDGs were established for this purpose to be accomplished through combined actions at governmental, organizational, institutional and societal levels in local, national and international scopes. The UN's Agenda 2030's Goal 12 aims at sustainable consumption and production, and focuses on local and global actions to reach the effective use of natural resources. Taking care of solid waste and diminishing pollutant emissions is also included in this goal. In terms of solid waste management, this goal can be reduced by decreasing waste generation and preventing, reducing, recycling and reusing both at the production and consumption levels [24]. The SDGs describe waste as any material that is not a product(s) made for sale, which the producer no longer needs for production, alteration or consumption and that the producer plans to or must dispose of [25].

The literature review shows that climate change and the increased carbon emissions have resulted in greater threats to the world. Everyday human and industrial activities

are contributing toward changing the atmosphere. The production of waste has been increasing because of industrialization, economic development and population growth, together with other different sources like commercial, domestic, agricultural, industrial or municipal waste. The fast rise in urbanization and industrialization has challenged urban sustainability, producing the need for smart strategies to monitor the environmental dynamics. The literature review also projects the annual production of municipal solid waste to 2.6 billion tons by the year 2025. Robust waste management strategies are imperative to address these issues. There is very important attention given to the practices of sustainable waste management, specifically on the reduction in the volume of waste and on mitigating the negative impact on human health and environment. The transition toward the circular economy, which integrates waste into the production cycle, like raw materials, new products or energy, is very important. The ongoing waste management techniques include incineration, landfills, composting and recycling of plastics, glass and aluminum. It is very important to choose the technique dependent on the kind of waste, industry and the requirements of the legislation. Despite its importance, the implementation of sustainable waste management remains limited. The launch of the SDGs in 2015 has brought environmental sustainability to the forefront. Goal 12 emphasizes sustainable consumption and production, targeting effective resource use and waste reduction at both production and consumption levels. The SDGs define the waste as any material discarded by the producers without any further purpose. It is very important to achieve sustainable waste management to protect the biosphere, prevent irreversible global damage, reduce pollution and conserve the ecosystem and natural resources. SDGs have different targets which deal with waste management, and each target has different indicators and measurements defined for sustainable waste management. Goal 11 of SDGs has target 11.6, "Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management," which has specific the indicator 11.6.1, which deals with the proportion of solid waste at the municipal level and is collected and treated out of total waste generation by the cities. Goal 12 of the SDGs also has targets and indicators to deal with sustainable waste management. The waste targets and indicators under these goals mention that target 12.3 has two indicators focusing on food waste. Under target 12.4, there are two indicators, including 12.4.1, focusing on several parties on international multilateral environmental agreements on hazardous waste and other chemicals, and 12.4.2, which has two parts: (a) one focusing on the per capita generation of hazardous waste and (b) one focusing on the type and proportion of treated hazardous waste. Under target 12.5, there is one waste target focusing on the rate of national recycling, further measuring the tons of recycled material. Similarly, SDG Goal 14 also deals with sustainable water management. Target 14.1 of SDG 14 deals with the waste indicators 14.1.1 (b) plastic debris density. The indicator focuses on reducing the effect of pollution by preventing and reducing all types of marine pollution, mainly from land-based activities such as marine debris [25].

#### *4.3. The Relationship between Waste Management and SDGs*

The United Nations has raised calls on various items to increase imagination and innovation for addressing global waste management challenges. According to the facts from the UN Human Settlement Programme, 99% of the items purchased are discarded within six months, and the world produces two billion tonnes of waste annually. The SDGs and other agendas and agreements on climate change all address solid waste management. There is a strong relationship between waste management and SDGs. There are various academic papers that have studied the relationship between waste management and SDGs.

A research study by ref. [26] explores an in-depth examination of waste management in towns specifically focusing on Langebaan in South Africa and Swakopmund in Namibia. The research explores the assimilation of the concepts of the circular economy into the waste management systems to ensure that the policies of municipal waste management, procedures and practices are aligned with the SDGs. The overall objective of this study

was tied to SDGs such as addressing poverty (SDG 1), promoting health and well-being (SDG 3), fostering decent work and economic growth (SDG 8), building sustainable cities and communities (SDG 11), and encouraging responsible consumption and production practices (SDG 12). It examines how implementing waste management strategies within a circular economy framework can play a role in advancing these SDGs by supporting sustainability, economic progress and societal welfare. The study specifically examined how waste reduction, recycling and reuse can lead to job creation, pollution reduction and resource efficiency, thereby contributing to sustainable urban development [26].

Innovative waste management and biofuel production methods can also significantly contribute to SDGs in many ways by reducing carbon footprint, enhancing energy security and promoting the sustainable usage of marine and terrestrial resources [27]. The research study by ref. [27] explored the strategies for achieving SDGs while restoring pre-industrial CO<sub>2</sub> levels by 2140. It focused on conceptual designs and techno-economic analyses for sustainable limits in seafood and macroalgae-for-biofuel production, leveraging wet and dry waste management. The study discussed the important relationship between innovative waste management and biofuel production for significant contribution toward achieving the SDGs [27].

The studies also found that effective waste management not only reduces environmental impact but also promotes health, well-being and economic efficiency, directly linking to the achievement of multiple SDGs. A research study by ref. [28] explored the linkages between waste management practices and SDGs, focusing on how innovative approaches to waste can contribute to achieving sustainability targets. The study discussed different SDGs, like SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production) and SDG 13 (climate action), highlighting how waste management intersects with these goals, and found that sustainable waste management practices can significantly contribute to achieving SDGs by reducing emissions, conserving resources and enhancing community health and economic development. Innovative waste management plays an important role in achieving the waste targets, environmental sustainability and targets of the UN's SDGs [28]. A study focusing on solid waste management systems in regard to a sustainable model from the economic and environmental perspective has been conducted by ref. [29]; it explored the linkages between waste management practices and their impact on achieving SDGs, with a specific focus on innovative and sustainable waste management solutions. The study emphasized that SDGs related to responsible consumption and production (SDG 12), climate action (SDG 13) and sustainable cities and communities (SDG 11) highlight the crucial role of waste management in achieving these goals. The analysis of the paper discussed how effective waste management practices not only mitigate environmental impact but also promote social and economic well-being, thus largely contributing to the broader agenda of sustainable development. It has also been discussed that innovative waste management practices, including recycling, composting and energy recovery, can significantly reduce environmental pollution, lower greenhouse gas emissions and foster sustainable urban development. Governance has a meaningful role in achieving the SDGs related to solid waste management. In this regard, a study is conducted focusing on resolving the governance issues to achieve priority SDGs related to solid waste management in developing countries [29]. Another study by ref. [12] explored the governance issues impacting solid waste management (SWM) systems in developing countries and how resolving these issues can help achieve certain SDGs (SDGs). The study highlighted governance challenges in SWM, including lack of funding, inadequate infrastructure and policy gaps. It emphasized the link between effective SWM and its contribution to achieving SDGs, particularly those related to health (SDG 3), clean water and sanitation (SDG 6), sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12) and climate action (SDG 13). It also discussed how improved governance in SWM can directly impact the achievement of the SDGs by enhancing public health, reducing environmental pollution, promoting sustainable economic growth and ensuring social inclusiveness.

While discussing the relationship between waste management and SDGs, the importance of solid waste management cannot be ignored because SDG 12 (responsible consumption and production), SDG 3 (good health and well-being), SDG 6 (clean water and sanitation) and SDG 15 (life on land) highlight the importance of solid waste management for human life. They highlight how effective waste management strategies can support these goals by reducing pollution, improve public health and conserve resources. A research study by ref. [30] the status of municipal solid waste (MSW) management and identified the challenges and opportunities within the framework of sustainable development. The study highlighted the lack of infrastructure, technical expertise and financial resources as major hurdles to improving MSW management. Waste management have direct and indirect impacts on the SDGs. The study suggested that improving the practices of waste management can result in better health outcomes, reduced environmental degradation and more sustainable consumption and production patterns [30]. Another research study by ref. [31] explored organic waste management strategies in developing countries through buyback programs. It examined the potential of such programs to improve sustainability and contribute to SDGs (SDGs), emphasizing the high organic content of waste and the role of informal waste sectors. The study uses case studies from Colombia and South Africa to illustrate implementation challenges and successes. It argued that organic waste buyback programs can positively impact environmental sustainability, economic stability and social welfare by promoting recycling and reducing landfill use, thereby addressing SDGs related to zero hunger, clean energy, climate action, clean water and sustainable cities. The paper argued that advancing sanitation access is crucial for broader sustainable development. It underscores the direct link between improved sanitation access and several SDGs, particularly those related to health (SDG 3), clean water (SDG 6), reduced inequalities (SDG 10) and climate action (SDG 13) [31].

There are innovative findings from various studies focusing on different regions of the world in terms of innovative waste management tools for helping the achievement of different indicators of waste in the SDGs, highlighting the relationship between SDGs and waste management. A study by ref. [32] focused on analyzing electronic waste “(e-waste) management” strategies in Malaysia, highlighting challenges and prospects. The paper discussed the importance of efficient e-waste management in achieving SDGs, especially the goals concerning clean water and sanitation, sustainable cities and communities, responsible production and consumption, and life below water. The paper identified the key socio-techno-economic challenges. It emphasizes the relationship between waste management and sustainable development, presenting key results on the effectiveness and gaps in Malaysia’s e-waste recycling efforts. The paper also highlighted the relevance of effective e-waste management to achieving several SDGs, especially those associated with environmental sustainability, health and responsible consumption and production. Regarding the relationship between waste management and SDGs, the paper highlighted how proper e-waste management could positively impact SDG targets by reducing environmental degradation, improving health outcomes and fostering sustainable industrialization [32].

The relationship between waste management and SDGs can be highlighted in many contexts, and each context has its importance. There is a paper that has discussed cigarette waste about SDGs. The study focused on the beaches of Thailand and was conducted by the authors of [33]. The study aimed at assessing the density and distribution of cigarette butts, a major component of tobacco product waste (TPW), across popular beaches in Thailand. It highlighted the environmental impact of such waste and advocated for policy interventions and public awareness campaigns to mitigate this issue. A cross-sectional observational survey at six popular beaches in Thailand was conducted by the authors. The research directly contributes to SDG 14 (life below water) by addressing marine pollution and SDG 15 (life on land) by focusing on terrestrial pollution. It also touches on SDG 3 (good health and well-being) by highlighting the health implications of TPW. It discusses the detrimental effects of cigarette waste on marine life and water quality, linking effective

waste management practices with achieving SDGs related to environmental sustainability and health.

There is an ongoing debate in the scientific world on the management of plastic waste. The studies in academic and non-academic sectors emphasize the policies to deal with plastic waste, the scientific ways of reducing the usage of plastics as well as bringing sustainable approaches toward plastic waste. The academic papers have highlighted very important perspectives on this area in different domains. An interesting study by ref. [34] was conducted in Brazil, focusing on developing an integrated plastic waste management strategy for Recife, Brazil, addressing the challenge of plastic pollution from river basins to urban beaches. The paper highlighted the critical link between effective waste management and achieving SDGs, emphasizing the importance of integrated approaches to tackle plastic pollution in aquatic and urban environments. It directly relates to SDG 6 (clean water and sanitation), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), and SDG 14 (life below water) by aiming at reducing plastic pollution and improving waste management practices [34].

The policy frameworks, practices and systems are important to manage every type of waste to achieve the SDGs. In this regard, there are studies in various regions of the world focusing on the conceptual frameworks, regulations, settlements or net zero constructions. All these domains directly link toward various SDG goals, and together, achieving waste management can lead to achieving the SDGs. A paper by ref. [26] presented a comprehensive analysis focusing on integrating circular economy principles into waste management systems. It also proposed a conceptual framework based on circular economy (CE) principles to enhance sustainability. The overall discussions of the study reveal that neither municipality has fully integrated CE principles into its waste management systems. Major challenges include regulatory frameworks, insufficient capacity, private sector involvement, technical solutions and financial resources. The study highlights the important role of effective waste management in achieving the achievements of SDGs, especially related to sustainable cities and communities, responsible consumption and production, and climate action [26]. There are also informal or traditional settlements of waste management in different countries, especially developing countries. A study focused on the collection of solid waste in informal settlements. It was found that a complex regulatory landscape often marginalizes informal waste collectors despite their significant role in the waste management ecosystem. It was further pointed out that the existence of stringent regulatory requirements favor formal entities and overlook the potential of informal sector contributions. It also identified a gap in localized policy-making that could foster better collaboration and efficiency in waste management. The study addresses the linkage between effective waste management practices and the achievement of several SDGs (SDGs), such as SDG 11 (sustainable cities and communities) and SDG 12 (responsible consumption and production), by highlighting the need for inclusive and efficient waste management systems [35]. There are various other interesting studies that have focused on larger contexts and led toward the achievement of the SDGs in various ways. Some studies focus on minimizing the environmental impacts of solid waste, aligning with SDGs. The larger focus of the studies broadly studied the waste management practices, policies, innovations and behaviors toward waste regarding sustainability approaches with broader focuses on environmental sustainability, sustainable development and the SDGs.

## 5. Discussion and Future Research Avenues

This decade has brought various challenges, which are not limited to climate change challenges and include additional challenges that are contributing at larger scales toward climate change. In previous years, especially from the year 2007 to today, climate change has been one of the key challenges of this age, which has had impacts on the global level as well as at national levels worldwide [1]. The SDGs (SDGs) were launched by the United Nations in the year 2015, also called the 2030 Agenda. The 2030 Agenda is capable of measuring the change in the well-being of people, the economic challenges and lead to

a better environment, but it also focuses on the ways of working on these changes. The 17 goals of the SDGs (SDGs) highlight the importance of enhancing implementation methods and vitalizing the Global Partnership for Development. Furthermore, Goals 6, 11 and 12 of the SDGs pinpoint on managing water and sanitation, promoting production and creating inclusive, safe and resilient cities by 2030 [3].

There is a solid relationship between climate change and waste management. Waste can be understood commonly as garbage, rubbish, junk or trash. The key waste that contributes more toward producing greenhouse gas emissions is plastic waste, which contributes to each stage [2]. SDGs have defined waste as any material that is not the primary product (i.e., the products which are produced for market) for the producer, has no further usage for production transformation or consumption, and which they discard or intend or are required to discard [25].

According to the International Institute for Sustainable Development (IISD), there are various goals and targets of the SDGs that focus on different areas, but the SDGs have two main goals, which have a special focus on waste management. Goal 11 of the SDGs entitled “sustainable cities and communities” possesses the target 11.6 to reduce the negative per capital impacts of the environment on the cities, and it also pays more attention to the quality of air and municipal waste management as well as other kinds of issues related to waste management. The International Institute for Sustainable Development also has SDG 12, entitled “responsible consumption and production”, that has different targets which focus on the environmentally sound management of all kinds of waste by the prevention, reduction, recycling, reusing of (mentioned by targets 12.4 and 12.5) and (target 12.3) reduction in food waste [26].

There is a wider connection between waste management and SDGs. The waste management at each stage builds a connection in regard to achieving the set targets, managing in environmentally friendly ways, considering the social profile of the residents, economic parameters and other domains of sustainable development [28–31]. Various studies like [26,35] or others have studied waste management in relation to the SDGs and focused on different aspects. There was a limited scope of this study in terms of papers as we gathered a limited number of papers; however, the study tried to focus on all regions like Asia, Europe, Africa and South America, and at the same time studies from 2007 to 2024 were also analyzed.

The future research avenues recommended by this study are listed below:

- This study has a limited scope to review a limited number of papers, so this study recommends the broader aspects in future studies by increasing the number of papers for review.
- This study has reviewed papers from Asia, Europe, Africa and South America. Nevertheless, there is the possibility of studying and reviewing the studies from other regions in the direction of waste management and SDGs.
- The world is facing many challenges, and food security is one of the biggest. This study recommends future research avenues to study food waste in terms of food security and waste management at large.
- In its limited scope, this literature review has studied the context of waste management and performance as of SDGs. Regardless, it has been reviewed by this paper that there were mechanisms and systems of waste management before the adoption of the SDGs, so this paper recommends future research avenues to analyze the performance of waste management and compare pre- and post-SDG waste management.
- This paper has touched on the policies and procedures slightly from a few studies, but it is possible to review and study the global environmental policies, which specifically focus on waste management policies, compare the policies of different countries and measure their impacts.
- The policy frameworks regarding waste management can also be reviewed in detail in different regions or countries.

## 6. Conclusions

This research paper had important objectives: to review waste management in general, discuss the waste indicators, and discuss the relationship between waste management and SDGs. This study mainly focused on four aspects while reviewing different areas, including waste management in general, the context of waste management and SDGs, waste indicators of SDGs, and the relationship between waste management and SDGs. The literature review is very significant in understanding waste management in general as well as understanding the waste management indicators of SDGs, which deal with waste treatment services and their relationship to SDGs. The literature review is also important in other ways to see waste management in the context of SDGs.

This paper studied different research publications from 2007 to 2024, but it focused on the most recent publications in the specific areas of this paper. This paper has widely discussed the understanding of the waste management concept and the solid waste management concept in the context of the SDGs and found associations between waste management and the SDGs.

This review paper further opens new areas for future research study. There can be different aspects of the SDGs that can be studied in future research studies. Waste management in different regions and countries can be studied in future studies in relation to the SDGs to focus on the impacts on each specific goal by the practices of waste collection and treatment in different regions, or they can focus on any particular region to know the achievement of SDGs for that specific region.

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