

# Solid Waste Management in Underdeveloped Countries: Study of Nigeria and Nepal for Achieving Circularity and Sustainable Development Goals

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**ABSTRACT.** The solid waste management system in underdeveloped countries lacks adequate infrastructure and efficient collection practices and has a limited focus on sustainability and circularity, causing environmental challenges and hindering socioeconomic progress. This review paper employed a methodology involving the purposive selection of one underdeveloped country each from Africa and Asia with the aim of identifying current solid waste management practices, analyzing circularity in waste management, assessing policy measures, evaluating progress towards achieving sustainable development goals (SDGs), and recommending effective waste management processes in Nigeria and Nepal. Researchers from these countries conducted a comprehensive literature search and analysis using secondary literature and case studies of solid waste management. The study revealed that both countries face challenges such as low recycling rates, inadequate waste collection services, and improper disposal methods. However, there is significant potential for waste recovery and circular economy practices due to the high proportion of recyclable and compostable waste in their waste streams. Addressing these challenges requires comprehensive waste management plans, improved recycling capabilities, and promoting public awareness and participation in waste reduction and recycling efforts. Collaboration between the government, private sector, and informal sector is crucial in developing innovative solutions and establishing effective waste management practices. Adopting circular economy principles can help minimize waste generation, conserve resources, reduce environmental pollution, and contribute to the achievement of SDGs.

**Keywords:** circularity, recycling, solid waste management, underdeveloped countries, waste reduction

## 1. Introduction

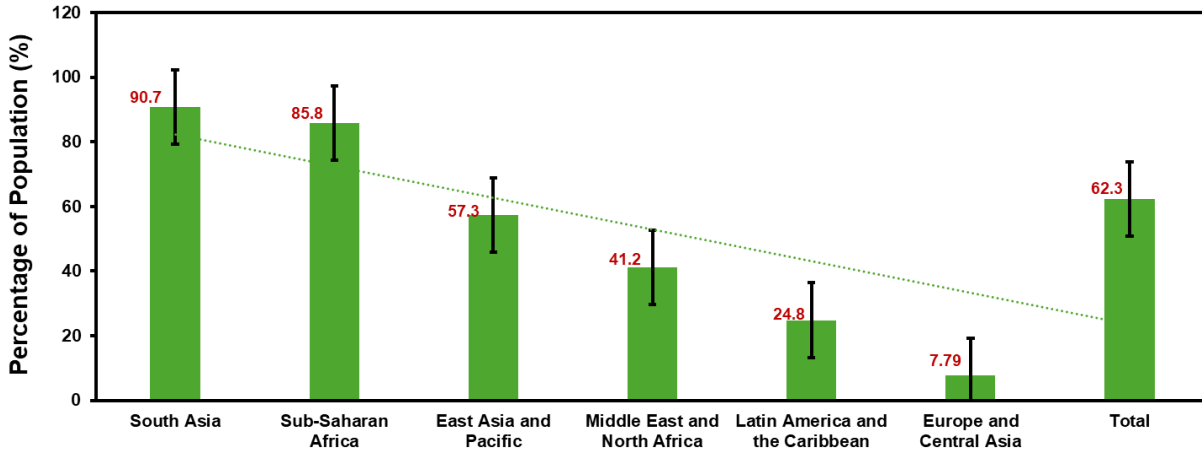
Global waste production is a complex issue that arises from a wide range of activities, encompassing individual, family, governmental, industrial, and developmental processes. However, in many locations, waste is haphazardly disposed of without consideration for its environmental impact or the potential harm it may cause to the surrounding areas, such as land, sewers, or water bodies (Raimi et al., 2022a). One significant concern associated with waste is the persistence of non-biodegradable or inorganic components over extended periods of time, which can pose serious hazards to the environment. Unlike organic components, which can undergo biological degradation and reenter the natural life cycle, non-biodegradable materials do not readily break down and can accumulate in the environment (Meereboer et al., 2020). This accumulation can lead to a range of detrimental effects, such as soil and water pollution, destruc-

tion of habitats, and threats to wildlife and human health.

Moreover, the issue of solid waste management (SWM) is further worsened by the constant introduction of new consumer goods into the market, driven by advancements in science and technology (Nnorom and Osibanjo, 2008). This continuous influx of products puts additional strain on the Earth's resources and challenges efforts to protect the environment and its ecosystems (Raimi et al., 2022b). The production and disposal of these goods often involve the extraction of raw materials, energy-intensive manufacturing processes, and the generation of substantial waste streams, contributing to the overall waste problem (Rene et al., 2021).

To mitigate the adverse effects of global waste production, it is imperative to adopt sustainable waste management practices at all levels, from individuals to governments and industries. This includes reducing waste generation through recycling and reuse, implementing effective waste treatment and disposal methods, promoting eco-friendly product design and manufacturing processes, and raising awareness about the importance of responsible waste management (Raimi et al., 2022c). Sustainable waste management encompasses waste prevention, reduction, recycling, composting, and environmentally friendly dis-

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**Figure 1.** Percentage of population in developing countries without access to regular collection and sound disposal of solid waste (Beamer et al., 2021; Dong et al., 2021).

posal (Giri, 2021; Subedi et al., 2023). A system for sustainable waste management integrates feedback loops, prioritizes processes, demonstrates adaptability, and redirects waste from disposal (Seadon, 2010).

Studies have shown that the global population is projected to reach 8.6 billion people in 2030, 9.8 billion in 2050, and 11.2 billion in 2100, resulting in increased resource consumption and potential resource scarcity (McKinsey, 2011). Therefore, the use of natural resources is expected to become more difficult, costly, and depleted for future use (Olalekan et al., 2018; Raimi et al., 2019; Raimi et al., 2021b). The global south, which houses a significant portion of the population, particularly in emerging nations, faces numerous challenges associated with high population density, including inadequate sanitation, water supply, air pollution, traffic congestion, and growing amounts of solid waste (Olalekan et al., 2018a, b; Raimi et al., 2019; Catherine et al., 2022; Raimi et al., 2022b). Most of the population growth is occurring in economically underdeveloped nations, contributing to an estimated annual global production of municipal solid waste (MSW) of about 1.3 billion tonnes, assuming an average trash generation rate of 0.5 kg/person/day (Sridhar et al., 2020).

Addressing the reduction of primary material usage, protecting material resources, and reducing carbon footprint can be achieved through the adoption of a circular economic system (EMF, 2014a). Circular economy (CE) integrates sustainable practices into business operations and is achieved through the utilization of renewable energy sources and the cyclic flow of materials, which emphasizes the redesign of products, waste elimination, efficient resource cycling, and the prolonged lifespan of products (Ferronato et al., 2023). Implementing CE principles is expected to have positive economic impacts, such as gross domestic product (GDP) growth, net material savings, job creation, and reduced risk of material price volatility and supply (EMF, 2012, 2013, 2014b; Kok et al., 2013; Bocken et al., 2017). The concept of CE advocates for changing production and consumption patterns that harm the planet and its ability to sustain life by promoting durable, reusable items and closing resource

loops through waste and resource reuse (Blomsma and Brennan, 2017; Homrich et al., 2018). CE represents a resource management approach that utilizes waste as a resource to generate value, thus enhancing productivity and efficiency in managing natural and human resources (Linder and Williander, 2017).

The importance of CE has gained global attention in efforts to meet local, national, and international sustainability goals (Accenture, 2014; Beamer et al., 2021; Dong et al., 2021). However, emerging nations, particularly low- and middle-income countries, have received less attention in comparison to developed nations. For instance, open dumping and burning of waste were common practices in many poor nations until the early 21st century, leading to the proliferation of dumpsites that pose significant environmental threats to surrounding communities. Both low-income and upper-middle-income countries continue to rely heavily on open dumping as the primary waste management approach (Figure 1) (Beamer et al., 2021; Dong et al., 2021).

CE represents a new and evolving business model that replaces the traditional linear model, offering a promising approach to address global sustainability concerns (Azizuddin et al., 2021; Hemidat et al., 2022). Governments worldwide, particularly in Africa and Asia, have embraced the concept of CE to advance the implementation of the United Nations' 2030 development agenda. These governments have adopted sustainable production and consumption plans aligned with CE principles and the United Nations' sustainable development goals (SDGs). To ensure the integration of CE practices and SDGs, governments have enacted legislation and provided guidance (Azizuddin et al., 2021; Hemidat et al., 2022). However, while numerous studies have explored the link between CE and the SDGs in industrialized countries, there is limited literature addressing the policy status and implementation challenges at the grassroots level.

Recent studies have highlighted the discrepancy in the adoption and implementation of circularity models between developed nations and low- and middle-income countries. Underdeveloped countries in Africa and Asia, such as Nigeria and Nepal, face significant challenges in SWM. To address this issue, a

study has been conducted to provide insights into achieving circularity in SWM and propose suitable policy measures that can benefit the governments of both countries (Azizuddin et al., 2021; Hemidat et al., 2022).

This study focuses on Nigeria and Nepal as representative underdeveloped countries in Africa and Asia, respectively, where SWM poses a substantial environmental challenge. These countries serve as crucial case studies to understand the current practices, circularity aspects, and policy measures in the context of waste management in underdeveloped nations. Despite the significant waste management challenges these countries face, there are less studies that comprehensively examine their current practices, circularity aspects, and policy measures. By filling this research gap, the study aims to provide a holistic understanding of the waste management systems in these countries and identify areas for improvement.

One of the primary objectives of the study was to explore the circularity models implemented by developed nations and explore their relevance and applicability in the context of Nigeria and Nepal. By studying the experiences and best practices of developed countries, valuable insights can be gained and tailored to the specific needs and challenges faced by these underdeveloped nations. This approach can contribute to the formulation of effective policy measures that promote circularity in SWM, which, in turn, can improve the overall environmental sustainability and resource efficiency of these countries.

The findings of this study are expected to have practical implications for the governments of Nigeria and Nepal, as well as other nations facing similar waste management challenges. The proposed policy measures can serve as a valuable reference and guide for developing effective strategies to enhance circularity in SWM.

The study was conducted with three main objectives: (i) to identify the current SWM practices in Nigeria and Nepal; (ii) to analyze the circularity in SWM in Nigeria and Nepal; (iii) to assess the current policy measures, progress towards achieving the SDGs, and recommend effective waste management processes.

## **2. Methods**

The methodology employed in this review paper aimed to conduct a comprehensive analysis of SWM in underdeveloped countries, specifically focusing on Nigeria and Nepal. The research was conducted in collaboration with the Global Research Institute and Training Center (GRIT), bringing together researchers from both countries to ensure a comprehensive and inclusive study.

To gather relevant information, the researchers employed a purposive selection approach, choosing one underdeveloped country from Africa and one from Asia. The selection process was based on the researchers' expertise and knowledge of the waste management challenges in these regions. The collaboration facilitated the exchange of ideas, experiences, and perspectives between the researchers from Nigeria and Nepal.

To conduct the literature review, the researchers performed

a comprehensive search for relevant articles and case studies related to SWM in Nigeria and Nepal. This involved utilizing secondary literature and case studies available in the selected databases. A combination of backward and forward search strategies was implemented to ensure the inclusion of all useful references in the review.

In the backward search step, the researchers identified relevant sources and examined the sources cited within those studies to identify additional relevant references. This approach helped to ensure that key studies were not missed during the review process. For the forward search step, the researchers searched for any sources that cited the identified relevant sources, expanding the search scope and capturing additional relevant literature.

To facilitate the search process, the researchers compiled a database of keywords, which documented the multiple keywords used and the rationale behind their inclusion. This keyword database assisted in systematically conducting the literature search across various reputable sources, including Google Scholar, Science Direct, Springer, ResearchGate, Sage, ProQuest, EBSCO, PubMed, as well as grey literature and expert working group reports.

The literature inclusion criteria included a geographic focus on these countries, relevance to CE, global challenges, consideration of SDGs status, and adherence to a comprehensive set of search terms outlined in Table 1. After identifying the full articles during the literature search, the researchers independently analyzed them. The initial analysis involved assessing the relevance and quality of each article. Subsequently, the researchers compared their findings and reached a consensus on which articles should be included in the study. This rigorous analysis ensured the inclusion of high-quality literature and case studies relevant to SWM in Nigeria and Nepal.

All researchers actively participated in the study, contributing case studies from their respective countries and collectively preparing the first draft based on the search criteria outlined in Table 1. The collaboration and contributions of all researchers were essential in ensuring a comprehensive and inclusive analysis. Subsequently, the document underwent several rounds of revisions, incorporating inputs and feedback from all researchers, leading to the development of the final paper.

Table 2 provides specific details of the countries involved in the study, namely Nigeria and Nepal. Nigeria is in West Africa and covers a total area of 923,769 square kilometers. The country faces significant waste management challenges, generating approximately thirty-two million tons of MSW annually. This corresponds to a per capita waste generation rate of 0.438 kg/person/day. The substantial waste generation in Nigeria emphasizes the urgency and importance of effective waste management strategies.

On the other hand, Nepal is a landlocked country in South Asia, with a total area of 147,516 square kilometers. Nepal also grapples with SWM issues, generating approximately 1.8 million tons of MSW per year. The per capita waste generation rate in Nepal is 0.30 kg/person/day. Although the waste generation in Nepal is lower than in Nigeria, it still presents significant chal-

**Table 1.** Different Search Terms Used to Gather and Analyze Secondary Literature

Search Phrase	Reason for Modifying
Circular economy	The original phrase used to search all databases
Circular economy + Solid waste management sector	Used to refine the search results to only include articles that focus on the implementation of circular economy
Circular economy + Solid waste management Sector + SDGs status	Used to eliminate studies that discussed circular economy implementation in solid waste management sector
Circular economy + Solid waste + Current policy + SDGs status	Used to find studies that were conducted globally
Circular economy + Solid waste management sector + SDGs status in Asian and African countries	Used to refine the search results to articles that focus on circular economy + solid waste management practice globally
Circular economy + Solid waste management sector + SDGs status + African and Asian countries in (name of country)	Names of countries known to have awareness and practice of circular economy such as Nigeria and Nepal were used in the search query to refine the search
Circular economy + Solid waste management sector + Global south	Variations of the above search phrase used for identifying articles that did not talk about awareness and practice of circular economy process but discussed probable causes of SDGs failures across the global south

lenges that need to be addressed.

These details regarding the waste generation and per capita waste generation rates in Nigeria and Nepal provide essential context for the study. They highlight the scale of the waste management challenge in both countries and lay the foundation for the subsequent analysis of their SWM practices and circularity aspects. By understanding the waste generation rates, researchers can assess the magnitude of the problem and identify areas for improvement.

The information on waste generation and per capita waste generation rates in Nigeria and Nepal is crucial for evaluating the effectiveness of existing waste management practices and identifying opportunities to promote circularity in these countries' waste management systems. It serves as a baseline for the subsequent analysis, enabling comparisons and assessments of the current practices and circularity initiatives in the two countries. To further contextualize the study, it is worth noting that the World Bank (2020) has provided data on waste generation rates in Nigeria and Nepal. This data, gathered from reliable sources, adds credibility and validity to the study's findings and supports the subsequent analysis and recommendations.

**Table 2.** Details of the Countries Involved in this Study (World Bank Data)

Countries	Population (2021)	GDP (2021, Billion US \$)	Population Growth (2021, %)	Per capita waste generation (kg/person/day)
Nigeria	211,400,704	440.78	2.5	0.438
Nepal	29,674,920	36.29	1.8	0.30

### 3. Results and Analysis

#### 3.1. Current Solid Waste Management Practices

The recycling rates in Nigeria and Nepal are extremely low, and waste collection services are not provided to all households (Table 3). It is always challenging to obtain waste-related data as there is a lack of a proper system for recording waste gen-

eration, collection, and disposal, and this variability is observed from one study to another (Khanal, 2023).

##### 3.1.1. Current Solid Waste Management Practices in Nigeria

In Nigeria, the average person generates 0.43 kg of solid waste per day, with approximately 80% of the waste stream consisting of organic and recyclable material (Ebikapaye et al., 2020; Sridhar et al., 2020). To effectively manage waste and minimize adverse effects on ecosystems, a comprehensive waste management strategy should consider all aspects of the waste stream. The hierarchy of waste management includes source reduction, reuse, recycling, waste combustion, and landfilling, and implementing such a plan in Nigeria would yield the desired results. Waste separation into biodegradable and nonrecyclable materials, and their conversion into organic fertilizer and raw materials for industrial needs, such as plastic/nylon pellets and scrap metal molten ingots, can be viable options (Ebikapaye et al., 2020).

Waste management in Nigeria is a shared responsibility among the federal, state, and municipal levels of government. Due to funding shortages in local governments, state agencies often take over waste management duties (Ebikapaye et al., 2020). Consequently, there are variations in garbage service policies across different cities in the country.

Several organizations are involved in waste management in Nigeria, including the State Environmental Protection Agency, waste management authorities, and sanitation agencies. However, these agencies encounter numerous challenges that impede effective waste management. These challenges include unnecessary bureaucracy, internal conflicts, a lack of clarity regarding duties and responsibilities, and inadequate monitoring and evaluation initiatives. Additionally, many agency executives lack the necessary expertise or qualifications. At the same time, personnel responsible for waste collection in municipalities often exhibit low morale and engage in corrupt practices, such as demanding payment from clients before removing their rubbish. Furthermore, due to a lack of trust in government services, some citizens choose not to pay sanitation charges. These issues collectively contribute to the complexities of waste management in

**Table 3.** Solid Waste Generation, Recovery, and Disposal of the Studied Countries

Countries	Total waste generation (million tons per year)	Waste collection efficiency (%)	Recycling rate (%)	Final disposal (%)	Status of landfills
Nigeria	32.0	75 (In urban areas)	6.8	93.2	Home to six of the biggest Landfills in Africa (Olusosun, Solous, Epe, Awotan, Lapite, Eneka). which are unregulated dumps, poorly managed
Nepal	1.8	62	4.1	95.9	6 out of 293 urban local bodies have constructed landfill sites, rest are dumping in open areas

Nigeria (Suleiman et al., 2019; Sridhar et al., 2020). Moreover, the scarcity of reliable waste management records and data poses an additional challenge. The lack of comprehensive data hinders the analysis and identification of solutions to address critical waste management issues in Nigeria effectively. Without accurate data, it becomes difficult to develop targeted strategies and make informed decisions in waste management (Suleiman et al., 2019; Sridhar et al., 2020).

Furthermore, the public's ambivalence and lack of concern towards waste management also contribute to the challenges faced in implementing sound environmental practices. The overall indifference among the general population further exacerbates the issues surrounding waste management in Nigeria (Suleiman et al., 2019; Sridhar et al., 2020).

### 3.1.2. Current Solid Waste Management Practices in Nepal

In Nepal, approximately 1.8 million tons of MSW is generated annually, with organic waste and dry recyclables comprising most of the waste stream (ADB, 2013; Kaza et al., 2018). Around 56% of the MSW is organic material, and 16% is plastic. Notably, about 90% of the waste generated in Nepal is either compostable or recyclable, indicating a high potential for waste recovery. However, despite this potential, more than 90% of the waste is still being transferred to landfill sites without proper treatment. Waste management in Nepal involves government entities, private companies, and local organizations. In many cases, household waste is directly sent to landfills without any treatment. In Kathmandu, the capital city of Nepal, around 466.14 tons of waste are generated daily, with the Kathmandu Metropolitan City (KMC) office responsible for collecting household solid waste from the core areas. Private companies and organizations manage around 80% of the solid waste generated in Kathmandu, and conflicts and competition arise among waste management companies due to the absence of binding contracts or renewed agreements with the KMC. This lack of clear agreements hampers monitoring and effective waste management guidance in the country.

In Nepal, several companies are actively engaged in composting organic waste and extracting recyclables from dry waste. However, the effectiveness of waste recovery initiatives is hindered by the absence of source segregation, which presents a significant challenge. Despite the government's efforts to promote household waste segregation through official notifications, the implementation has been insufficient (Khanal, 2022; Khanal et al., 2023b). A huge portion of the urban population in Nepal, approximately 80%, already practices waste segregation or expresses a willingness to do so at their households. This demon-

strates a positive inclination towards waste management among the Nepali people (Khanal, 2022; Khanal et al., 2023b). Moreover, research indicates that if appropriate incentives were provided, approximately 41% of the population would actively engage in proper source segregation. This finding suggests that incentivizing waste management practices could yield considerable results (Khanal et al., 2023b).

Apart from the lack of source segregation, Nepal faces additional challenges in waste recovery due to the limited availability of land for waste sorting and recycling purposes. Furthermore, the absence of automated machines for waste management further impedes the progress of waste recovery efforts in the country. These factors collectively contribute to the overall difficulty in effectively managing and recovering waste in Nepal (Khanal, 2022; Khanal et al., 2023b).

### 3.2. Circularity in Solid Waste Management

Circularity in SWM is a pressing issue in both Nigeria and Nepal. In Nigeria, recycling has not gained mainstream attention, and most of the waste is poorly disposed of in open fields (Olawuni, 2022). Although Lagos has a higher number of recycling plants compared to other cities in Nigeria, they are unable to keep up with the accelerating pace of waste production in the megacity (Oyelola et al., 2018). However, there is increased awareness among Nigerians regarding the negative effects of single-use materials, leading to a growing demand for reusable alternatives. "Wastepreneurs" are also emerging as they adopt resource recovery methods, which involve segregating plastic waste at the source, collecting waste from dumpsites, and transforming it for new purposes. Despite these initiatives, the SWM issue is exacerbated by the country's rising population and a lack of effective local and national waste management plans. Historically, the focus has been on collecting and storing trash, and this approach is still prevalent in many parts of the country (Babayemi and Dauda, 2010).

Nigeria's current waste management plans, like those in many developing nations, primarily rely on conventional garbage treatment methods. Waste is typically gathered and disposed of in unregulated landfills outside municipal limits, which is not sustainable (Awopetu et al., 2013). The government has established various waste recycling plants and management organizations to improve cleanliness in streets and neighborhoods, but the success of these initiatives varies. Despite the introduction of recycling initiatives, the recycling rate is far below the rate of waste generation. The waste management system is not only inadequate but highly inefficient, resulting in more than half of the trash remaining uncollected on the streets and other locations.

In Nepal, only 14% of municipalities are recycling their waste, which accounts for only 4.1% of the total waste generated (CBS, 2021). Waste management companies face challenges in recovering recyclables due to the mixed waste collected from households and institutions. The common practices for managing organic waste in Nepal are composting and bio-gas production. Dry recyclables are manually extracted and sold to scrap centers. However, due to the lack of sufficient recycling facilities in Nepal, a huge portion of the recyclables collected is sent to neighboring India (Glawe et al., 2005). Waste segregation is often done manually by workers on the roadside or directly from the collection vehicles, resulting in a lack of proper records of daily recovered recyclables. Approximately 49% of municipalities in Nepal pile up collected waste in landfill sites, while 32% burn the waste, and 27% dispose of it along riverbanks (CBS, 2021). The government's lack of proper planning and waste management facilities has led to the private and in-formal sectors taking on a significant role in waste reduction efforts (Khanal, 2021).

A study found the Waste-to-Energy (WtE) potential in Nigeria and Nepal (Khanal et al., 2024a). Nigeria's approach includes incineration and anaerobic digestion, with costs varying based on scale and technology. Nepal focuses on bio-compressed natural gas (Bio CNG) and biogas from organic waste. Despite Nepal's lower current electricity generation from waste, which is 178 megawatt (MW) compared to Nigeria (26,000 MW), there is significant potential for growth in the WtE sector. However, both Nigeria and Nepal face significant challenges in achieving circularity in their SWM systems (Table 4). The lack of adequate recycling infrastructure, inefficient waste collection practices, and a limited focus on sustainable waste management contribute to these challenges. To move towards a more circular waste management approach, it is crucial for both countries to prioritize comprehensive waste management plans, improve recycling capabilities, and promote public awareness and participation in waste reduction and recycling efforts. Additionally, collaboration between the government, private sector, and informal sector can play a vital role in developing innovative solutions and establishing effective waste management practices (Khanal et al., 2021; Khanal et al., 2023a). Only through concerted efforts and sustainable strategies, can Nigeria and Nepal work towards a CE and mitigate the environmental impacts of solid waste.

### 3.3. Solid Waste Management Practices to Achieve SDGs

CE aims to achieve a balance between the economy, environment, and society by prolonging the lifespan of products or reintroducing discarded goods and materials into the system for reuse (Huang et al., 2018). It serves as a strategy for addressing sustainable development issues and aligns with the goals of the SDGs (Schroeder et al., 2019). CE practices have the potential to make a positive impact on the environment, society, and economy (Milios, 2018; Millar et al., 2019).

The involvement of individuals in economic activities creates momentum for CE practices in daily life, contributing to the overarching objectives of poverty eradication, reduced en-

vironmental degradation, and the creation of new value (Azizuddin et al., 2021). International entities such as the United Nations and the European Union, as well as nations worldwide, emphasize the importance of preserving natural resources. The concept of CE aligns with various international development agendas, including energy, economic growth, sustainable cities, sustainable consumption and production, climate change, ocean health, and terrestrial biodiversity (Azizuddin et al., 2021; Hemidat et al., 2022).

In Nigeria, the implementation of effective waste management strategies can contribute to SDG targets such as ensuring sustainable cities and communities (SDG 11), promoting responsible consumption and production (SDG 12), and protecting the environment (SDG 15). By adopting CE principles, such as recycling and resource recovery, Nigeria can minimize waste generation, conserve resources, and reduce environmental pollution. Similarly, in Nepal, proper waste management practices are essential for achieving SDGs related to clean water and sanitation (SDG 6), sustainable cities and communities (SDG 11), and climate action (SDG 13). By promoting waste segregation, recycling, composting, and reducing reliance on landfills, Nepal can improve resource efficiency, mitigate climate change impacts, and create healthier living environments. Despite the efforts made by Nigeria and Nepal towards achieving the SDGs, both countries still face challenges in achieving socioeconomic improvements that target these goals. Both countries need to prioritize investment in infrastructure, raise public awareness, and strengthen collaboration between government, private sectors, and communities to effectively manage solid waste and contribute to the achievement of the SDGs.

### 3.4. Government Policies and Actions

Government policies and actions play a crucial role in SWM and the transition towards a CE in Nigeria and Asia. In Nigeria, although there is a systemic flaw in policy formation and implementation, the government recognizes the importance of sustainable waste control and environmental conservation. To address waste management challenges, various governmental authorities and agencies have been established at the national and state levels. These include the national policy on environment, national policy on environmental sanitation, national policy on chemical management, national policy on municipal and agricultural waste management, national healthcare waste policy, national policy on SWM, and national policy on plastic life cycle management. These policies aim to ensure efficient and effective waste management practices and protect the environment and the well-being of the population (Ezeudu et al., 2021).

In Nepal, the SWM act of 2011 provides provisions for waste segregation at the source, distinguishing between organic and inorganic components. It also places the responsibility of managing hazardous or chemical waste on the individuals or organizations generating such waste. Local bodies are tasked with the construction and operation of essential waste management infrastructure such as transfer stations, landfill sites, processing plants, compost plants, and biogas plants. The act categorizes solid waste into domestic waste, industrial waste, chemical

**Table 4.** Comparison Matrix for CE in SWM of Nigeria and Nepal

Parameters	Nigeria	Nepal
Waste generation	Approximately 32 million tons per year	Approximately 1.8 million tons per year
Per capita waste generation	0.438 kg/person/day	0.30 kg/person/day
Responsibility for waste management	Federal, state, and municipal levels of government, with state agencies sometimes taking over waste management duties	Government entities, private companies, and local organizations involved in waste management
Challenges	Funding shortages, bureaucracy, lack of clarity regarding duties and responsibilities, ineffective monitoring and evaluation initiatives, low morale, corruption issues	Transfer of waste to landfills without treatment, conflicts and competition among waste management companies, lack of binding contracts or renewed agreements
Circular economy approach	Focus on recycling and infrastructure	Focus on waste segregation, recycling, and reducing reliance on landfills
Policy implementation	Inconsistent enforcement	Improvement required
Government involvement	Shared responsibility, lack of coordination	Involvement of government, private companies, and local organizations
Sustainable development goals (SDGs) Alignment	Sustainable cities and communities, responsible consumption and production, environmental protection	Clean water and sanitation, sustainable cities and communities, climate action
Socioeconomic impact	Challenges in achieving improvements aligned with SDGs	Challenges in achieving socioeconomic improvements aligned with SDGs
Collaboration	Need for collaboration between government, private sectors, and communities	Collaboration between government, private sectors, and communities crucial for effective waste management and circular economy transition

waste, health institution-related waste, and harmful waste. Additionally, the Local Self-Governance Act of 1999 imposes fines of up to Nepalese Rupees (NRs.) 15,000 for haphazard dumping of solid waste. Nepal prohibits the importation of harmful electronic products from developed countries as well (Khanal et al., 2024b). However, despite the existence of these policies and laws, there are challenges in their implementation in Nepal.

In both Nigeria and Nepal, there is a need for stronger enforcement and implementation of existing waste management policies and regulations. This requires allocating sufficient resources, enhancing institutional capacity, and establishing monitoring and compliance mechanisms. Additionally, public awareness and education campaigns should be conducted to promote responsible waste disposal practices and the adoption of CE principles. Collaboration between government bodies, private sectors, and communities is crucial for effective waste management and the transition to a CE. By aligning their policies and actions with the principles of a CE, Nigeria and Nepal can improve waste management practices, reduce environmental pollution, conserve resources, and contribute to the achievement of SDGs in their respective regions.

#### 4. Discussion

The implications of these findings extend to the global waste problem, as Nigeria and Nepal's challenges are reflective of broader issues in waste management. The lack of adequate recycling infrastructure, inefficient waste collection practices, and a limited focus on sustainability are common themes. To move towards a more circular waste management approach, comprehensive waste management plans should be prioritized, recycling capabilities should be improved, and public awareness and participation in waste reduction and recycling efforts should be promoted. Collaboration between the government, pri-

private sector, and informal sector can play a vital role in developing innovative solutions and establishing effective waste management practices. Only through concerted efforts and sustainable strategies can Nigeria and Nepal work towards a CE and mitigate the environmental impacts of solid waste.

The adoption of CE principles in SWM can contribute to achieving the SDGs in both countries. By minimizing waste generation, conserving resources, and reducing environmental pollution, Nigeria can contribute to SDG targets related to sustainable cities and communities, responsible consumption and production, and environmental protection. Similarly, Nepal's proper waste management practices are essential for achieving SDGs related to clean water and sanitation, sustainable cities and communities, and climate action. By promoting waste segregation, recycling, composting, and reducing reliance on landfills, Nepal can improve resource efficiency, mitigate climate change impacts, and create healthier living environments. However, both countries still face challenges in achieving socioeconomic improvements that target these goals, requiring investment in infrastructure, public awareness, and collaboration between government, private sectors, and communities.

Government policies and actions play a crucial role in SWM and the transition towards a CE in Nigeria and Nepal. Both countries have established policies and laws related to waste management, but their enforcement and implementation require improvement. Allocating sufficient resources, enhancing institutional capacity, and establishing monitoring and compliance mechanisms are necessary to strengthen waste management practices. Public awareness and education campaigns should also be conducted to promote responsible waste disposal practices and the adoption of CE principles. Collaboration between government bodies, private sectors, and communities is crucial for effective SWM and the transition to a CE. Aligning policies and actions with the principles of a CE will contribute to sustainable

development and the achievement of SDGs in Nigeria and Nepal.

## 5. Conclusions

Nigeria and Nepal's SWM practices face significant challenges, including low recycling rates, inadequate waste collection services, and improper disposal methods. Both countries have a high proportion of recyclable and compostable waste in their waste streams, indicating a substantial potential for waste recovery and CE practices. However, the lack of recycling infrastructure, inefficient waste collection practices, and limited focus on sustainable waste management hinder progress towards achieving circularity in SWM.

In Nigeria, the current waste management approach primarily relies on conventional garbage treatment methods, leading to inadequate and inefficient waste collection and disposal. The lack of effective local and national waste management plans, coupled with the rising population, exacerbates the SWM issue. Similarly, in Nepal, the absence of sufficient recycling facilities, mixed waste collection, and the lack of source segregation contribute to the challenges in waste recovery efforts. The government's inadequate planning and waste management facilities have resulted in the private and informal sectors playing a significant role in waste reduction efforts.

To address these challenges and move towards a circular waste management approach, both countries need to prioritize comprehensive waste management plans, improve recycling capabilities, and promote public awareness and participation in waste reduction and recycling efforts. Collaboration between the government, private sector, and informal sector is crucial in developing innovative solutions and establishing effective waste management practices. By adopting CE principles such as recycling, resource recovery, and waste segregation, Nigeria and Nepal can minimize waste generation, conserve resources, reduce environmental pollution, and contribute to the achievement of SDGs.

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