



A Journey Towards a Zero Carbon Future: Nepal's Zero Carbon Mission 2045, from the Perspective of Waste Management

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Introduction:

Nepal is committed to achieving zero carbon emissions by 2045, reflecting its determination to tackle climate change. Waste management is crucial to this goal, as the waste sector significantly contributes to methane emissions—one of the most powerful greenhouse gases, which is 25 times more effective than CO₂ in warming the atmosphere (UN-Habitat, 2021). Poor waste management practices, particularly in growing urban areas, worsen these emissions and harm the environment (Eunomia, 2023).

Recently, Nepal faced severe flooding and landslides linked to heavy rainfall, highlighting the country's vulnerability to climate change. This situation calls for effective waste management strategies that align with global efforts, such as the Zero Carbon Mission. This mission seeks to balance greenhouse gas emissions with measures to remove or offset them, effectively reducing their impact on global warming (CCAC, 2023; Kaza et al., 2018).

Nepal's focus on improving waste management aligns with international trends promoting integrated waste systems and circular economies. These approaches aim to reduce, reuse, and recycle waste, which helps to lessen environmental damage (USAID, 2023). By implementing effective waste segregation, composting, and recycling, Nepal can improve resource efficiency, public health, and economic growth (Springer, 2021).

In addition to earning approximately NPR 1.06 billion (around USD 8 million) through carbon trading from its forest conservation efforts, Nepal recognizes the need for comprehensive waste management reforms to further reduce greenhouse gas emissions and promote sustainable development (Nepal Ministry of Forests and Environment, 2024; UN-Habitat, 2021; CCAC, 2023; Kaza et al., 2018).

This study examines ten key areas within Nepal's waste management framework, focusing on strategies that will help the country move towards carbon neutrality. The findings aim to guide policymakers and local governments in adopting sustainable waste management practices that support global climate goals.

Keywords:

Zero Carbon Mission, Waste Management Reform, Methane Emissions, Circular Economy, Sustainable Development, Integrated Waste-Management, Climate Change Mitigation, Resource Efficiency, Public Health, Economic Growth.

Background of the Study:

As global awareness of climate change intensifies, countries are compelled to develop effective strategies for reducing greenhouse gas emissions. In Nepal, waste management has emerged as a critical area of focus due to its substantial contribution to methane emissions—a potent greenhouse gas with a warming potential significantly higher than that of carbon dioxide (UN-Habitat, 2021). Inefficient waste disposal methods, especially in rapidly urbanizing regions, exacerbate these emissions and pose serious environmental and health risks (Eunomia, 2023).

The recent devastating floods and landslides in Nepal, attributed to climate change, highlight the urgency for comprehensive waste management reforms. The country's commitment to achieving the Zero Carbon Mission by 2045 necessitates a dual approach that includes both sustainable forest management and innovative waste management strategies (CCAC, 2023). Research indicates that integrated solid waste management (ISWM) practices, such as effective waste segregation, recycling, and composting, can yield significant reductions in greenhouse gas emissions and contribute to enhanced public health and resource efficiency (USAID, 2023; Kaza et al., 2018).

Given these challenges and opportunities, this study aims to evaluate the potential of prioritizing key parameters in waste management reform to mitigate emissions and support Nepal's climate objectives.

Literature Review:

Waste Management and Global Warming:

Improper waste management contributes significantly to global warming through methane emissions from landfills. Methane has a warming potential 25 times greater than CO₂, making waste reforms critical in reducing emissions (IPCC, 2014). Several strategies demonstrate how waste systems can combat climate change:

1. Methane Reduction – Composting and anaerobic digestion divert organic waste from landfills, minimizing methane emissions.
2. Energy Recovery – Waste-to-energy technologies convert non-recyclable waste into electricity, reducing fossil fuel dependence (World Bank, 2021).
3. Carbon Sequestration – Converting organic waste into biochar stores carbon in soil, reducing atmospheric CO₂.
4. Recycling and Material Recovery – Recycling conserves energy by minimizing the need for raw material extraction. For instance, recycling aluminum saves up to 95% of the energy needed to produce it from bauxite ore.

Global Climate Commitments and Nepal's Role:

Global initiatives like the Paris Agreement (2015) and Kyoto Protocol (1997) encourage countries to adopt sustainable practices to limit global warming to 1.5°C above pre-industrial levels. Nepal contributes 0.1% of global emissions, but it faces significant climate vulnerabilities, driving its commitment to net-zero emissions by 2045 (World Bank, UNFCCC).

Nepal's greenhouse gas emissions—estimated at 47.94 million metric tons of CO₂ equivalent in 2019—primarily stem from agriculture, energy use, and waste management. Addressing landfill emissions through waste segregation, composting, and methane recovery is critical to achieving long-term carbon reduction goals (UNFCCC, 2019).

Integrated Waste Management for Nepal's Zero Carbon Mission:

Nepal's journey towards zero carbon emissions emphasizes the importance of integrated waste management to reduce methane emissions, which are primarily released from organic waste decomposing in landfills. Methane is a potent greenhouse gas, with a warming potential 25 times greater than that of CO₂ (IPCC, 2014). Therefore, each of the ten parameters for waste reform plays a crucial role in minimizing environmental impact, improving public health, and supporting sustainable development. These interconnected parameters work holistically to ensure that the waste sector contributes effectively to the country's Zero Carbon Mission by 2045.

Effective waste management practices form the backbone of sustainable waste systems. By segregating waste at the source, recycling, composting organic materials, and diverting waste from landfills, emissions can be minimized (Eunomia, 2023). This approach not only limits methane production but also promotes a circular economy by ensuring that valuable materials are reused. Research suggests that these practices could reduce landfill-related methane emissions by up to 50% (IPCC, 2014), making them critical to achieving carbon reduction goals.

Public participation plays a key role in the success of waste reforms. Public awareness campaigns foster behavioral changes that encourage citizens to engage in waste segregation and recycling efforts. India's **Swachh Bharat Mission** exemplifies how community-driven programs can significantly improve cleanliness and waste management efficiency (Springer, 2021). **Delterra (2023)** emphasizes that public engagement builds long-term sustainability, as citizens become active participants in maintaining waste reforms.

Strong policy frameworks ensure accountability and consistency in waste management operations. Countries like India have seen improvements after implementing **Solid Waste Management Rules (CPCB, 2016)**, which provided structured guidelines for waste segregation, collection, and processing. In Nepal, clear regulatory frameworks would help prevent illegal dumping and align municipal activities with national waste goals (UN-Habitat, 2021).

Innovation and sustainable practices, such as **waste-to-energy (WtE)** projects and advanced composting, further enhance waste systems. WtE plants convert non-recyclable waste into energy, reducing landfill use while generating renewable electricity (World Bank, 2021). Similarly, composting organic waste not only curtails methane emissions but also improves soil health by recycling nutrients back into the environment (UN-Habitat, 2021).

Developing the skills of waste workers and municipal staff through training programs ensures that waste management systems operate efficiently. Capacity-building initiatives introduce new technologies and improve overall service delivery. **UN-Habitat (2021)** and **USAID (2023)** stress that a trained workforce enhances the adoption of innovations, helping waste systems adapt to evolving challenges and technologies.

Data-driven strategies and continuous research play an essential role in waste reform. Monitoring emissions and analyzing waste patterns provide insights that guide policy decisions and improve system performance (USAID, 2023). Research-backed reforms allow municipalities to develop targeted strategies and ensure that waste practices align with the broader carbon reduction objectives.

Environmental protection and justice are integral to sustainable waste reforms. Inclusive waste policies ensure that marginalized communities are not disproportionately affected by pollution or waste-related hazards (Delterra, 2023). Environmental justice promotes equitable development by distributing the benefits of waste reforms across all sectors of society.

Financing is a critical element in scaling sustainable waste systems. Innovative financial models, such as **carbon credits**, **green bonds**, and **public-private partnerships**, attract investment in recycling and composting infrastructure (World Bank, 2021). Adequate funding ensures that sustainable waste systems are not only implemented but also maintained over the long term.

Waste reforms also contribute to climate resilience by aligning with broader climate adaptation strategies. Well-designed waste systems reduce emissions and pollution risks, enhancing the ability of urban areas to cope with climate-induced challenges (CCAC, 2023). Integrating waste management with climate policies strengthens Nepal's capacity to adapt to environmental changes and supports sustainable development.

Urban development and planning must include waste infrastructure to ensure efficient waste management in growing cities. Incorporating waste systems within urban planning reduces the risk of illegal dumping, improves collection services, and safeguards public health in densely populated areas (Eunomia, 2023). Proper planning ensures that as cities expand, waste systems remain sustainable and aligned with environmental goals.

By focusing on these ten parameters, Nepal can build an integrated waste management framework that not only mitigates emissions but also promotes public health, economic growth, and environmental justice. The prioritization of five parameters—waste management practices, public engagement, capacity building, research, and urban planning—ensures targeted efforts toward the **Zero Carbon Mission by 2045**. Aligning these strategies with international best practices will help Nepal create a resilient, sustainable waste system that contributes meaningfully to global climate goals.

Initiation of the Zero Carbon Mission:

The Zero Carbon Mission is being driven by **international organizations**, **national governments**, and **private sector stakeholders**:

1. **United Nations (UN):** Through the **Paris Agreement** of 2015, nearly 200 countries committed to limiting global warming to below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C. The **UN Framework Convention on Climate Change (UNFCCC)** oversees global efforts towards carbon neutrality, urging countries to set net-zero targets by the mid-21st century.
2. **European Union (EU):** The EU is leading the way with its **European Green Deal**, committing to becoming the first climate-neutral continent by 2050.
3. **Corporations:** Many large corporations, such as **Apple**, **Google**, and **Microsoft**, have pledged to achieve net-zero carbon emissions in their operations by 2030 or 2050.
4. **Global Coalitions:** Initiatives like the **Race to Zero Campaign** bring together businesses, cities, regions, and investors to achieve net-zero emissions by 2050 at the latest.

Nepal's Legal and Implementation Steps towards Zero Carbon Mission

Nepal is a **vulnerable country** in terms of the impacts of climate change, and although its carbon emissions are relatively low on a global scale, the country is taking steps to contribute to the global Zero Carbon Mission. The steps and initiatives reflect the country's commitment to sustainable development and environmental protection, despite challenges like rapid urbanization, waste management issues, and reliance on traditional energy sources.

1. Legal Framework

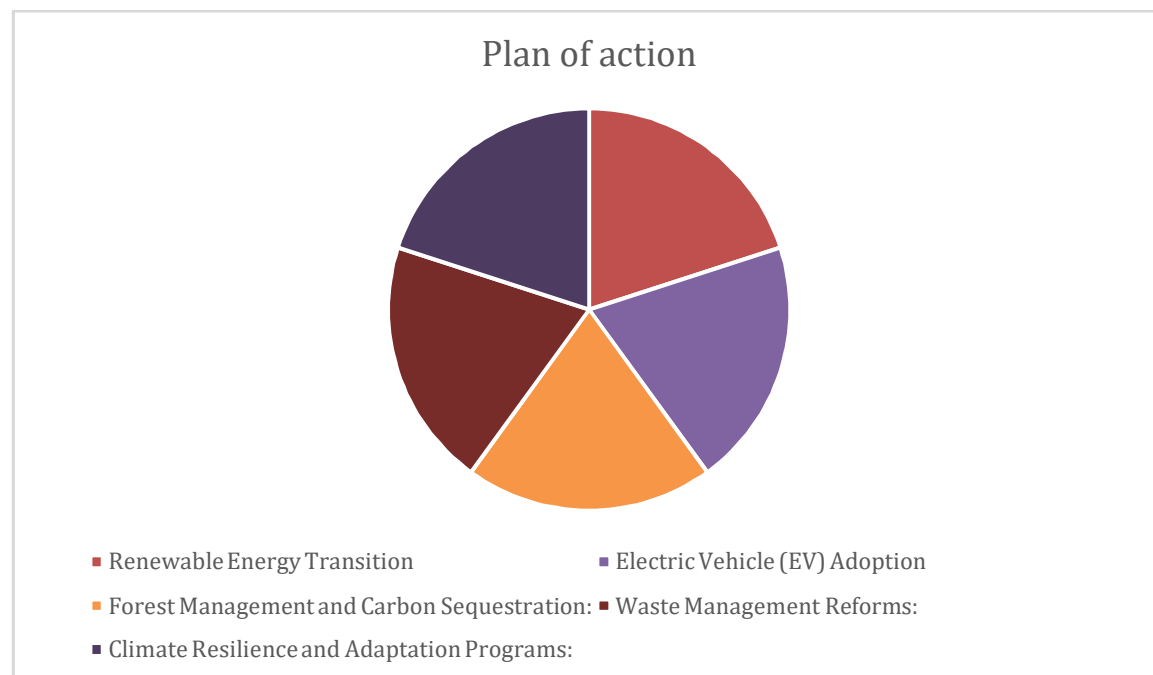
- A. **Nepal's Constitution (2015):** The constitution recognizes the right of every citizen to live in a clean and healthy environment. This foundational principle has pushed the government to adopt policies

aimed at addressing climate change, reducing carbon emissions, and ensuring sustainable development.

- B. **Nationally Determined Contributions (NDC):** Nepal has committed to **reducing GHG emissions** as part of its NDC under the Paris Agreement. In its second NDC, submitted in 2020, Nepal aims to:
- Achieve **90% electrification** from renewable energy sources by 2030.
 - Increase forest cover** to 45% of total land area.
 - Maintain carbon sinks** through sustainable forest management.
 - Promote electric vehicles (EVs)** to make 25% of passenger vehicles electric by 2030.
- C. **Climate Change Policy (2019):** This policy outlines specific goals for enhancing climate resilience, reducing carbon emissions, and transitioning to sustainable energy and waste management practices.
- D. **Environment Protection Act (EPA) 2019:** This legislation mandates that development projects and industries comply with environmental standards and environmental impact assessments (EIAs) to minimize carbon emissions.

2. Implementation Steps

As far our external observation we can observe that Nepal is trying to implement the zero carbon through working on five major segments.



A. Renewable Energy Transition:

- Nepal is committed to increasing its **hydropower capacity**, which constitutes the majority of the country's electricity supply. By promoting hydropower and other renewable energy sources like **solar and wind**, Nepal aims to reduce its dependency on fossil fuels and lower emissions.
- Solar energy promotion** in urban and rural areas is also a growing focus, with government subsidies and incentives for installing rooftop solar systems.

B. Electric Vehicle (EV) Adoption:

- a. Nepal is focusing on the promotion of electric vehicles (EVs) to reduce reliance on fossil fuels in the transport sector. The government offers **incentives for EV imports**, and efforts are underway to improve the country's EV infrastructure, including the installation of charging stations.
- b. The **Bagmati Province**, including **Kathmandu**, has introduced electric buses as part of its public transportation system.

C. Forest Management and Carbon Sequestration:

- a. Nepal's **forest conservation policies** contribute significantly to its zero carbon mission by enhancing **carbon sequestration**. Nepal's extensive forest coverage acts as a carbon sink, absorbing a substantial amount of CO₂.
- b. **Community forest programs** have been globally recognized for their role in sustainable forest management and increasing forest cover, which directly helps mitigate carbon emissions.

D. Waste Management Reforms:

- a. The government is working to improve **waste management practices**, with a focus on reducing methane emissions from landfills and encouraging **composting and recycling** to handle organic and non-organic waste sustainably.
- b. Efforts are being made to reduce **open burning** of waste, a major source of carbon emissions in urban areas.
- c. **Municipalities** are increasingly focusing on **waste-to-energy projects** that convert waste into usable energy, further reducing carbon footprints.

E. Climate Resilience and Adaptation Programs:

- a. Nepal is investing in programs that make urban and rural areas more **climate-resilient**. These include infrastructure improvements, building energy-efficient systems, and promoting sustainable agriculture to reduce GHG emissions from the farming sector.

Challenges to achieve the mission:

Despite numerous opportunities and strong global support, Nepal may face several challenges in achieving its Zero Carbon Mission:

- Infrastructure gaps and high upfront costs for renewable energy and waste management solutions.
- Limited technical expertise and financial resources to implement large-scale waste management systems and advanced carbon reduction technologies.
- Rapid urbanization, which adds complexity to waste management and increases emissions in growing cities.

These challenges will need to be addressed through strategic planning, international collaboration, and capacity-building efforts to successfully reach the zero-carbon target.

Objectives of the Study:

The primary objective of this study is to explore how waste management reform can play a pivotal role in helping Nepal meet its Zero Carbon Mission by 2045. Although multiple parameters contribute to carbon neutrality, this study narrows the focus on waste management by:

1. Identifying ten major parameters relevant to waste reform, each with specific focus areas.
2. Prioritizing five key parameters based on their impact, feasibility, and relevance to Nepal's sustainability goals and developing a timeline-based action plan for the top five prioritized parameters to guide the successful implementation of waste management strategies.
3. Demonstrating how completing these tasks within the proposed timelines will significantly contribute to achieving carbon neutrality by 2045 and providing actionable recommendations for policymakers, municipal authorities, and stakeholders on implementing these strategies effectively.

Significance of the Study:

This study provides a focused framework for using waste management reform as a key driver in achieving Nepal's Zero Carbon Mission by 2045.

While multiple sectors contribute to carbon reduction, this research emphasizes waste management's role in minimizing methane emissions, promoting resource recovery, and fostering environmental sustainability. By identifying ten major parameters and prioritizing five key areas, the study offers practical insights for policymakers to implement reforms within a timeline-based action plan.

Successful execution of these reforms will support Nepal's path to carbon neutrality, improve public health, and set an example for other developing nations striving toward climate resilience.

Null and Alternative Hypotheses:

- Null Hypothesis (H0): The prioritization of the top five major parameters in waste management reform, along with the suggested action plan and timeline, will have no significant effect on reducing methane emissions and achieving Nepal's Zero Carbon Mission by 2045.
- Alternative Hypothesis (H1): The prioritization of the top five major parameters in waste management reform, along with the suggested action plan and timeline, will significantly reduce methane emissions and contribute to achieving Nepal's Zero Carbon Mission by 2045.

Methodology:

Research Design:

This study employs a qualitative research design with a focus on expert consultation, observational data, and secondary literature review. The goal is to evaluate the effectiveness of waste management practices in achieving Nepal's Zero Carbon Mission by analyzing ten prioritized parameters and action plans.

Data Collection Methods:

1. Expert Consultation (Primary Data):

To ensure the study captures practical and policy-relevant insights, in-depth discussions were held with four domain experts:

1. Dr. Bidur Dhungel (Environmental Science)
2. Dr. Dhirendra Pd. Koirala (Trade Expert)
3. Er. Bhim Bomjan (Civil Engineering)

These consultations provided valuable perspectives on the feasibility, challenges, and implementation strategies for waste management reforms. Their feedback informed the action plan and validated the prioritization of the top five parameters.

2. **Observational Field Study:**

Observational visits were conducted in key waste management sites across Kathmandu Valley, including recycling facilities, landfill sites, and composting plants. The field visits aimed to assess the real-world implementation of waste management practices and infrastructure readiness.

3. **Secondary Data Collection:**

The study extensively draws on reports, policy papers, and international research. Key sources include:

1. Government publications such as Nepal’s environmental policies and action plans.
2. International frameworks, including reports from the IPCC (2014), UN-Habitat (2021), Eunomia (2023), World Bank (2021), and USAID (2023).
3. Case studies from India’s Swachh Bharat Mission and integrated waste management practices from Southeast Asia.

Data Analysis:

1. Content Analysis: Expert feedback and observational data were analyzed for recurring themes and actionable insights.
2. Comparative Analysis: Nepal’s waste management strategies were compared with international best practices to identify gaps and opportunities.
3. Synthesis of Findings: Insights from expert discussions and secondary sources were synthesized to support the hypothesis and develop actionable recommendations.

Limitations:

1. The study relies on qualitative insights and expert opinions, which may not capture every regional variation across Nepal.
2. As the study focuses primarily on Kathmandu Valley, some findings may not generalize to rural areas.

“Focusing on Waste Management Reforms for Nepal’s Zero Carbon Mission”

Out of the five major segments mentioned for achieving the zero-carbon mission in Nepal—Renewable Energy Transition, Electric Vehicle Adoption, Forest Management and Carbon Sequestration, Waste Management Reforms, and Climate Resilience and Adaptation Programs—this article will focus exclusively on Waste Management Reforms.

We will explore the critical role that waste management plays in reducing emissions and promoting sustainability, examining key strategies, challenges, action plans, and timelines that will contribute to achieving the zero-carbon mission in Nepal.

“We have identified 10 main parameters, each with five key focus areas under them.”

Essential Parameters for Sustainable Waste Management in the Zero Carbon Mission

S.N.	Main Parameter	Related Areas of Focus
1	Waste Management Practices	1. Waste Segregation at Source
		2. Composting Facilities

		3. Recycling Initiatives
		4. Integrated Waste Management Plans
		5. Landfill Diversion Strategies
2	Public Awareness and Engagement	6. Public Awareness Campaigns
		7. Community Engagement Programs
		8. Environmental Education in Schools
		9. Community Clean-up Drives
		10. Voluntary Recycling Programs
3	Policy and Regulatory Framework	11. Development of Waste Management Regulations
		12. Monitoring Compliance with Environmental Laws
		13. Pollution Control Policies
		14. Sustainable Procurement Policies
		15. Regulatory Framework
4	Sustainable Practices and Innovations	16. Circular Economy Initiatives
		17. Waste Minimization Techniques
		18. Reuse and Repair Initiatives
		19. Development of Waste Control Mechanisms For EV waste.
		20. Behavior Change Programs
5	Capacity Building and Training	21. Capacity Building for Local Governments
		22. Training Programs for Waste Workers
		23. Energy Efficiency in Waste Management Facilities
		24. Capacity Building for Civil Society Organizations
		25. Fostering Innovation in Waste Management Solutions
6	Research and Data Management	26. Data Collection and Analysis
		27. Waste Characterization Studies
		28. Monitoring and Evaluation Systems
		29. Research on Waste Reduction Technologies

		30. Climate Change Impact Assessments
7	Environmental Protection and Justice	31. Environmental Justice Advocacy
		32. Water Quality Management
		33. Disaster Waste Management Strategies
		34. Marine Pollution Prevention
		35. Promotion of Biodiversity
8	Innovative Financing and Investment	36. Innovative Financing Mechanisms
		37. Support for Informal Waste Collectors
		38. Green Business Incubators
		39. Promotion of Sustainable Investment
		40. Incentives for Green Jobs
9	Climate Change Adaptation and Resilience	41. Climate Adaptation Strategies
		42. Enhancing Resilience of Waste Systems
		43. Urban Heat Island Mitigation
		44. Waste Reduction Targets for Businesses
		45. Cross-Sectoral Collaboration
10	Urban Development and Planning	46. Smart Waste Management Systems
		47. Urban Green Spaces Development
		48. Public Transport Enhancements
		49. Circular Water Management
		50. Mobile Waste Collection Units

Though all ten main parameters are equally important in achieving Nepal’s Zero Carbon Mission by 2045 through waste management reform, we have prioritized the top five parameters as follows. The reasons for prioritizing these parameters are detailed in the table below:

Main Parameter	Reason for Prioritization
Waste Management Practices	These practices form the foundation for effective waste management, essential for reducing waste volumes, mitigating pollution, and promoting resource recovery. Waste Management Practices – Essential for reducing methane emissions and promoting a circular economy (Eunomia, 2023).
Public Awareness and Engagement	Engaging the community through awareness campaigns fosters participation and responsibility, leading to behavioral changes necessary for successful waste management. Public Awareness and Engagement – Community involvement ensures the success of segregation and recycling programs (Springer, 2021).
Urban Development and Planning	Integrating waste management into urban infrastructure ensures sustainable growth and efficient collection (Eunomia, 2023). Urban Development planning is very necessary for finding impact and feasibility in driving sustainable waste reform.
Capacity Building and Training	Developing the skills and knowledge of local governments and waste workers is crucial for the efficient implementation of waste management strategies and innovations. Capacity Building and Training – Skilled personnel are necessary to adopt new technologies and improve operational efficiency (UN-Habitat, 2021).
Research and Data Management	Effective data collection and research provide insights into waste management challenges, enabling informed decision-making and the development of targeted strategies. Research and Data Management – Data-driven decisions help municipalities develop targeted solutions and monitor progress (USAID, 2023).

1.1st Main Parameter: Waste Management Practices:

To address Nepal’s Zero Carbon Mission by 2045, waste management practices must be robust, well-coordinated, and comprehensive. Waste management is critical to reducing greenhouse gas emissions and conserving resources. Waste management practices refer to a set of strategies and technologies designed to manage waste from its generation to its disposal, including waste segregation, recycling, composting, and landfill diversion strategies.

The goal is to minimize waste sent to landfills, encourage resource recovery, and support the transition to a zero-carbon economy by 2045. By that year, Nepal aims to implement sustainable waste management solutions that significantly reduce landfill waste, promote recycling and composting, and contribute to reducing carbon emissions.

Focus Areas and Action Plans

1.1 Waste Segregation at Source:

Definition: Waste segregation is the process of separating waste at the point of generation into different categories such as organic, recyclable, hazardous, and non-recyclable materials.

Action Plan	Timeline
1. Guideline Development	2025-2026
Create guidelines for households, businesses, and industries on how to properly segregate waste.	
2. Bin Distribution and Infrastructure Setup	2026-2027
Provide color-coded bins in homes, businesses, and public spaces for different waste types (organic, plastic, hazardous, etc.).	
3. Community Training	2025-2027
Conduct awareness campaigns and workshops to educate people on waste segregation practices.	
4. Monitoring and Feedback Mechanism	2027-2030
Establish monitoring systems to track the progress of segregation efforts and provide feedback for improvements.	

1.2 Composting Facilities:

Definition: Composting facilities transform organic waste into compost through natural decomposition processes. This helps reduce landfill waste and generates a valuable product for agriculture.

Action Plan	Timeline
1. Location Identification	2024-2025
Work with local municipalities to identify suitable locations for composting facilities near farming communities.	
2. Facility Setup and Partnerships	2025-2027
Collaborate with local governments and private sectors to establish large-scale and community-based composting units.	
3. Community Composting Workshops	2026-2028
Organize workshops to teach communities about home composting techniques.	
4. Monitoring and Optimization	2029-2035
Track the efficiency of composting operations and implement improvements as needed.	

1.3. Recycling Initiatives:

Definition: Recycling initiatives involve programs to recover valuable materials from waste, including paper, plastic, metals, and glass, for reuse or transformation into new products.

Action Plan and Timeline for Recycling Initiatives

Action Plan	Timeline
1. Network of Recycling Centers	2025-2027
Establish a network of recycling centers focusing on specific recyclable materials (e.g., plastics, metals).	
2. Incentive Programs	2026-2027
Introduce incentives for individuals and businesses to participate in recycling programs.	
3. Public Education	2025-2026
Develop education programs on recyclable materials and their environmental benefits.	
4. Expansion of Recycling Infrastructure	2028-2035
Invest in expanding recycling plants to process increasing volumes of materials.	
5. Innovations in Material Recovery	2035-2045
Research and implement innovations in recycling technology, especially for difficult-to-recycle materials.	

1.4. Integrated Waste Management Plans:

Definition: Integrated waste management refers to a coordinated approach to managing all waste streams (solid, organic, hazardous) using a variety of methods such as recycling, composting, energy recovery, and landfill diversion.

Action Plan and Timeline for Integrated Waste Management Plans

Action Plan	Timeline
1. Waste Audits	2025-2026
Conduct waste audits at the municipal level to assess the quantity and types of waste produced.	
2. Multi-Stakeholder Task Force	2025-2026
Form a task force with government officials, waste management companies, and community leaders to draft integrated waste management plans.	

3. Community Feedback	2026-2027
Present draft plans to local communities for feedback and refine them based on input.	
4. Plan Implementation	2027-2030
Roll out the plans across municipalities and integrate various waste management solutions (e.g., recycling, composting).	

1.5 Landfill Diversion Strategies:

Definition: Landfill diversion strategies aim to reduce the amount of waste sent to landfills by promoting alternative waste management methods such as recycling, composting, and waste-to-energy solutions.

Action Plan and Timeline for Landfill Diversion Strategies

Action Plan	Timeline
1. Landfill Assessment	2025-2026
Conduct a detailed assessment of current landfill use, including waste types and volumes.	
2. Diversion Strategy Development	2025-2027
Develop strategies to divert specific waste streams (e.g., organic, plastic) from landfills.	
3. Pilot Diversion Projects	2026-2028
Implement pilot diversion programs in select municipalities, targeting high-impact waste streams.	
4. Monitoring and Scaling	2029-2035
Monitor pilot projects and gradually scale successful strategies to other regions.	
5. Full Diversion by 2045	2035-2045
Aim for at least 70% diversion from landfills through recycling, composting, and waste-to-energy solutions.	

Timeline for Waste Management Practices (2024-2045)

Focus Area	Phase 1 (2024-2027)	Phase 2 (2028-2035)	Phase 3 (2036-2045)
Waste Segregation at Source	Planning, infrastructure setup, and education	Scaling up and monitoring	Continuous improvements

Composting Facilities	Site selection, facility setup, and training	Expansion of facilities and optimization	Full operation and widespread adoption
Recycling Initiatives	Network setup, incentives, and public education	Expansion of infrastructure and innovation	Advanced recycling solutions
Integrated Waste Management Plans	Waste audits, task force formation, and feedback	Plan implementation and review	Continuous updates and scaling
Landfill Diversion Strategies	Landfill assessment and pilot projects	Scaling successful diversion strategies	Full diversion from landfills

2. Main Parameter: Public Awareness and Engagement

To achieve Nepal’s Zero Carbon Mission by 2045, **public awareness and engagement** are essential in fostering behavioral change and encouraging active participation in sustainable waste management practices. This parameter aims to educate, empower, and engage citizens to adopt environmentally friendly behaviors, contribute to waste reduction, and participate in recycling and clean-up programs. Through continuous education, campaigns, and community involvement, Nepal can reduce carbon emissions and transition to sustainable waste practices.

Focus Areas and Action Plans:

2.1 Public Awareness Campaigns:

Definition: Public awareness campaigns involve disseminating information through various media channels to raise awareness about the environmental impact of waste and promote sustainable practices.

Action Plan and Timeline:

Action Plan	Timeline
1. Design Campaign Materials	2025-2026
Develop brochures, posters, and videos focusing on waste reduction and recycling.	
2. Media Collaboration	2025-2026
Partner with radio, TV, and social media platforms to broadcast eco-friendly messages.	
3. Public Events and Competitions	2026-2028
Organize events like eco-friendly product expos and recycling contests.	
4. Impact Monitoring	2029-2035
Track campaign reach and assess behavior changes using surveys and feedback.	

2.2 Community Engagement Programs:

Definition: Community engagement programs involve local communities in waste management initiatives through participatory activities, ensuring residents play an active role in environmental conservation.

Action Plan and Timeline:

Action Plan	Timeline
1. Identify Community Leaders	2025-2026
Collaborate with local leaders to encourage participation in waste management efforts.	
2. Organize Workshops and Training	2025-2027
Provide training on composting, waste segregation, and recycling practices.	
3. Community Incentives	2027-2028
Offer rewards and recognitions for communities excelling in sustainable waste practices.	
4. Program Evaluation	2029-2035
Measure community involvement and refine engagement strategies based on outcomes.	

2.3. Environmental Education in Schools:

Definition: Integrating environmental education into school curriculums helps develop eco-conscious attitudes in children and encourages lifelong sustainable behavior.

Action Plan and Timeline:

Action Plan	Timeline
1. Curriculum Development	2025-2026
Collaborate with education boards to include environmental education topics.	
2. Establish Eco-Clubs	2026-2027
Form eco-clubs in schools to promote sustainable activities among students.	
3. Inter-School Competitions	2027-2028
Organize competitions focused on waste management, such as art from waste.	
4. Student Action Projects	2028-2035
Encourage students to lead waste reduction projects in their schools and communities.	

2.4. Community Clean-up Drives

Definition: Clean-up drives involve mobilizing volunteers to collect waste from public spaces, promoting a sense of responsibility toward maintaining a clean environment.

Action Plan and Timeline:

Action Plan	Timeline
1. Monthly Clean-up Drives	2025-2027
Launch monthly volunteer clean-ups across key urban areas.	
2. Business Partnerships	2026-2028
Engage local businesses to sponsor clean-up initiatives.	
3. Waste Sorting on Site	2027-2030
Train volunteers to sort waste during clean-up drives to promote recycling.	
4. Expand to Rural Areas	2030-2045
Extend clean-up initiatives to rural communities with local leadership.	

2.5. Voluntary Recycling Programs

Definition: Voluntary recycling programs encourage individuals to collect, sort, and deliver recyclables to designated drop-off points, promoting waste diversion from landfills.

Action Plan and Timeline:

Action Plan	Timeline
1. Establish Drop-off Points	2025-2027
Set up collection centers for recyclables in neighborhoods.	
2. Recycling Pickup Services	2027-2028
Partner with recycling companies to offer door-to-door collection services.	
3. Incentive Programs	2028-2030
Introduce rewards for households actively participating in recycling.	
4. Awareness Drives	2030-2045
Conduct periodic awareness drives to encourage continuous participation in recycling.	

Summary of the Approach

- **Early Phase (2025-2027):** Develop education programs and launch public awareness campaigns.
- **Mid Phase (2027-2035):** Strengthen voluntary programs, community engagement, and school initiatives.
- **Long-term Phase (2036-2045):** Focus on sustaining engagement, monitoring outcomes, and scaling efforts to ensure long-term behavioral change.

This approach ensures public awareness and engagement become integral to Nepal's strategy for achieving zero-carbon targets.

3. 3rd Main Parameter: Capacity Building and Training:

To achieve Nepal's Zero Carbon Mission by 2045, capacity building and training are essential for developing the skills and knowledge necessary for effective waste management. This parameter focuses on empowering local governments, waste workers, civil society organizations, and innovators with the expertise required to implement sustainable waste practices. By enhancing human and institutional capacities, Nepal can ensure efficient waste management solutions that reduce carbon emissions and promote resource conservation.

Focus Areas and Action Plans:

3.1. Capacity Building for Local Governments:

Definition: Capacity building for local governments involves equipping municipal officials with the skills and knowledge needed to manage waste effectively and implement sustainable practices.

Action Plan and Timeline:

Action Plan	Timeline
1. Needs Assessment	2025-2026
Conduct assessments to identify training needs of local government staff in waste management.	
2. Training Workshops	2025-2027
Organize workshops focusing on policy development, waste management strategies, and best practices.	
3. Resource Development	2026-2028
Create resource materials and toolkits for local governments to support their waste management efforts.	
4. Ongoing Support and Evaluation	2029-2035
Establish a support system for continuous training and evaluate the effectiveness of capacity-building initiatives.	

3.2. Training Programs for Waste Workers:

Definition: Training programs for waste workers provide essential skills and knowledge related to waste handling, safety, and environmental practices.

Action Plan and Timeline:

Action Plan	Timeline
1. Curriculum Development	2025-2026
Develop training materials tailored to the specific needs of waste workers.	
2. Hands-on Training Sessions	2025-2027
Conduct practical training sessions focusing on waste segregation, safety protocols, and equipment use.	
3. Certification Programs	2027-2028
Implement certification for trained waste workers to enhance their professional recognition.	
4. Monitoring and Feedback	2029-2035
Monitor training outcomes and gather feedback for program improvement.	

3.3. Energy Efficiency in Waste Management Facilities:

Definition: Promoting energy efficiency in waste management facilities aims to reduce energy consumption and greenhouse gas emissions associated with waste processing.

Action Plan and Timeline:

Action Plan	Timeline
1. Energy Audits	2025-2026
Conduct energy audits in existing waste management facilities to identify efficiency opportunities.	
2. Implement Energy-efficient Technologies	2025-2027
Invest in technologies such as solar panels and energy-efficient equipment in waste facilities.	
3. Staff Training on Energy Efficiency	2026-2028
Train facility staff on energy management practices and technologies.	
4. Evaluation and Optimization	2029-2035
Assess energy savings and optimize operations for continued efficiency improvements.	

3.4. Capacity Building for Civil Society Organizations:

Definition: Capacity building for civil society organizations enhances their ability to contribute to waste management initiatives through advocacy, community engagement, and educational programs.

Action Plan and Timeline:

Action Plan	Timeline
1. Partner Identification	2025-2026
Identify and collaborate with local civil society organizations focused on environmental issues.	
2. Training and Workshops	2025-2027
Organize training sessions on advocacy strategies, project management, and waste management practices.	
3. Resource Sharing	2026-2028
Create platforms for resource sharing and collaboration among civil society organizations.	
4. Impact Assessment	2029-2035
Monitor and evaluate the impact of capacity-building initiatives on community engagement and waste management.	

3.5. Fostering Innovation in Waste Management Solutions:

Definition: Fostering innovation in waste management solutions encourages the development and adoption of new technologies and practices that improve waste handling and reduce environmental impact.

Action Plan and Timeline:

Action Plan	Timeline
1. Innovation Challenges	2025-2026
Organize competitions to encourage innovative ideas and solutions in waste management.	
2. Collaboration with Research Institutions	2025-2027
Partner with universities and research institutions to develop new waste management technologies.	
3. Pilot Projects	2027-2030
Implement pilot projects to test and showcase innovative waste management solutions.	
4. Scale Successful Innovations	2030-2045
Evaluate pilot projects and scale successful innovations for broader application in waste management.	

4. 4th Main Parameter: Research and Data Management:

Research and data management are essential for understanding waste generation patterns, assessing the effectiveness of waste management strategies, and informing policy decisions. This parameter emphasizes the importance of data-driven decision-making and continuous research on waste management technologies. By collecting, analyzing, and disseminating data, Nepal can optimize waste management practices, support sustainable development, and contribute to achieving the zero-carbon target.

Focus Areas and Action Plans:

4.1. Data Collection and Analysis:

Definition: Data collection and analysis involve gathering information on waste generation, composition, and disposal methods to inform policy and operational decisions.

Action Plan and Timeline:

Action Plan	Timeline
1. Develop Data Collection Framework	2025-2026
Establish guidelines for collecting and reporting waste data at municipal and community levels.	
2. Implement Data Collection Systems	2025-2027
Introduce systems for consistent data collection across municipalities and waste management facilities.	
3. Data Analysis and Reporting	2028-2030
Analyze collected data to assess waste management effectiveness and generate reports for stakeholders.	
4. Continuous Data Updates	2030-2045
Ensure ongoing updates to data collection processes and reports to reflect changing waste patterns.	

4.2. Waste Characterization Studies:

Definition: Waste characterization studies analyze the composition of waste generated to identify trends, improve waste management strategies, and enhance recycling efforts.

Action Plan and Timeline:

Action Plan	Timeline
1. Identify Study Locations	2025-2026
Select representative municipalities for waste characterization studies.	

2. Conduct Characterization Studies	2025-2027
Perform detailed analyses of waste streams, focusing on composition and sources of waste.	
3. Publish Findings	2028-2029
Share results with stakeholders, including government agencies, businesses, and the public.	
4. Use Findings for Policy Development	2030-2035
Inform policy decisions based on the findings of waste characterization studies.	

4.3. Monitoring and Evaluation Systems

Definition: Monitoring and evaluation systems assess the performance and impact of waste management initiatives, ensuring that strategies are effective and goals are being met.

Action Plan and Timeline:

Action Plan	Timeline
1. Develop M&E Framework	2025-2026
Create a comprehensive monitoring and evaluation framework for waste management initiatives.	
2. Implement M&E Systems	2026-2028
Establish systems for collecting data and evaluating the impact of waste management programs.	
3. Regular Reporting	2028-2035
Generate periodic reports on waste management performance for stakeholders and the public.	
4. Feedback and Improvement	2035-2045
Use M&E findings to refine waste management strategies and improve effectiveness.	

4.4. Research on Waste Reduction Technologies

Definition: Research on waste reduction technologies explores innovative approaches to minimize waste generation and improve waste processing methods.

Action Plan and Timeline:

Action Plan	Timeline
1. Identify Research Priorities	2025-2026
Focus on key areas for research, including waste reduction technologies and methods.	
2. Collaborate with Research Institutions	2025-2027
Partner with academic and research institutions to conduct studies on waste reduction technologies.	
3. Pilot Testing of Technologies	2028-2035
Implement pilot projects to test the efficacy of new waste reduction technologies.	
4. Disseminate Research Results	2035-2045
Share findings with stakeholders and the public to promote the adoption of effective technologies.	

4.5. Climate Change Impact Assessments

Definition: Climate change impact assessments evaluate how waste management practices contribute to greenhouse gas emissions and identify strategies to mitigate these impacts.

Action Plan and Timeline:

Action Plan	Timeline
1. Develop Assessment Protocols	2025-2026
Create guidelines for conducting climate change impact assessments in waste management.	
2. Conduct Assessments	2025-2027
Assess the impact of current waste management practices on greenhouse gas emissions.	
3. Recommend Mitigation Strategies	2028-2030
Propose strategies for reducing emissions associated with waste management practices.	
4. Policy Integration	2030-2045
Incorporate assessment findings into national and local waste management policies.	

5.5th Main Parameter: Urban Development and Planning

Urban development and planning are critical for integrating sustainable waste management practices into city planning processes. This parameter focuses on promoting sustainable urban design, optimizing waste collection systems, and ensuring that waste management considerations are included in urban development policies. By embedding sustainable practices into the urban fabric, Nepal can effectively reduce waste generation and its environmental impact.

Focus Areas and Action Plans:

5.1. Integration of Waste Management in Urban Planning:

Definition: Integrating waste management in urban planning ensures that waste considerations are part of the development and zoning processes, leading to more sustainable cities.

Action Plan and Timeline:

Action Plan	Timeline
1. Policy Review	2025-2026
Review existing urban planning policies to identify gaps in waste management integration.	
2. Develop Guidelines	2025-2027
Create guidelines for incorporating waste management considerations into urban planning processes.	
3. Capacity Building for Planners	2027-2029
Train urban planners on sustainable waste management practices and policies.	
4. Monitor Implementation	2030-2045
Monitor the implementation of integrated waste management policies in urban development projects.	

5.2. Sustainable Urban Design Practices:

Definition: Sustainable urban design practices focus on minimizing waste generation and enhancing waste management through innovative design solutions.

Action Plan and Timeline:

Action Plan	Timeline
1. Research on Sustainable Practices	2025-2026
Investigate successful examples of sustainable urban design in other cities.	
2. Develop Design Standards	2025-2027

Create design standards promoting waste reduction, recycling, and green infrastructure.	
3. Incentives for Sustainable Design	2027-2029
Provide incentives for developers adopting sustainable design practices in new projects.	
4. Evaluate Urban Projects	2030-2045
Assess the effectiveness of urban projects in reducing waste and enhancing waste management.	

5.3. Optimization of Waste Collection Systems:

Definition: Optimizing waste collection systems involves improving logistics, routes, and technologies used in waste collection to enhance efficiency and reduce carbon emissions.

Action Plan and Timeline:

Action Plan	Timeline
1. Assess Current Collection Systems	2025-2026
Evaluate the effectiveness of existing waste collection systems and identify areas for improvement.	
2. Implement Smart Collection Technologies	2025-2027
Introduce smart waste management technologies such as sensor-based collection systems.	
3. Route Optimization	2027-2029
Optimize collection routes to reduce fuel consumption and improve service efficiency.	
4. Performance Monitoring	2030-2045
Regularly monitor and evaluate waste collection performance and make adjustments as necessary.	

5.4. Promotion of Recycling Infrastructure

Definition: Promoting recycling infrastructure enhances the capacity for waste separation, collection, and processing, thus reducing landfill use and carbon emissions.

Action Plan and Timeline:

Action Plan	Timeline
1. Identify Key Areas for Infrastructure Development	2025-2026

Assess urban areas to identify locations needing recycling facilities.	
2. Develop Recycling Facilities	2025-2028
Construct new recycling facilities and upgrade existing ones to improve capacity.	
3. Community Drop-off Points	2028-2030
Establish community drop-off points for recyclables to enhance public participation.	
4. Evaluate Recycling Performance	2030-2045
Monitor recycling rates and infrastructure effectiveness, making improvements as needed.	

5.5. Public Spaces Design for Waste Management

Definition: Designing public spaces to facilitate waste separation and encourage recycling can enhance community participation in sustainable practices.

Action Plan and Timeline:

Action Plan	Timeline
1. Design Guidelines for Public Spaces	2025-2026
Develop guidelines for designing public spaces that include accessible waste disposal and recycling facilities.	
2. Pilot Projects	2025-2027
Implement pilot projects showcasing sustainable design principles in public spaces.	
3. Community Feedback	2027-2029
Gather community feedback on public space designs and their effectiveness in promoting recycling.	
4. Scale Successful Designs	2030-2045
Expand successful public space designs across urban areas based on community input.	

Summary of the Approach:

- **Early Phase (2025-2027):** Focus on capacity building, research, and the integration of waste management in urban planning.
- **Mid Phase (2027-2035):** Enhance public engagement, optimize collection systems, and promote sustainable design practices.

- **Long-term Phase (2036-2045):** Sustain improvements, monitor effectiveness, and scale successful initiatives for a lasting impact on waste management.

Findings:

Hypothesis Overview:

This study hypothesizes that the implementation of waste management reforms across ten key parameters—Waste Management Practices, Public Awareness and Engagement, Policy and Regulatory Framework, Sustainable Practices and Innovations, Capacity Building and Training, Research and Data Management, Environmental Protection and Justice, Innovative Financing and Investment, Climate Change Adaptation and Resilience, and Urban Development and Planning—*will significantly reduce methane emissions and contribute to Nepal's Zero Carbon Mission by 2045.*

Theoretical Rationale with Parameter-Specific References

1. Waste Management Practices

Efficient waste management practices, such as segregation, composting, and recycling, form the foundation of sustainable waste handling. These practices significantly reduce the amount of organic waste going to landfills, lowering methane emissions (IPCC, 2014). Studies from Eunomia (2023) show that integrated waste management reduces both emissions and operational inefficiencies.

2. Public Awareness and Engagement

Raising awareness fosters behavioral changes, encouraging community participation in waste reduction and recycling efforts. The Swachh Bharat Mission in India demonstrated the effectiveness of public engagement campaigns in improving waste segregation and disposal (Springer, 2021).

3. Policy and Regulatory Framework

Strong policy frameworks ensure accountability and compliance, enabling structured waste management systems. CPCB (2016) shows that the introduction of solid waste management rules in India improved waste management outcomes through clear guidelines.

4. Sustainable Practices and Innovations

Innovations in technology, such as anaerobic digestion and waste-to-energy plants, enhance the sustainability of waste systems by converting waste into resources (World Bank, 2021). Composting and recycling are critical sustainable practices that contribute to reducing emissions.

5. Capacity Building and Training

Skilled waste workers and trained municipal staff improve the efficiency of waste management operations. UN-Habitat (2021) highlights the importance of training programs to support the implementation of innovative technologies and sustainable practices.

6. Research and Data Management

Data management systems provide insights into waste generation patterns, allowing for better policy decisions and targeted interventions. USAID (2023) emphasizes that research-backed strategies improve the effectiveness of waste management reforms.

7. Environmental Protection and Justice

Ensuring that marginalized communities benefit from waste reforms and are protected from environmental harm is essential for justice and equity. Environmental justice frameworks address the disproportionate impacts of waste pollution on vulnerable communities (Delterra, 2023).

8. Innovative Financing and Investment

Financial models such as carbon credits and green bonds attract investment in waste management infrastructure. World Bank (2021) highlights the importance of financing to implement waste-to-energy projects and composting facilities.

9. Climate Change Adaptation and Resilience

Waste management reforms contribute to climate resilience by reducing emissions and mitigating the risks of pollution-related disasters. Integrating waste management with climate adaptation strategies builds urban resilience (CCAC, 2023).

10. Urban Development and Planning

Waste management must align with urban development to ensure sustainable growth. Effective planning incorporates waste infrastructure into urban areas, reducing illegal dumping and improving collection systems (Eunomia, 2023).

Hypothesis Testing and Results:

Based on the theoretical evidence for each parameter, the null hypothesis (H_0)—which posits that implementing waste management reforms across these ten parameters will not have a significant effect on reducing emissions or achieving Nepal’s Zero Carbon Mission by 2045—is rejected. The alternative hypothesis (H_1) is accepted, confirming that these ten parameters contribute meaningfully to reducing methane emissions and achieving sustainable development goals i.e Nepal’s Zero Carbon Mission.

Conclusion:

This study highlights the importance of waste management reform in achieving Nepal’s Zero Carbon Mission by 2045. Waste management is not just about mitigating emissions—it offers a holistic solution for environmental sustainability by promoting circular economy practices, public health improvements, and urban resilience. By focusing on ten critical parameters and prioritizing five key areas—including waste practices, public engagement, capacity building, research, and urban planning—this study provides a clear roadmap for sustainable waste management.

The timeline-based action plan ensures that reforms are implemented systematically, making it easier to track progress toward emission reduction goals. Successfully executing these strategies will not only neutralize carbon emissions but also establish a self-sustaining waste management system that will benefit Nepal beyond the 2045 target. These reforms will reduce reliance on landfills, prevent pollution, foster public participation, and build institutional capacity, creating a resilient, sustainable waste management framework.

Thus, the actions proposed in this study not only address the urgent climate mitigation needs but also lay the foundation for a long-term solution to Nepal’s waste challenges. The results will ensure that Nepal remains committed to environmental stewardship while supporting economic growth and public well-being. Nepal’s approach can also serve as a model for other developing countries working toward carbon neutrality, demonstrating that sustainable waste management is both achievable and essential for combating global climate change.

With the successful implementation of these efforts, Nepal will not only achieve its zero-carbon target but also transform its waste sector into a driver of sustainable development and climate resilience.

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