

Circular Economy and Sustainable Waste Management

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Abstract:

This research explores the challenges and opportunities of implementing a Circular Economy (CE) for Sustainable Waste Management (SWM) in Pakistan, with a particular focus on Khyber Pakhtunkhwa (KP). Although developed countries have transitioned towards CE, developing nations like Pakistan face technological, human resource, institutional, and financial limitations. Current waste management policies in Pakistan focus primarily on hazardous waste disposal, neglecting broader CE principles such as resource recovery, recycling, and reuse. The study critically examines the legal frameworks, such as the Pakistan Environmental Protection Act, 1997, and the Khyber Pakhtunkhwa Climate Policy 2022, revealing gaps in policy enforcement and regulatory capacity. Through a thorough analysis, the paper presents policy and implementation-level recommendations, including regulatory amendments, incentives for industries, and capacity building. The findings underscore the importance of public-private partnerships (PPP), integration of the informal waste sector, and technological upgrades in modern recycling facilities.

Key words:

Circular economy, Sustainable waste management, Pakistan, Khyber Pakhtunkhwa, public-private partnerships

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Introduction

With the increase in population, conurbations, dependence on processed/furnished materials, and industrialization, waste management is becoming more challenging. Most developed countries have shifted towards a Circular Economy (CE) to ensure Sustainable Waste Management (SWM) (Khan & Ali, 2021). This paradigm shift actively engages people, local bodies, environmental institutions, and industries to responsibly act by reducing, recycling, and reusing waste. However, this shift is a gigantic task that developing countries are struggling to achieve. The challenges of transitioning to a circular economy range from a lack of technological infrastructure to human resource capacity constraints, as well as institutional and financial limitations (Ferronato, 2019).

In this context, this study explores the use of CE in SWM in Pakistan at the federal level and specifically in Khyber Pakhtunkhwa at the provincial level. Pakistan's current policies on waste management predominantly focus on hazardous waste disposal and sanitation; they lack the broader vision of a circular economy, which emphasizes resource recovery, reuse, and sustainable practices (Iqbal et al., 2022). The situation in KP is no exception. Both the federal and KP governments have introduced numerous laws, such as the "Pakistan Environmental Protection Act, 1997," the "Pakistan Climate Change Act, 2017," and the "Khyber Pakhtunkhwa Environmental Protection Act, 2014." Additionally, various policies like the "National Climate Change Policy, 2021," and the "Khyber Pakhtunkhwa Climate Policy 2022" have been implemented. Pakistan established the "Pakistan Environmental Protection Agency," while the KP government established the "Environment Protection Authority." The Capital Development Authority was authorized for waste collection and disposal in the Islamabad Capital Territory. Similarly, KP amended the Local Government Act 2014 (by inserting Section 115(A)) to empower Water and Sanitation Services Companies (WSSCs) for municipal functions of waste collection and disposal, which were previously managed by Tehsil Municipal Administrators (TMAs). However, their performance on the ground is below optimal, raising serious questions about the existing legal and institutional framework. In the global shift towards a circular economy, there is a growing need to assess Pakistan's legal and institutional frameworks to align them with sustainable waste management principles. This paper analyzes the issues, challenges, and opportunities to provide pragmatic suggestions.

Statement of Problem

There is no denying that Pakistan, and especially KP, has made considerable progress in waste management and established new institutions to shift towards a Circular Economy. However, it appears that Pakistan and KP have not fully transitioned to a Circular Economy and Sustainable Waste Management. Therefore, there is a need to review the existing situation, analyze the issues and challenges, and propose a way forward.

Scope

The scope of the research includes an assessment of Pakistan's and KP's existing policies, frameworks, and initiatives aimed at promoting a circular economy. The study will analyze both federal and provincial strategies to determine their effectiveness in addressing waste management challenges. Additionally, the research will explore the roles of key institutions, such as the KPEPA and Water and Sanitation Services Peshawar (WSSP), in implementing sustainable practices. The study aims to identify issues in the current system, examine operational challenges, and provide actionable recommendations for enhancing waste management systems in KP and across Pakistan by integrating circular economy principles.

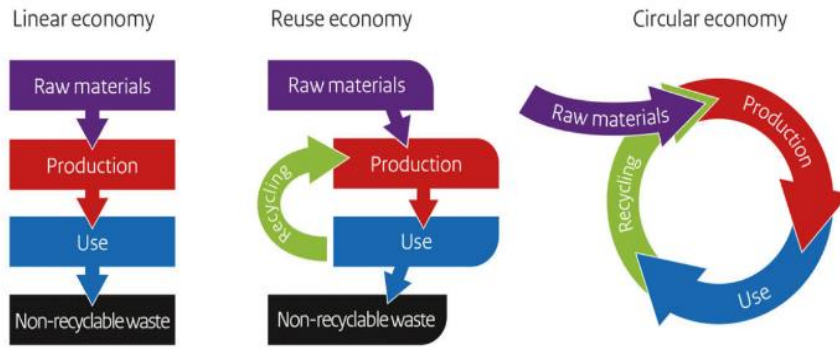
Research Methodology

This study follows a descriptive analysis consisting of primary and secondary data. Research articles, existing laws, and various reports are analyzed. It further employs analytical tools such as regulatory framework analysis, situational analysis, gap analysis, comparative analysis, PESTEL analysis, SWOT analysis, and EETH analysis for the identification of issues and resolution of the problem.

Circular Economy and Sustainable Waste Management

The CE concepts have garnered significant attention in achieving sustainable development goals in Pakistan. However, the implementation of CE in solid waste management remains a distant dream, as it envisions a transformation of processes from a linear model to CE and SWM, as shown in the diagram below (Contec, 2024).

From a linear to a circular economy



There are drivers and barriers in the implementation process, as well as multiple dimensions of waste concepts at household and industrial levels. For a country like Pakistan, the concept of CE in SWM is crucial because it produces 3.3 million tons of plastic waste per year, which is higher than the height of K2 (UNDP Report, 2022).



International Obligations

Pakistan is a signatory to the Paris Agreement and, in its Nationally Determined Contribution (NDC), has committed to reducing 50% of its greenhouse gas emissions by 2030. Pakistan has also adopted the Sustainable Development Goals (SDGs), among which SDG No. 13 pertains to climate change. The linked sectors include clean energy, industrial innovation, and sustainable cities and communities. The current estimates of greenhouse gas emissions from the waste sector are unreliable, and no mitigation measures have been planned by the government. These commitments require Pakistan to focus on Circular Economy (CE) and Solid Waste Management (SWM) concepts. Thus, adopting CE becomes a priority, as waste is eliminated in the design of products, materials are used and reused multiple times, and nature thrives due to a reduction in the extraction rate of raw materials (Hazemba, 2023). It will help reduce land and water source pollution, make it easier to quantify GHG emissions, and improve visual aesthetics (ADB, 2019).

Regulatory and Institutional Framework Analysis

Legal Framework

At the federal level, Pakistan's primary environmental legislations, the Pakistan Environmental Protection Act (1997) and the Pakistan Climate Change Act (2017), along with the Khyber Pakhtunkhwa Environmental Protection Act (2014) at the provincial level, provide a general framework for environmental protection but lack specific provisions for Circular Economy (CE) and Solid Waste Management (SWM).

Institutional Framework

Institutions involved in CE and SWM fall into two categories: regulatory institutions and implementing agencies. The Pakistan Environmental Protection Agency and the Khyber Pakhtunkhwa Environmental Protection Agency are the regulatory bodies at the federal and provincial levels, respectively. The implementing bodies include the Capital Development Authority (CDA), the Commerce Division in Islamabad, and in Khyber Pakhtunkhwa, the Water and Sanitation Services Peshawar (WSSP), Water and Sanitation Services Companies (WSSC), Tehsil Municipal Administrations (TMAs), and the Industries Department. The regulatory and implementing bodies at both the federal and provincial levels face similar issues, such as a lack of clear vision, inadequate institutional capacity, and no prioritization of SWM.

Policies

Pakistan's existing waste management policies are primarily focused on hazardous waste and sanitation. Two key policies include:

1. **National Climate Change Policy (2021):** This policy is designed to ensure environmentally sound management.
2. **Khyber Pakhtunkhwa Climate Change Policy (2022):** This policy has relevance to circular economy and waste management but includes broad parameters that have not been properly conveyed to relevant stakeholders. It also lacks specific areas of intervention.
3. **Khyber Pakhtunkhwa Climate Change Action Plan (2022):** Like the policy, the action plan lacks coordinated efforts toward CE and SWM practices. A thorough analysis of the plan reveals that it merely references terminologies and assigns tasks to various departments, but has not resulted in concerted and coordinated efforts.

New Projects

- WSSP has initiated a new project, the "Khyber Pakhtunkhwa Cities Improvement Project," which includes an integrated sustainable waste management system in the Water Supply and Sanitation Companies of Khyber Pakhtunkhwa, worth Rs. 10 billion with assistance from the Asian Development Bank. The project includes a source segregation plant and the reuse of waste material.
- Another project, converting "Waste to Energy in District Peshawar," is in the proposal stage. The project objectives include the CE concept at the provincial level. The Environment Department is seeking a grant of US \$900 million. While the objectives seem promising, the estimated amount is inflated and may be difficult to secure.
- Additionally, WSSP is actively working on a public-private partnership model of CE in SWM. The project is based on a Build-Own-Operate (BOO) model, where WSSP will receive a nominal fee. However, this project overlaps with the ADB's Citizen Improvement Project.

Situational Analysis

Current Situation

In Pakistan, recent economic growth has triggered rapid migration toward urban areas. This growth leads to increased municipal solid waste generation, while government institutions are only able to collect 50 to 60% of the total waste (Pak-EPA, 2020).

The country generates approximately 49.6 million tons of solid waste annually, including 30% food waste. Waste generation is increasing by more than 2.4% annually. Like many developing countries, Pakistan faces challenges in waste management infrastructure, resulting in significant environmental issues. In big cities, 60% of solid waste is collected daily, while 40% remains in empty plots, street corners, abandoned buildings, open drains, and nullahs. In rural areas, where municipal services are often non-operational, nearly all garbage stays in open fields, rainwater streams, and street corners. Even 60% of the waste collected by municipal authorities in big cities is disposed of at a few landfill sites (ITA, 2024). Therefore, it is clear that SWM is essential and can be practiced efficiently by incorporating CE concepts.

Current Status of Household Waste Management

a. Solid Waste Generation

Islamabad and Peshawar produce approximately 0.5 to 0.6 kg of waste per person daily, aligning with Pakistan's national averages. Urban centers like Peshawar and Islamabad are the largest contributors, where 60-65% of waste is organic, and 10-15% consists of plastic. Municipal services collect a portion of this waste, but a significant amount remains uncollected or is openly dumped, leading to environmental contamination (World Bank, 2018).

b. Waste Collection and Disposal

Islamabad has comparatively better waste collection services than Peshawar, which has limited coverage, particularly in rural and peri-urban areas. Unsanitary landfill practices are widespread, and open dumping remains the norm, causing land and water contamination. Only a small fraction of the waste generated is processed in an environmentally safe manner (JICA, 2016).

c. Recycling Practices

Recycling practices in Peshawar and Islamabad remain underdeveloped. Although informal recycling activities exist, the overall recycling rate is low. According to WWF-Pakistan (2020), only 10% of plastic waste is

recycled, with the remainder improperly managed, contributing to pollution in rivers and agricultural fields.

Current Status of Industries in Circular Economy

Several industries in Pakistan are shifting toward CE concepts, such as National Foods (reusable glass bottles), Gul Ahmed Textile Mills (recycling textile waste), Engro Polymer and Chemicals (recycling plastic waste, renewable energy), and Waste Buster (composting organic waste and other materials). However, the industry as a whole is lagging in CE adoption. Major companies still operate on a linear economic model and rely on conventional waste disposal techniques.

Issues of Waste Management

a. Inadequate Collection and Segregation

The majority of households do not practice waste segregation, leading to the contamination of recyclable materials (Ali et al., 2020).

b. Plastic Pollution

Plastic waste, especially plastic bags, continues to pollute the environment despite a government ban (Pak-EPA, 2020).

c. Informal Sector Dominance

The informal waste collection sector dominates the waste management system. Waste pickers collect recyclable materials from dumpsites but often lack institutional support or access to modern tools, limiting the efficiency and scale of recycling (Wilson et al., 2012).

d. Lack of Institutional Capacity

WSSP, WSSCs, and TMAs in KP lack the financial and technical resources to build modern waste management infrastructure. There is little investment in recycling or waste-to-energy projects (ADB, 2019). Islamabad has also not implemented CE concepts in SWM due to capacity issues.

e. Industrial-Level Issues

Small industries in isolated areas and industrial parks are neither energy-efficient nor working on sustainable waste management philosophies. There are even reports that large industries are involved in linear production, leaving waste in open air and water. Additionally, there is weak enforcement, and environmental protection agencies have not succeeded in enforcing their regulations.

Regional Comparative Analysis

Countries across the globe have embraced circular economy principles to manage waste sustainably and mitigate environmental impacts. Neighboring countries like India, Bangladesh, and Sri Lanka offer valuable lessons for Pakistan.

India's Circular Economy Approach

India has made significant strides in managing its waste, particularly through its Swachh Bharat Mission (2014), which focuses on cleanliness, sanitation, and waste management at a national scale. Under this initiative, cities have implemented strict policies on waste segregation at the source, recycling, and composting. For example, Indore, known as the cleanest city in India, practices door-to-door waste collection, segregation, and composting of organic waste, leading to a recycling rate of over 75% (Singh & Kumar, 2021). India's focus on creating a recycling economy has resulted in around 100 waste-to-energy plants operating across the country (Central Pollution Control Board, 2022).

Bangladesh's Waste Management Initiatives

Bangladesh, despite being one of the most densely populated countries in the world, introduced the 3R Strategy (Reduce, Reuse, Recycle) in 2015, focusing on waste minimization and resource recovery. The Dhaka North City Corporation implemented waste segregation at the household level and promoted community-based waste management initiatives. The country's focus on recycling plastic has reduced around 36% of its plastic waste (Islam & Hossain, 2020).

Sri Lanka's Waste Reduction Efforts

Sri Lanka has been a regional leader in waste minimization through its National Waste Management Strategy (2007). The Kelaniya Waste-to-Energy Project, which began operations in 2020, converts 500 tons of solid waste daily into energy, contributing to both energy production and waste reduction (Wijesinghe, 2021).

Comparative Analysis

Aspect	Peshawar (Pakistan)	Indore (India)	Dhaka North City (Bangladesh)	Kelaniya (Sri Lanka)
Policy Framework	KP Climate Change Policy (2022), and Action Plan (2022)	Plastic Waste Management Rules (2016)	National Waste Management Policy (2006)	National Solid Waste Management Policy (2007)
Waste Generation (per capita)	0.5 to 0.6 kg/day (2019)	0.54 kg/day (2020)	0.60 kg/day (2020)	0.70 kg/day (2020)
Recycling Rate	Landfill practice	~30% (2021)	~15% (2021)	~30% (2021)
Public Participation	Low awareness, limited community engagement	High public participation in initiatives	Moderate, with awareness campaigns	Strong community engagement initiatives
Investment in Infrastructure	Limited, inadequate waste management systems	Significant investments in recycling	Moderate, focus on landfill management	Investment in waste-to-energy facilities
Use of Technology	Minimal adoption of advanced technologies	Growing use of technologies in recycling	Limited technological implementation	Advanced waste-to-energy technologies
Economic Incentives	Limited, minimal support for circular economy	Government incentives for recycling	Some incentives for waste management	Strong support for green job creation
Success Stories	Peshawar Waste Management Company (WSSP)	Swachh Bharat Mission (Clean India)	Urban Resilience Program	Waste-to-Energy Projects
Challenges	Poor enforcement, lack of infrastructure	Fragmented implementation, pollution issues	Inadequate infrastructure, funding	Waste management issues in urban areas

Lessons Learned for Pakistan

- Strong public participation and awareness.
- A robust policy and regulatory framework.
- Significant investment in infrastructure development.
- India introduced economic incentives for recycling.
- Sri Lanka has made significant contributions to waste-to-energy projects.

PESTEL Analysis of EPA (Regulatory Body)

- **Political:** Strong government support for environmental initiatives. The Chief Minister is the head of the Environment Protection Council under the EPA Act, 2014. However, meetings are not held regularly, hindering its performance.
- **Economic:** The EPA issues NoCs to industries and various bodies. However, the CE concept is not assessed in their framework, and little emphasis is placed on SWM. Additionally, the EPA is facing financial constraints, which adversely affect its performance.
- **Social:** EPA's policies lack a participatory approach. There is a need to engage the intelligentsia and increase public awareness.
- **Technological:** Emerging technologies in recycling and waste-to-energy offer promising solutions, but the EPA has not utilized these technologies in SWM solutions.
- **Environmental:** There is significant potential to reduce landfill use and environmental degradation through circular economy practices, but the EPA, as a regulator, has not focused on this critical area.
- **Legal:** Existing laws, such as the Environmental Protection Act (2014), Climate Policy (2022), and Action Plan (2022), provide a framework, but the implementation and enforcement mechanisms are lacking.

Issues in EPA

- No mention of CE in the EPA Act.
- Weak institutional framework of the EPA.
- Lack of coordination among implementing bodies and federal-level entities.
- Lack of an integrated policy framework (Hussain et al., 2024).
- Issuance of 18 NoCs to housing societies in Peshawar recently⁵ without SWM assessment.

How to Address Issues

1. An exhaustive review of policies and their realignment towards CE and SWM is required.
2. The EPA should strengthen its institutional framework.
3. The EPA should thoroughly review its NoC issuance process to housing societies to achieve SWM through CE.
4. The EPA should enhance coordination with all stakeholders.
5. The EPA should encourage PPPs to promote innovation in waste management technologies, recycling processes, and sustainable production methods (Ahmed et al., 2021).

⁵ EPA Website (<https://epakp.gov.pk/environmental-approvals>)

SWOT & EETH Analysis of WSSP (Implementing Body)

S.W.O.T. Analysis	E.E.T.H. Analysis
<p>Strengths:</p> <ul style="list-style-type: none"> • Strong legal mandate (115A of Local Government Act) • Has HR staff • Waste collection mechanism • Strong internal control • ADB funding for SWM 	<p>How these can be Enhanced?</p> <ul style="list-style-type: none"> • Needs to focus on SWM. • Increase field presence • Increase waste collection per day • Focus on efficient utilization of ADB resources in SWM.
<p>Weaknesses:</p> <ul style="list-style-type: none"> • Garbage containers are less than the required number • Linear waste disposal (landfill disposal) • Lack of clear directions • Duplicity of projects 	<p>How these can be Eliminated?</p> <ul style="list-style-type: none"> • Needs to formulate a clear CE and SWM strategy • Increase number of containers • Remove duplicity of projects
<p>Opportunities:</p> <ul style="list-style-type: none"> • Unofficial CE market • Unofficial CE workers, retailers • Private firms interested 	<p>How to Take Advantage?</p> <ul style="list-style-type: none"> • Bring unofficial CE market in to main net • Train and capacitate private workers • Introduce PPP
<p>Threats:</p> <ul style="list-style-type: none"> • Increase in urbanization • Dependence on processed/industrial products • People's deviant behavior 	<p>How to Hedge Against?</p> <ul style="list-style-type: none"> • Increase public awareness campaigns • Focus on at source segregations

Issues and Challenges

There is a lack of infrastructure to support large-scale recycling and waste-to-energy projects. WSSCs lack proper waste segregation facilities, resulting in continued reliance on landfills, which are reaching capacity at alarming rates.

Public-private partnerships, which are crucial for the expansion of waste management infrastructure, are still in their infancy due to unclear regulatory frameworks and insufficient incentives for private sector involvement. Both WSSP and EPA are lacking in this area.

Another pressing issue is the low level of public awareness and participation in waste segregation and recycling programs. Surveys conducted in Peshawar and other urban areas reveal that fewer than 30% of households participate in any form of waste segregation, leading to inefficiencies in the collection and recycling processes.

Weak enforcement of existing regulations is another major issue. Although the KP Environmental Protection Act (2014) mandates waste segregation at the source, enforcement mechanisms are poorly resourced, leading to widespread non-compliance.

Conclusion

The transition towards a circular economy (CE) in Pakistan, particularly in Khyber Pakhtunkhwa, presents significant challenges but also opportunities for improvement in solid Both regulatory and implementation issues persist. These issues include a lack of clear policies and approaches towards CE and SWM, a weak regulatory framework, limited institutional capacity, poor enforcement, a weak monitoring regime, a lack of coordinated efforts, low public awareness and participation, insufficient incentives for the industrial sector, and limited public-private partnerships (PPP). By prioritizing resource reuse, recycling, reduction, and sustainable practices, the goal of CE can be achieved effectively. Waste management (SWM). However, under the present circumstances, it remains a distant dream.

Recommendations

Policy Level Recommendations

- The government should promote the use of biodegradable and reusable materials by offering tax incentives to industries.
- The government should amend the EPA Law to provide explicit provisions for CE and SWM.
- Further, amended laws and policies should strengthen regulatory frameworks like Extended Producer Responsibility (EPR), making manufacturers responsible for the disposal of their products. Incentives should also be offered to businesses adopting eco-friendly practices.
- The government should introduce policies to integrate the informal CE sector into the formal economy. The informal waste-picking sector should be provided better wages, health benefits, and modern tools.
- The EPA should strengthen its institutional capacity for the enforcement of existing waste management policies.
- The EPA should increase the frequency of Environment Protection Council meetings to garner more political support.
- It should focus on robust monitoring and evaluation.

Implementation Level Recommendations

- The WSSP should focus on dumping-site level segregation, as household segregation is a challenging task that requires a change in civic behavior, and the WSSP's collection model is container-based.
- The WSSP needs to focus on modern recycling facilities that process not only plastics but also metals and organic waste. Additionally, focusing on waste-to-energy technologies can help reduce landfill dependency and generate clean energy.
- Engaging the private sector through PPP can expedite CE and SWM.
- The WSSP should focus on capacity building for its staff, as enhanced technical and managerial capacities are required to implement CE strategies.

Action Plan

Proposed Actions (20%)	Rationale/Impact (80%)	Responsibilities	Resources	Timeline	KPIs
<p>Amend EPAs</p> <p>Laws and</p> <p>Develop CE</p> <p>Strategy</p>	<ul style="list-style-type: none"> • Explicit mention of CE in EPA laws • A unified policy framework for CE and SWM will drive coordination between federal and provincial efforts among all stakeholders • Increase Extended Producer Responsibility • Provide tax incentive to CE sector • Will increase CE documentation • Increase number of jobs • Revenue generation • Contribute to GDP 	<ul style="list-style-type: none"> • Ministry of Climate Change and Environmental Coordination • Provincial governments 	<ul style="list-style-type: none"> • Policy drafting teams (Legal experts) • Stakeholder consultations 	12-18 months	<ul style="list-style-type: none"> • Laws amended • Strategy published • Public awareness campaigns conducted
<p>Policy to formalize informal CE</p>	<ul style="list-style-type: none"> • Will increase CE documentation • Increase number of jobs • Revenue generation • Contribute to GDP 	<ul style="list-style-type: none"> • Ministry of Climate Change and Environmental Coordination • Planning and Development Department • Provincial governments 	<ul style="list-style-type: none"> • Policy drafting (Legal experts) • Stakeholder consultation 	1-12 months	<ul style="list-style-type: none"> • Number of businesses registered • Number of labours registered
<p>Institutional Capacity Building of EPA and WSSP</p>	<ul style="list-style-type: none"> • Enhance institutional capacity to implement CE strategies • Focus on research oriented and evidence-based policies • Ensure strong enforcement mechanism 	<ul style="list-style-type: none"> • EPAs • WSSP 	<ul style="list-style-type: none"> • Training of staff • Logistic support to staff (funding available through ADB) 	0-6 months	<ul style="list-style-type: none"> • Number of trainings imparted • Gadgets provided to staff • Monitoring and evaluation increased
<p>Promote PPP and Waste-to-Energy (WTE) Projects</p>	<ul style="list-style-type: none"> • Boost infrastructure and technology • Attracting private investment for CE and SWM 	<ul style="list-style-type: none"> • Ministry of Climate Change and Environmental Coordination • KP Environment Department • Industries Department 	<ul style="list-style-type: none"> • Investment incentives • Tax breaks • Technical experts and • WTE infrastructure 	12-24 months	<ul style="list-style-type: none"> • Number of PPP agreements signed • Number of WTE projects initiated
<p>Launch Public Awareness Campaigns</p>	<ul style="list-style-type: none"> • Influence Public Behaviour • Sensitize stakeholders • Increase compliance trends 	<ul style="list-style-type: none"> • Private sector partners • EPA • WSSP • Information Department • Education Departments • Local Government Department • Tourism Department • EPA • WSSP • City Mayors 	<ul style="list-style-type: none"> • Activate social media • Educational institution-based awareness • Start radio campaigns • Print media campaigns • Billboards at prominent public places and tourist spots • Workshops with stakeholders • Include in Trainings of NSPP & NIM 	Ongoing	<ul style="list-style-type: none"> • Number of Advertisements • Number of awareness campaigns • Number of workshops conducted
<p>Implement Monitoring and Waste Audits</p>	<ul style="list-style-type: none"> • Will reduce use of waste • Will increase enforcement • Highlight issues for corrective measures 	<ul style="list-style-type: none"> • EPA • WSSP 	<ul style="list-style-type: none"> • Training of existing staff • Technical Staff for monitoring • Hiring of reputable environment audit firms (ADB fund) 	3 to 6 months	<ul style="list-style-type: none"> • Number of staff trained • Number of firms hired • Number of monitoring visits • Number of audits conducted

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