Sustainable Development Policy Institute

Institute for Global Environmental Strategies

State of Circular Economy in Pakistan

Table of Contents

Executive Summary 3

1. Introduction 6
   - Methodology 7
   - Structure of the Report 8
2. Policy & Regulatory Landscape 9
   - Waste Management 9
   - Water Conservation 13
   - Energy Efficiency 14
   - International Agreements and Commitments 14
   - Stakeholder feedback on regulatory bottlenecks 15
3. Sector-Wise Assessment 17
   - Waste Management 17
     - Plastics 17
     - E-Waste 20
     - Organic Waste 23
     - Textiles 30
     - Construction & Demolition Waste 35
   - Water in Industry and Agriculture 41
   - Energy Sector 46
4. Economic and Social Implications of Circular Economy Transition 52
   - Job Creation Potential 52
   - Economic Benefits from Resource Efficiency and Reduced Waste Management Costs 52
   - Social Equity Aspects, Including Formalizing the Informal Waste Sector 53
   - Stakeholder Perspectives on Financing Opportunities and Social Impact 53
5. Key Barriers to Circular Economy Adoption 55
   - Financial Constraints and Limited Investment 55
   - Lack of Infrastructure and Technology 55
   - Regulatory and Policy Enforcement Gaps 55
   - Public Awareness and Skill Development Challenges 55
   - Stakeholder Recommendations for Overcoming Barriers 56
6. Recommendations & Roadmap 57
7. Conclusion 60
8. Annexures 61

Acknowledgements

The Annual State of Circular Economy in Pakistan is the result of a collaborative effort between the Sustainable Development Policy Institute (SDPI) and the Institute for Global Environmental Strategies (IGES), Japan. The report has been developed under SDPI's Program on Ecological Sustainability and Circular Economy, with the generous technical support and guidance of IGES.

The authors — Zainab Naeem (Associate Research Fellow), Ebadat ur Rehman (Research Associate), Ama Arooj (Research Associate), Nelam Pari (Research Associate), and Ihtesham ul Haq (Research Assistant) — express their deepest appreciation to all institutions and individuals who contributed valuable insights, data, and feedback throughout the research process.

We are particularly grateful to our key national stakeholders — the Ministry of Climate Change and Environmental Coordination (MoCC&EC), Ministry of Commerce, and the Ministry of Planning, Development and Special Initiatives (MoPD&SI) — for their continued engagement and policy guidance. We also extend our gratitude to the Provincial Environment Protection Departments of Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan for their collaboration and support.

Special thanks are due to the United Nations Environment Programme (UNEP) for its technical inputs and coordination in promoting circular economy transitions in Pakistan and the wider South Asian region. We also acknowledge the constructive participation of representatives from the recycling industry, SMEs, start-ups, and academic and civil-society organizations, including NIMA, National University of Sciences and Technology (NUST), Akhtar Hameed Khan Foundation, University of Engineering and Technology (UET) Peshawar, and the German Development Cooperation (GIZ).

The team is sincerely thankful to Dr. Abid Qaiyum Suleri, Executive Director, SDPI, for his visionary guidance and leadership throughout the development of this report, and to the broader SDPI research and communications teams for their support in facilitating consultations, stakeholder engagement, and publication processes.

Finally, SDPI acknowledges the invaluable contribution of all experts, policymakers, and practitioners who participated in stakeholder consultations, key informant interviews, field assessments, and policy dialogues, helping shape this report into a comprehensive reflection of Pakistan's circular economy landscape.

Executive Summary

Pakistan stands at a decisive moment where the shift from a linear "take-make-dispose" model to a circular economy offers a pathway to resilience, growth, and sustainability. The country produces nearly 49.6 million tonnes of solid waste every year, of which less than 20% is formally collected and an even smaller fraction recycled. Plastic waste alone exceeds 2 million tonnes annually, yet only 15-18% is recycled and just 3% through formal systems, with more than 85% mismanaged through dumping or open burning. This linear trajectory imposes heavy costs, with the economic loss of

unrecycled plastics estimated at over USD 300 million per year and municipal cleanup costs exceeding USD 50 million. Similar inefficiencies mark other waste streams: nearly 30% of food produced in Pakistan goes uneaten, construction debris is left unmanaged in urban landfills, and electronic waste already surpasses 500,000 tonnes annually, over 90% of which is processed informally using unsafe methods that expose workers, often women and children, to toxic substances.

Water use presents an equally stark challenge. Agriculture consumes over 90% of Pakistan's freshwater, yet outdated flood irrigation methods recover only around 10% of delivery costs, perpetuating wastage and stress on already scarce resources. Urban water utilities lose nearly 40% of their supply as non-revenue water, while industries discharge significant volumes untreated due to limited wastewater treatment capacity. Although the National Water Conservation Strategy sets a target of reducing agricultural water intensity by 20% and cutting urban losses by 15% by 2027, structural gaps in enforcement, technology, and finance persist.

The energy sector, meanwhile, embodies both opportunity and inertia. Pakistan has set ambitious efficiency targets through the 2023 National Energy Efficiency and Conservation Policy, which aims to save 9 million tonnes of oil equivalent and reduce carbon dioxide emissions by 35 million tonnes by 2030. Yet implementation remains limited: fewer than 40% of large industrial and commercial users comply with mandatory energy audits, while banks allocate less than 2% of their green lending portfolio to efficiency or circular economy projects. Without stronger policy enforcement, investment, and capacity building, the sector risks falling short of its potential to anchor circular solutions.

Despite these systemic inefficiencies, Pakistan demonstrates unique strengths that can serve as building blocks for a circular transition. The second-hand clothing sector, for instance, achieves a reuse and recycling rate of nearly 99%, with less than 2% of textiles ending in landfills, positioning it as one of the most circular industries globally. Informal networks of waste collectors and recyclers already provide critical services, though largely outside formal recognition. Renewable energy adoption is accelerating, and SMEs have piloted innovative models in plastic recycling, composting, and resource recovery that point to scalable solutions. By aligning these strengths with targeted reforms and investment, Pakistan can unlock climate-smart growth, reduce dependence on imported raw materials, and create thousands of green jobs while meeting its Sustainable Development Goals and Nationally Determined Contributions.

The pathway forward requires a multi-pronged approach. Policymakers must strengthen and harmonize regulations across provinces and the federation, enforce extended producer responsibility frameworks for plastics and e-waste, and incentivize circular practices through tax credits, subsidies, and one-window clearance systems. Financial institutions and donors should expand access to low-interest loans, blended finance, and microfinance to empower SMEs and startups working in recycling, repair, and green innovation. Investments in technology ranging from chemical recycling and pyrolysis of plastics to wastewater treatment plants, smart irrigation, and waste-to-energy facilities must be scaled up to modernize resource management. Equally vital is capacity building: integrating circular economy into university curricula, providing vocational training for recycling and resource efficiency, and launching public private campaigns to change consumer behaviour and build awareness. At the heart of this transition lies collaboration. Establishing multi-stakeholder forums at national and provincial levels can ensure government, industry, academia, civil society, and communities work in alignment, integrating informal workers into formal systems, driving innovation, and creating a culture of sustainability.

Pakistan's transition to a circular economy is not only an environmental necessity but also a strategic economic opportunity. By embedding circular principles into waste management, water use, and energy systems, the country can enhance competitiveness, build resilience against climate shocks, and improve quality of life for its citizens. The challenge is urgent, the benefits are clear, and the time to act is now.

1. Introduction

The concept of a circular economy (CE) has gained increasing recognition worldwide as a transformative approach to sustainable development, resource efficiency, and climate mitigation. Unlike the traditional linear model of "take-make-dispose," a circular economy emphasizes keeping materials in productive use for as long as possible through strategies such as recycling, reuse, and industrial symbiosis. In the context of Pakistan, where rapid urbanization, population growth, and industrial expansion have intensified resource consumption and waste generation, adopting circular economy principles is critical to addressing environmental degradation, resource scarcity, and economic inefficiencies. CE offers a framework to reduce material imports, minimize greenhouse gas emissions, and create employment opportunities while simultaneously enhancing resilience to climate risks.

Pakistan's current waste and resource management practices underscore the urgency of this transition. The country generates approximately 2 million tons of plastic waste annually, of which less than 15% is recycled, leading to both environmental degradation and the loss of economic opportunities. Similarly, with 49.6 million tonnes of solid waste produced each year, the absence of a unified waste management system and lack of waste sorting at source exacerbate inefficiencies. Food waste is another critical challenge, as nearly 30% of food produced goes unmanaged, with no structured disposal or valorisation systems in place.

Sectoral inefficiencies further highlight the need for CE-driven reform. In agriculture, which consumes more than 90% of Pakistan's freshwater, inefficient practices contribute to severe water stress. The textile industry, while accounting for almost 60% of exports, remains highly resource-intensive and environmentally taxing. Conversely, the used textiles sector, which demonstrates 99% circularity with less than 2% of waste reaching landfills, remains largely underrecognized and undervalued as a model for scalable circular practices. In addition, the unchecked accumulation of electronic waste, construction debris, and unmanaged landfills points to systemic gaps in waste governance.

Against this backdrop, transitioning to a circular economy presents Pakistan with an opportunity to optimize resource flows, reduce dependency on material imports, unlock value from waste, and build climate resilience. The objectives of this assessment are to provide a comprehensive analysis of Pakistan's circular economy potential, identify sector-specific challenges and gaps, and outline evidence-based pathways for transitioning towards a resource-efficient and climate-resilient economy. Specifically, the study aims to:

- Examine the current policy and regulatory landscape for CE-related sectors, including waste management, water use, and energy.
- Assess the operational, technological, and financial challenges in key sectors such as plastics, e-waste, organic waste, textiles, construction and demolition (C&D) waste, water in industry and agriculture, and the energy sector.
- Quantify the economic, social, and environmental implications of CE adoption, including potential job creation, cost savings, and greenhouse gas mitigation.
- Develop actionable recommendations and a roadmap for policymakers, industries, and other stakeholders to facilitate CE transition in Pakistan.

Methodology

The circular economy needs assessment in Pakistan employed a multi-method approach, combining literature review, primary data collection, and stakeholder engagement to provide a robust evidence base for policy and practice. The methodology aimed to capture both the technical feasibility and socio-economic implications of CE adoption across key sectors.

Data Sources

The assessment drew upon multiple data sources to ensure comprehensive coverage:

- National and provincial government reports, statistical datasets, industry publications, academic research, and international frameworks were reviewed to provide background on waste generation, resource use, energy consumption, and environmental impacts.
- SDPI policy papers and working papers to provide historical context, sectoral insights, and evidence-based recommendations for circular economy practices in Pakistan.
- Webinars, site visits, and stakeholder consultations conducted with government departments, industry representatives, SMEs, NGOs, and civil society to capture operational challenges, policy bottlenecks, and opportunities for collaboration.
- Life Cycle Assessment (LCA) undertaken under the UNEP-funded plastic feasibility study to evaluate environmental impacts, energy efficiency, greenhouse gas reductions, and resource savings from SME-led plastic recycling initiatives.

Stakeholder Consultation

Stakeholder engagement was central to the assessment, providing qualitative insights to complement quantitative analysis:

- ***Government Agencies:*** Ministries, regulatory authorities, and municipal departments shared perspectives on policies, enforcement gaps, and incentive structures.
- ***Industry and SMEs:*** Plastics, e-waste, construction, textile, and water sector actors provided data on operational practices, cost structures, and innovation potential.
- ***Financial Institutions:*** Microfinance institutions (MFIs) were consulted to understand funding constraints and potential instruments to support CE adoption.
- ***Civil Society and NGOs:*** Organizations engaged in environmental management, gender inclusion, and community development provided insights on social equity, informal sector engagement, and community-based approaches.

Analytical Approach

The study integrated quantitative and qualitative methods:

- ***Sectoral Assessment:*** Evaluated challenges, negative economic costs, circular economy potential, and best practices for each sector. Operational data from SMEs, pilot projects, and site visits were incorporated.
- ***Cost-Benefit Analysis (CBA):*** Estimated potential savings, emissions reductions, resource efficiency gains, and employment creation through CE adoption.
- ***Policy Gap Analysis:*** Reviewed national and provincial policies against international best practices, identifying regulatory gaps and enforcement challenges.

Scope and Limitations

The assessment focused on major CE sectors, waste management, water, and energy, covering SMEs, pilot projects, and representative urban areas across Punjab, Sindh, and Khyber Pakhtunkhwa. Informal sector activities and data gaps were addressed through expert consultation and triangulation. The study emphasizes practical, scalable, and financeable CE interventions aligned with Pakistan's climate commitments, NDC targets, and Sustainable Development Goals (SDGs).

Structure of the Report

The structure of the report is organized to provide a clear, sector-wise, and thematic analysis. Following the executive summary, the report begins with this introduction, setting the stage with definitions, objectives, and methodology. The subsequent sections examine the policy and regulatory landscape, sector-wise assessments of waste, water, and energy, economic and social implications, barriers to adoption, and recommendations and roadmaps for CE implementation. Finally, the report concludes with strategic insights, actionable priorities, and a call to action for multi-stakeholder collaboration to advance Pakistan's circular economy transition.

2. Policy & Regulatory Landscape

Pakistan's environmental ambitions are supported by comprehensive policies on waste management, water conservation, and energy efficiency, as well as binding international commitments. However, institutional fragmentation, resource constraints, and enforcement gaps hinder effective implementation. Strengthening regulatory coherence, capacity building, and stakeholder collaboration is imperative to achieve sustainable outcomes.

Waste Management

National Policy Framework

Pakistan's policy and regulatory framework for solid waste management (SWM) has gradually evolved over the past two decades, reflecting growing recognition of the environmental, public health, and climate risks linked to unregulated waste disposal. At the federal level, policy direction is anchored in the Pakistan Environmental Protection Act (PEPA) 1997, under which a series of national policies and provincial regulations have been introduced. These instruments address sanitation, hazardous waste, plastic management, and hospital waste, while recent strategies increasingly align with circular economy principles such as waste reduction, recycling, and Extended Producer Responsibility (EPR). Key elements of the policy landscape include:

- ***Plastic bans and regulations:*** Several provinces (Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan) and the Islamabad Capital Territory have enacted specific bans on non-biodegradable or single-use plastics, with provisions on thickness, labelling, and safe disposal. These measures are complemented by the Single-use Plastics (Prohibition) Regulations 2023 at the federal level, which also introduce mandatory EPR obligations for manufacturers.
- ***Sanitation and hazardous waste management:*** Instruments such as the National Sanitation Policy 2006 and the National Hazardous Waste Management Policy 2022 provide frameworks for sanitation services and safe hazardous waste handling, aligned with international conventions.
- ***Provincial strategies:*** Punjab has advanced SWM reforms through its Plastic Management Strategy 2023 and the Production and Consumption of Single-Use Plastics Regulations 2023, offering financial incentives for biodegradable alternatives and creating compliance mechanisms.
- ***Innovative initiatives:*** Programs such as the Collect and Recycle (CoRe) Alliance and Plastic Road Initiatives represent early-stage industry-led circular economy interventions, signalling new opportunities for private sector participation.
- ***Integration with climate policy:*** The National Climate Change Policy 2021 links waste management with mitigation and adaptation priorities, recognizing that unmanaged waste contributes to methane emissions, urban flooding, and health hazards.

A comprehensive list of key policies, acts, and initiatives related to SWM is provided in Table 1.

Table 1: Key policy frameworks and regulations related to SWM in Pakistan

No.	Policy/Act/Initiative	Regulatory Authority	Key Provisions/Description
1.	Punjab Prohibition Ordinance on Polythene Bags, 2002[1][2]	Government of Punjab	- Prohibits manufacture, sale, use, and import of black polythene bags - Bans bags with wall thickness below 15 microns to reduce environmental harm

[1] https://punjabcode.punjab.gov.pk/uploads/articles/the-punjab-prohibition-on-manufacture-sale-use-and-import-of-polythene-bags-black-or-any-other-polythene-bag-below-fifteen-micron-thickness-ordinance-2002-pdf.pdf

[2]

2.	National Sanitation Policy, 2006[3]	Federal Government	- Aims to provide adequate sanitation coverage - Improves the quality of life - Ensures a healthy physical environment for residents
3.	The Sindh Prohibition of Non-degradable Plastic Products Rules, 2014[4]	Sindh Environmental Protection Agency (Sindh-EPA)	- Ban on non-degradable plastic products - Regulation of oxo-biodegradable plastic products - Registration of manufacturers, wholesalers, and retailers - Marking recycled plastic products as unsafe for food contact
4.	Khyber Pakhtunkhwa Prohibition of Non-Biodegradable Plastic Products and Regulation of Oxo-Biodegradable Plastic Products Rules, 2017[5]	Khyber Pakhtunkhwa Environmental Protection Agency (KP-EPA)	- Ban on non-biodegradable plastic carrier bags - Ban on plastic bags with wall thickness below 50 microns - Requires labelling with essential information - Prohibits the use of hazardous raw materials
5.	Ban on Polythene Bags Regulations, 2019[6]	Islamabad Capital Territory Authority (ICTA)	- Prohibits the unauthorised manufacture, import, sale, purchase, storage, and use of polythene bags in Islamabad Capital Territory
6.	National Climate Change Policy, 2021[7]	Federal Government	- Builds resilience to climate change through adaptation measures - Reduces emissions and promotes renewable energy - Focuses on afforestation and climate action
7.	National Hazardous Waste Management Policy, 2022[8]	Federal Government	- Framework for managing hazardous waste - Covers licensing, handling, storage, and transportation under PEPA Act, 1997
8.	World Economic Forum's National Plastic Action Partnership (NPAP) programme, 2022[9]	Federal Government	- Focuses on reducing plastic waste through a circular economy - Phases out single-use plastics - Promotes industry-wide sustainable practices
9.	Single-use Plastics (Prohibition) Regulations, 2023[10]	Pakistan Environmental Protection Agency (Pak-EPA)	- Ban on single-use plastic bags, crockery, cutlery, food containers, stirrers - Ban on single-use plastic straws (effective by August 2025)

[3] https://mocc.gov.pk/PolicyDetail/OTYyZjg5ODktYjE2ZS00NmZiLWI3YTktMjJmMDgwMTdjMjU2
[4] http://sindhlaws.gov.pk/setup/publications_SindhCode/PUB-15-000259.pdf
[5] http://kpcode.kp.gov.pk/uploads/Prohibition_of_Non-Biodegradable_Plastic_Products_and_Regulation_of_Oxo-Biodegradable_Plastic_Products_Rules_2017.pdf
[6] https://environment.gov.pk/SiteImage/Misc/files/Regulations/PlasticBan2019.pdf
[7] https://mocc.gov.pk/SiteImage/Policy/NCCP%20Report.pdf
[8] https://mocc.gov.pk/SiteImage/Misc/files/National%20Hazardous%20Waste%20Management%20Policy%202022.pdf
[9] https://www.globalplasticaction.org/pakistan-partners-with-world-economic-forum-to-fight-plastic-pollution
[10] https://www.mocc.gov.pk/PublicationDetail/Mzk2ZmQ1ZTAtMzA2Ny00NjFlLWFlOWYtMGU1MDI1MmQ4YWUy

			- Beverage containers to be made of 50% recycled plastic by 2028 - Mandatory Extended Producer Responsibility (EPR) for producers
10.	Production and Consumption of Single-Use Plastic Products Regulations, 2023[11]	Environmental Protection and Climate Change Department, Government of Punjab	- Ban on single-use plastics such as disposable utensils, cutlery, food boxes, plastic flags - Ban on PVC banners with thickness below 80 microns - Registration of manufacturers, consumers, collectors, and recyclers - Mandatory EPR for plastic products
11.	Extended Producer Responsibility (EPR) in the Single-Use Plastic Regulations, 2023[12]	Federal Government	- Requires producers, importers, and beverage manufacturers to create plans for plastic waste collection and recycling - Plans are subject to federal approval
12.	The Plastic Management Strategy, Punjab, 2023[13]	Environmental Protection and Climate Change Department, Government of Punjab	- Bans production, sale, and use of certain single-use plastic products - Penalties for non-compliance - Development of EPR regulations - Public education and infrastructure for recycling - Support for eco-friendly alternatives - Financial incentives for biodegradable and compostable plastics
13.	Punjab Environmental Policy, 2015[14]	Government of Punjab	- Provides a framework for addressing environmental issues, focusing on pollution of water bodies, air pollution, lack of proper waste management, and climate change
14.	Punjab Hospital Waste Management Rules, 2014[15]	Government of Punjab	- States that every hospital, public and private, is responsible for the proper management of waste generated until its final disposal
15.	The Balochistan Use of Plastic Shopping and Flat Bags Act, 2023[16]	Balochistan Environmental Protection Agency (Balochistan-EPA)	- Ban on plastic carrier bags with thickness below 50 microns - Exemption for biodegradable, compostable bags, industrial packing, and hazardous waste - Development of solid waste management plans

[11] https://punjablaws.punjab.gov.pk/uploads/articles/punjab-environmental-protection-production-and-consumption-of-single-use-plastic-product-regulations-2023-95-of-2023-pdf.pdf
[12] https://resolutions.unep.org/resolutions/uploads/pakistan_16112023_extended_producer_responsibility.pdf
[13] https://punjablaws.punjab.gov.pk/uploads/articles/the-plastic-management-strategy-punjab-pdf1.pdf
[14] https://epd.punjab.gov.pk/system/files/Draft%20Punjab%20Environment%20Policy%202015_0.pdf
[15] https://epd.punjab.gov.pk/system/files/Punjab%20Hospital%20Waste%20Management%20Rules%2C%202014_0.pdf
[16] https://balochistancode.gob.pk/Document.aspx?wise=opendoc&docid=224&docc=204

16.	The Collect and Recycle (CoRe) Alliance[17]	Producer-led Initiative	- Focuses on testing and implementing solutions for plastic packaging and recycling - Primarily targets downstream recycling solutions
17.	Plastic Road Initiatives[18]	Federal and Provincial Governments	- Uses plastic waste in road construction - Aims to protect the environment and improve infrastructure in both rural and urban areas

Institutional and Regulatory Frameworks

The National Hazardous Waste Management Policy (2022)[19] establishes a cradle-to-grave framework for hazardous waste governance. It mandates clear responsibilities for waste generators, introduces standardized waste classification systems, and requires licensing of collectors and disposal facilities. Financial assurance mechanisms are built into the policy to ensure environmental liability coverage. Governance is structured around three institutional bodies:

— an Inter-Ministerial Implementation Committee to oversee enforcement,
— a Technical Committee to prepare operational guidelines, and
— a Central Directorate to coordinate and report progress.

Complementing this, the Solid Waste Management Sector Road Map (ADB, 2021)[20] extends the focus from hazardous waste to municipal solid waste (MSW). It advocates for:

— adoption of the waste hierarchy (prevention, minimization, reuse, recycling, recovery, disposal),
— clearer delineation of federal, provincial, and municipal roles,
— performance-linked financing and tariff reforms, and
— establishment of a National Steering Committee with representation from public and private sectors to monitor targets and budgets.

Policy Gaps and Enforcement Challenges

Despite this progress, significant shortcomings persist:

— ***Capacity Shortfall****:* Provincial Environmental Protection Agencies (EPAs) lack trained inspectors, accredited laboratories, and operational budgets. Nationwide, fewer than 20 hazardous-waste audits are conducted annually.
— ***Mandate Overlap****:* Since the 18th Constitutional Amendment, federal ministries retain policy-making authority while provinces oversee execution, resulting in ambiguous lines of responsibility.
— ***Weak Compliance Incentives****:* Penalties for illegal dumping or non-registration are rarely enforced, with fewer than 10 prosecutions annually despite widespread violations.[21]

[17] https://weforum.ent.box.com/s/ktt9gdte1ldo4pwtaa9lbyxrushils3q
[18] https://www.coca-cola.com/pk/en/sustainability/pakistans-first-plastic-road-inauguration#:~:text=Chiefly%2C%20the%20objective%20of%20the%20project%20is,the%20strategic%20leadership%20of%20the%20National%20Incubation
[19] https://mocc.gov.pk/SiteImage/Misc/files/National%20Hazardous%20Waste%20Management%20Policy%202022.pdf
[20] https://www.adb.org/sites/default/files/publication/784421/solid-waste-management-pakistan-road-map.pdf
[21] https://contemporaryjournal.com/index.php/14/article/download/545/456

- ***Insufficient Data Systems**:* No national waste-tracking database exists; municipalities rely on manual, paper-based systems, producing unreliable statistics on waste generation and recycling rates.

Water Conservation

Policy Instruments

The National Water Policy (2018)[22] marked a major shift in Pakistan's water governance by formally adopting an Integrated Water Resource Management (IWRM) approach. The policy recognizes the critical interlinkages between water availability, quality, and competing sectoral demands, and seeks to address them through structural reforms. It calls for the establishment of basin-level authorities with mandates that cut across provincial boundaries, allowing for more coordinated and equitable allocation of resources in transboundary river systems. To improve efficiency, the policy emphasizes demand-management instruments, including the introduction of metering, rationalized tariff structures, and incentives to promote modern irrigation techniques such as drip and sprinkler systems. At the legal and institutional level, it highlights the need to harmonize provincial legislation with federal standards on water rights, quality assurance, and allocation priorities. Furthermore, the policy encourages the expansion of public–private partnerships (PPPs), particularly in wastewater treatment and reuse, to supplement public sector capacity and mobilize private finance for water infrastructure.

Building on this foundation, the National Water Conservation Strategy (2023–2027)[23] provides an operational framework for translating policy objectives into measurable outcomes. The strategy sets quantitative conservation targets, aiming for a 20% reduction in agricultural water-use intensity, a sector that currently accounts for over 90% of national withdrawals, and a 15% reduction in urban supply losses, which remain among the highest in the region. It underscores the role of technology-driven solutions, recommending the use of remote sensing to optimize crop water requirements and smart meters to improve monitoring and billing in urban utilities. To ensure accountability and coordination, the strategy assigns distinct roles: Provincial Water Commissions are tasked with leading on-the-ground implementation, while the Pakistan Council of Research in Water Resources (PCRWR) is mandated to track and report progress. The private sector is positioned as a critical partner in financing and delivering infrastructure upgrades, including wastewater treatment plants, canal lining, and water-efficient urban distribution systems. Together, the policy and strategy provide a complementary framework that moves beyond supply-side measures to embed efficiency, accountability, and innovation into Pakistan's water governance landscape.

Gaps and Enforcement Challenges

- ***Fragmented Governance:*** Seven major river basins lack empowered basin authorities to regulate cross-provincial allocations.
- ***Underpricing of Water:*** Agricultural tariffs recover only ~10% of delivery costs, discouraging efficiency.
- ***Weak Monitoring:*** Only 30% of tubewells are metered, while urban utilities report non-revenue water (NRW) rates exceeding 40%.
- ***Slow Legal Reform:*** Outdated provincial laws limit adoption of modern federal quality standards and public-health safeguards.

[22] https://lpr.adb.org/resource/national-water-policy-2018-pakistan
[23] https://pcrwr.gov.pk/wp-content/uploads/2023/02/National-Water-Conservation-Strategy-for-Pakistan-2023-27.pdf

Energy Efficiency

Evolution of Regulatory Framework

Pakistan has progressively strengthened its energy efficiency and conservation framework over the past decade, moving from broad institutional establishment to more ambitious, sector-specific targets. The Energy Efficiency & Conservation Act of 2011 laid the foundation by creating the National Energy Efficiency & Conservation Authority (NEECA)[24], with a mandate to develop energy performance standards, labelling schemes, and promotional campaigns for efficient technologies. This was further consolidated through the Energy Efficiency & Conservation Act of 2016, which significantly expanded NEECA's authority[25]. Under this revised framework, NEECA was empowered to enforce mandatory energy audits for large industrial and commercial consumers, establish Minimum Energy Performance Standards (MEPS) for appliances and equipment, and impose penalties for non-compliance, marking an important step towards regulatory enforcement.

Building on this foundation, the NEECA Strategic Plan (2020–2023)[26] set out medium-term priorities with a target of achieving 3 million tonnes of oil equivalent (MTOE) in energy savings. The plan identified five priority areas, appliances, buildings, industry, transport, and power generation, and introduced measures such as energy labelling, energy codes for buildings, and efficiency benchmarks for industrial processes. Recognizing that these incremental steps were insufficient in the face of Pakistan's rising energy demand and climate commitments, the government launched the National Energy Efficiency and Conservation (NEEC) Policy in 2023. This policy raises the ambition significantly, aiming for 9 MTOE of savings and 35 Mt of CO_2-equivalent reductions by 2030.[27] It also introduces sector-specific roadmaps, time-bound targets for different industries, and stronger coordination mechanisms with provincial energy regulators. Importantly, the 2023 policy emphasizes mainstreaming energy efficiency into national climate goals, positioning efficiency not only as an economic necessity but also as a cornerstone of Pakistan's transition to a low-carbon and resilient energy system.

Gaps and Challenges

- ***Weak Enforcement:*** Only 40% of large energy users comply with mandatory audits, and fines are seldom enforced.
- ***Limited Technical Capacity:*** Pakistan lacks accredited energy auditors and trained facility managers to mainstream energy retrofits.
- ***Financial Barriers:*** Commercial banks allocate less than 2% of green lending to energy efficiency projects, constraining investment.
- ***Data Transparency:*** Utilities do not publicly disclose consumption data, limiting benchmarking and market transparency.

International Agreements and Commitments

Pakistan is a party to 15 major Multilateral Environmental Agreements (MEAs)[28], which collectively reinforce its transition towards a circular economy framework by embedding sustainability obligations into national policy and regulatory systems.

---

[24] https://data.sbfnetwork.org/sites/default/files/NEEC%2520Policy%25202023-1%2520(1).pdf
[25] https://www.nipapeshawar.gov.pk/KJPPM/PDF/P31.pdf
[26] https://climate-laws.org/document/energy-efficiency-conservation-strategic-plan-2020-23-by-national-energy-efficiency-and-conservation-authority-neeca_6d9b
[27] https://www.nipapeshawar.gov.pk/KJPPM/PDF/P31.pdf
[28] https://mocc.gov.pk/Detail/MWYwYTEwMWYtNGQ0OC00ZWY4LWE1ZWUtMTNlZTRkYWE1OTlh

- ***Climate Change Commitments:*** Under the United Nations Framework Convention on Climate Change (UNFCCC, 1992), Pakistan is required to submit National Communications and Biennial Transparency Reports, framing mitigation and adaptation strategies. The Kyoto Protocol (1997) provided access to the Clean Development Mechanism (CDM), though utilization remained limited. The Paris Agreement (2016) places binding obligations on Pakistan to pursue its Nationally Determined Contributions (NDCs), with conditional emission reduction and adaptation targets linked to international finance, technology transfer, and capacity building.
- ***Chemicals and Wastes Management:*** The Basel Convention (1992) restricts import/export of hazardous waste, requiring Pakistan to regulate transboundary movement and establish disposal infrastructure. The Rotterdam Convention (1998) obliges Pakistan to implement Prior Informed Consent (PIC) procedures for hazardous pesticides and industrial chemicals. The Stockholm Convention (2004) commits Pakistan to eliminate Persistent Organic Pollutants (POPs), aligning with circular economy approaches to phase out harmful substances. The Minamata Convention (2013) mandates reductions in mercury use in industrial processes, healthcare, and waste streams. The Montreal Protocol (1989) obligates a phasedown of ozone-depleting substances (ODS) and Hydrofluorocarbons (HFCs), where Pakistan has already phased out CFCs and is implementing Kigali Amendment targets on HFC reductions.
- ***Biodiversity and Land Resources:*** Pakistan ratified the Convention on Biological Diversity (CBD, 1994), committing to prepare National Biodiversity Strategies and Action Plans (NBSAPs), mainstream biodiversity in sectoral policies, and establish protected areas. The Convention on International Trade in Endangered Species (CITES, 1976) regulates wildlife trade, with provincial wildlife departments serving as enforcement agencies. The Ramsar Convention on Wetlands (1976) designates 19 sites in Pakistan as Wetlands of International Importance. The UN Convention to Combat Desertification (UNCCD, 1996) obliges Pakistan to implement land degradation neutrality targets, particularly critical in drought-prone districts such as Tharparkar. The Convention on Migratory Species (CMS, 1983) requires protection of migratory birds, freshwater fish, and mammals through habitat conservation and regional cooperation.
- ***Marine and Regional Governance:*** Pakistan's accession to the United Nations Convention on the Law of the Sea (UNCLOS, 1997) provides the legal basis for Exclusive Economic Zone (EEZ) management, sustainable fisheries, and marine pollution control. It underpins circular economy priorities in marine plastic reduction and sustainable blue economy initiatives.

At the federal level, implementation is coordinated by the Ministry of Climate Change (MoCC) through its Multilateral Environmental Agreements (MEAs) Secretariat, which handles compliance reporting, liaison with treaty bodies, and international negotiations. At the sub-national level, provincial Environmental Protection Agencies (EPAs) are tasked with execution, monitoring, and enforcement. However, capacity gaps in scientific monitoring, data management, and inter-agency coordination persist, leading to reliance on donor-funded projects for reporting obligations.

Taken together, Pakistan's MEA commitments create an enabling framework for advancing a circular economy transition. They drive regulatory reforms in hazardous waste and chemicals management, promote biodiversity-friendly land and water use, strengthen climate change adaptation, and embed sustainability into marine governance. The challenge lies in operationalizing these commitments through stronger institutional capacity, compliance mechanisms, and integration into national development and industrial policies.

Stakeholder feedback on regulatory bottlenecks

Stakeholders from industry associations, academia, NGOs, and local communities have identified critical regulatory bottlenecks and recommended solutions:

- ***Regulatory Coherence**:* Establish a one-window clearance for environmental approvals at the district level to reduce procedural delays.
- ***Need for Public-Private Dialogue:*** Stakeholders emphasize inclusive forums for aligning policy objectives with business and civil-society priorities, reducing uncertainty, and fostering trust.
- ***Capacity Enhancement**:* Launch joint training programs, led by federal and provincial EPAs, for inspectors, auditors, and local government officials, leveraging public-private partnerships for technical expertise.
- ***One-Stop Regulatory Bodies:*** Calls for streamlined, performance-based regulatory processes near business hubs to minimize overlapping approvals and lengthy hierarchies.
- ***Data-Driven Regulation**:* Develop integrated digital platforms for real-time tracking of waste streams, water use, and energy consumption, with publicly accessible dashboards to foster accountability.
- ***Incentive Mechanisms**:* Introduce tiered water and energy tariffs rewarding efficiency improvements, subsidized loans for waste recycling facilities, and tax credits for green building certifications.
- ***Inclusive Engagement**:* Institutionalize regular multi-stakeholder forums at national and provincial levels to align policy updates with ground-level challenges, ensuring feedback loops for adaptive management.
- ***Enhanced Transparency & Feedback Loops:*** Demand for two-way communication channels, timely feedback on permit applications, compliance audits, and environmental assessments, to build confidence and accountability.
- ***Leveraging Technology:*** Proposals for real-time water metering, waste-tracking systems, and digital compliance platforms to improve monitoring and public-sector responsiveness.

3. Sector-Wise Assessment

Waste Management

Plastics

Existing Challenges & Gaps

Pakistan consumes approximately 2.7 million tons of plastic waste annually, with nearly 86% mismanaged through landfilling[29], open dumping, or leakage into waterways, placing the country among the top ten global plastic polluters. Major urban centres such as Karachi and Lahore are the primary contributors, with per capita waste generation ranging from 0.24 to 0.65 kilograms per day and increasing at an annual rate of 2.4%.[30] [31] The waste management system remains highly fragmented and largely informal. Less than 10% of plastic waste is segregated at the source[32], as municipal systems typically mix plastics with general waste, hindering recycling and material recovery. Approximately 30% of total waste remains uncollected. Only about 7-9% of plastic waste is recycled due to limited recycling infrastructure, low-value polymers such as thin films, and weak coordination between formal and informal sectors.[33] While small and medium enterprises (SMEs) achieve mechanical recycling yields of up to 84% and closed-loop PET recycling offers high environmental benefits, such processes demand significant capital investment.[34]

Regulatory fragmentation further exacerbates the issue, federal bans on single-use plastics coexist with inconsistent provincial regulations, resulting in uneven enforcement and continued production of prohibited items.[35] [36] Implementation of Extended Producer Responsibility (EPR) remains weak, with no binding mandates or effective monitoring mechanisms in place. Informal labour practices also pose serious challenges, as thousands of scavengers, including child workers, operate in unsafe and unregulated conditions. Gender-blind policies and the absence of cooperative or financial inclusion structures prevent women from gaining formal recognition or access to financing. Moreover, data and performance monitoring gaps, such as the lack of life cycle assessment (LCA) tools, limit the ability of SMEs to pursue performance-based financing or access climate-related funds. According to SDPI's SME survey conducted across Punjab, Khyber Pakhtunkhwa, and Sindh, most enterprises depend on low-tech or hybrid recycling models due to capital and infrastructure constraints. Initial investment requirements range between PKR 1–20 million, while monthly operational costs vary from PKR 0.5–5 million. Raw material prices fluctuate between PKR 30 and 350 per kilogram, directly impacting profitability. SMEs primarily process HDPE, LDPE, PVC, PP, and multilayer plastics (MLP) into value-added products such as pipes, tiles, bricks, and eco-pavers, maintaining rejection rates below 5%.

Negative Economic Costs

Plastic mismanagement in Pakistan imposes significant economic, environmental, and social costs. Riverine and urban plastic pollution alone generates annual cleanup expenses estimated at USD 50

---

[29] https://www.switch-asia.eu/site/assets/files/4387/plastic_policies_pk.pdf
[30] https://sustainabledevelopment.un.org/content/unosd/documents/37697.Waste%20to%20Energy%20Potential%20in%20Pakistan.pdf
[31] https://doi.org/10.18034/apjee.v6i2.264
[32] https://www.karandaaz.com.pk/ur/research/blogs/resolving-plastic-waste-crisis-pakistan
[33] https://unctad.org/system/files/information-document/unda2030d32-pakistan-plastics_en.pdf
[34] https://sdpi.org/from-waste-to-wealth-the-role-of-microfinance-institutions-as-a-catalyst-for-sme-led-plastic-recycling-in-pakistan/publication_detail
[35] https://www.wwfpak.org/?392255%2FPlastics-pose-a-serious-threat-to-humans-and-the-environment-WWF-Pakistan
[36] https://pid.gov.pk/site/press_detail/28069

million.[37] The failure to recover and recycle plastic waste results in approximately USD 300 million worth of raw materials being lost each year.[38] Marine debris further exacerbates economic losses by reducing fishery yields by nearly 20%, thereby undermining livelihoods and export revenues linked to coastal economies.[39] Public health and environmental risks are also rising, as microplastics infiltrate food chains, contributing to long-term health complications and increased healthcare expenditures. Additionally, the widespread practice of open burning releases toxic emissions, aggravating air pollution and respiratory illnesses. From an energy and resource efficiency perspective, landfilling achieves only around 55% material recovery while emitting high levels of methane, a potent greenhouse gas. In contrast, SME-led mechanical recycling powered by solar energy has demonstrated substantial benefits, reducing energy costs by up to 30% and greenhouse gas emissions by 70–80%, showcasing the potential of sustainable circular economy models.[40]

Why Circular Economy is Needed

A circular economy approach offers a transformative pathway to address both the environmental and economic challenges posed by plastic waste in Pakistan. By keeping polymers in productive use, CE strategies reduce dependence on virgin resin imports, potentially cutting national demand by an estimated 25% within five years. This not only lowers the environmental footprint associated with polymer production but also strengthens domestic material security, providing cost savings for manufacturers and reducing vulnerability to global supply fluctuations.

Beyond resource efficiency, CE approaches promote economic resilience by stimulating the development of domestic recycling industries. Expanding the recycling sector, particularly through small and medium enterprises (SMEs) and startups, can create substantial employment opportunities across the waste management value chain. Jobs generated in collection, sorting, and processing are estimated to reach around 50,000, offering livelihoods to marginalized groups, including women and youth engaged in informal waste work. By formalizing these roles and integrating SMEs into structured recycling networks, the CE framework enhances both economic inclusion and social equity.

Pollution mitigation is another critical benefit of circular approaches. Implementing closed-loop systems in pilot basins has demonstrated the potential to reduce riverine and urban plastic litter by approximately 40%. These systems prevent plastics from entering waterways and ecosystems, protecting biodiversity and sustaining fisheries and tourism revenue. By diverting waste from open dumping and landfills, circular models also help manage methane emissions and other pollutants, contributing to cleaner urban environments and healthier communities.

CE principles support the development of sustainable business models by encouraging SMEs and startups to innovate in recycling technologies, product design, and material recovery. Companies that adopt design-for-recyclability standards and closed-loop production processes can create scalable solutions that not only enhance profitability but also align with national climate and sustainability targets. In parallel, these businesses foster circular supply chains that integrate environmental responsibility into economic activity, reinforcing the concept that sustainability and profitability are mutually reinforcing.

---

[37] https://documents1.worldbank.org/curated/en/099519105182220186/pdf/IDU0c63b027d07bea04c530a5d20fb328528dfd6.pdf
[38] https://www.karandaaz.com.pk/ur/research/blogs/resolving-plastic-waste-crisis-pakistan
[39] https://www.wwfpak.org/?392255%2FPlastics-pose-a-serious-threat-to-humans-and-the-environment-WWF-Pakistan
[40] https://sdpi.org/from-waste-to-wealth-the-role-of-microfinance-institutions-as-a-catalyst-for-sme-led-plastic-recycling-in-pakistan/publication_detail

From a climate perspective, mechanical recycling and closed-loop PET recycling systems provide substantial benefits. SME-led mechanical recycling can reduce greenhouse gas emissions by 70–80% compared to virgin plastic production, while closed-loop PET systems offer the highest mitigation potential among existing recycling technologies. These approaches also optimize water use and improve landfill diversion, addressing both resource efficiency and environmental sustainability. Conversely, incineration and landfilling exacerbate carbon emissions and contribute to water scarcity, highlighting the importance of promoting circular, climate-smart waste management practices. Integrating renewable energy into recycling operations, such as solar-powered mechanical recycling, further amplifies environmental gains, reducing operational energy costs and associated emissions.

Finally, the circular economy opens new market and export opportunities for SMEs. As global demand for recycled plastics and sustainable products rises, enterprises that adopt CE principles can access emerging export markets, participate in government-supported sustainable procurement programs, and develop community-based business models. These pathways not only expand revenue streams but also strengthen the resilience of local recycling ecosystems, positioning Pakistan to transition from a predominantly linear waste economy to a resource-efficient, circular system that delivers environmental, economic, and social co-benefits.

Best Practices

Global and local best practices offer valuable insights for strengthening Pakistan's plastic waste management system. The Global Plastic Action Partnership (NPAP) underscores the importance of a unified national roadmap that harmonizes standards, enforces Extended Producer Responsibility (EPR), and integrates digital waste-tracking platforms to enhance accountability and data transparency.[41] [42] Drawing inspiration from Türkiye's Zero Waste model, Islamabad's pilot initiative demonstrated the potential of localized implementation, achieving a 20% increase in recycling rates through mandatory source segregation and incentives for community-led enterprises.[43] Private-sector innovation has also played a key role, with PET-to-fibre conversion projects showcasing how discarded plastic bottles can be transformed into textile fibres, thereby creating higher-value recycling pathways and avoiding the downcycling typically seen in granule production.[44] Furthermore, the adoption of technology-driven tracking and sorting systems has improved transparency and operational efficiency by enabling real-time monitoring of plastic flows, facilitating performance-based interventions, and strengthening circular economy outcomes.

Stakeholder Insights

Insights from industry experts, startups, SMEs, MFIs, and NGOs highlight critical operational and policy considerations:

- SMEs and startups (e.g., Concept Loop, DAVAAM Life, Irverde, Trash Bee) are innovating in localized segregation, category-wise processing, and digital tracking.
- Frequent policy changes, fragmented provincial rules, and slow EPR implementation constrain scaling of recycling operations.
- SMEs struggle with high operational costs, low-access to low-interest loans, and insufficient subsidies. MFIs can enable access to tailored green finance, technical support, and performance-based funding.

---

[41] https://please-project.org/wp-content/uploads/2024/09/Official-Summary-Document-_-Pakistan-RTD.docx.pdf
[42] https://www.globalplasticaction.org/case-study-details/pakistan-national-action-roadmap-to-reduce-plastic-pollution/aJYTG0000000Pcj4AE
[43] https://pid.gov.pk/site/press_detail/28069
[44] https://afpak.boell.org/en/2025/01/27/circular-economy-pakistan-challenges-and-opportunities

- Companies like Unilever emphasize integrating recycled plastics into supply chains and providing funding and technical capacity-building support to startups.
- Women in informal recycling play a central role but face mobility, financial, and recognition barriers; targeted empowerment programs are essential.
- Digital waste-tracking apps and platform-based logistics (e.g., TrashIT, ReUpCycleApp) improve operational efficiency and data-driven decision-making.
- SDPI surveys indicate SMEs achieve 35-40% cost savings through innovative practices, hybrid recycling models, and solar-powered solutions, but face persistent competition from cheap virgin plastics and low consumer awareness.

Operational recommendations from stakeholders:

- Enforce EPR frameworks with clear timelines and inter-provincial harmonization.
- Strengthen Producer Responsibility Organizations (PROs) to connect manufacturers and recyclers.
- Promote SME-friendly financial instruments such as green bonds, blended finance, and low-interest loans.
- Provide technical advisory services and training to improve SME operational efficiency.
- Foster public-private partnerships to address infrastructure gaps and support incubation hubs.
- Encourage digital solutions for traceability, monitoring, and reporting of plastic flows.
- Prioritize women and youth empowerment through cooperative structures, training programs, and dedicated incubation support.
- Formalize and license SMEs through a unified national registration framework to enable access to finance and government support.
- Institutionalize Life Cycle Assessment (LCA) as a prerequisite for SME financing, supporting climate-smart and performance-based investment.
- Leverage emerging export opportunities and community-based engagement to expand market reach and strengthen financial sustainability.

E-Waste

Existing Challenges & Gaps

Pakistan's electronic waste (e-waste) problem is escalating at an alarming rate. According to the *Global E-Waste Monitor 2020*, the country generates nearly 500,000 tons of e-waste annually, a figure that continues to rise due to rapid digitalization, the affordability of consumer electronics, and increased imports of second-hand devices. Globally, e-waste grew by 21% between 2014 and 2019, and similar patterns are evident in Pakistan, where urbanization and rising household incomes have spurred higher consumption of electronic goods. The proliferation of mobile phones, laptops, televisions, and household appliances, combined with frequent upgrades and shorter product life cycles, has accelerated obsolescence, resulting in a mounting stream of discarded electronics.

The e-waste sector in Pakistan is overwhelmingly dominated by informal operations, with more than 90% of waste processed through unregulated channels. Informal recyclers typically dismantle electronic equipment manually and recover metals using crude methods such as open burning or acid leaching, which release hazardous pollutants into the environment. Workers, often women and children, operate without protective gear or occupational safety measures, exposing themselves to serious health hazards.[45] Compounding the issue, Pakistan lacks modern recycling facilities capable of

[45] UNEP (2021). E-Waste Management in Developing Countries.

handling large volumes of e-waste safely. While a few private initiatives have emerged, they address only a small fraction of the total waste generated, and hazardous components such as leaded glass, lithium batteries, and mercury lamps are seldom disposed of in a safe manner.

Regulatory and institutional weaknesses further exacerbate the crisis. Although Pakistan is a signatory to the Basel Convention, the country has yet to develop a dedicated national e-waste management law or a comprehensive Extended Producer Responsibility (EPR) framework. Existing hazardous waste regulations do not specifically address electronic products, leaving producers and importers without clear responsibilities for collection, recycling, or disposal. Weak enforcement and overlapping mandates between federal and provincial agencies have hindered progress.[46] Meanwhile, illegal imports of near end-of-life electronics, often mislabelled as second-hand devices, continue to flood local markets, adding further pressure to an already overburdened system. The absence of reliable data on e-waste generation and flows, coupled with low public awareness and a lack of collection infrastructure, means that consumers and businesses have few options for safe disposal.

Pakistan's electronic waste problem is growing at an alarming pace. The *Global E-Waste Monitor 2020* estimates that Pakistan generates nearly 500,000 tons of e-waste annually, and the figure is rising due to rapid digitalization, affordability of consumer electronics, and increased imports of second-hand devices.[47] Globally, e-waste grew by 21% between 2014 and 2019, and similar trends are visible in Pakistan, where urbanization and rising incomes drive higher demand for electronic goods.

Negative Economic Costs

The economic, environmental, and social consequences of e-waste mismanagement are profound. Economically, Pakistan loses valuable resources embedded in discarded electronics, such as gold, silver, copper, palladium, and rare earth elements. Globally, these materials represent an estimated recoverable value of USD 62.5 billion annually, yet much of this value in Pakistan is lost through unsafe and inefficient recovery methods.[48] Health-related costs are also substantial, as exposure to toxic substances like lead, mercury, cadmium, and brominated flame retardants has been linked to respiratory illnesses, neurological disorders, and developmental issues among children living near informal recycling sites.[49] This translates into higher healthcare expenditures, reduced labour productivity, and long-term human capital losses.

Environmental degradation from e-waste is another major concern. Toxic residues contaminate soil, air, and groundwater, leading to reduced agricultural productivity and costly remediation needs. International examples, such as Ghana's Agbogbloshie site, a global hotspot for informal e-waste, illustrate the scale of damage and multimillion-dollar cleanup costs that could similarly burden Pakistan.[50] The lack of formal recycling infrastructure also represents a missed opportunity for economic growth. Without a regulated system, Pakistan forgoes potential investment in high-value industries such as refurbishment hubs, component recovery, and certified recycling plants. Socially, the dominance of the informal sector perpetuates poverty cycles, child labour, and exclusion from social protection systems, leaving thousands of workers in unsafe and exploitative conditions.

Why CE is Needed

46 Government of Pakistan, Ministry of Climate Change (2022). National Hazardous Waste Management Baseline Study.
47 ITU, United Nations University, UNITAR (2020). Global E-Waste Monitor 2020.
48 ITU, United Nations University, UNITAR (2020). Global E-Waste Monitor 2020.
49 WHO (2021). Children and Digital Dumpsites: E-Waste Exposure and Child Health.
50 Grant, R. & Oteng-Ababio, M. (2019). The Globalization of E-Waste and the Agbogbloshie Problem.

A circular economy (CE) approach is essential for turning Pakistan's growing e-waste challenge into a strategic opportunity. By emphasizing the principles of closing material loops, designing out waste, and maximizing resource efficiency, CE provides a pathway to recover value from discarded electronics while reducing environmental and social risks. In the context of e-waste, formalized recycling plays a central role. Establishing licensed recycling facilities allows for the safe extraction of valuable metals and plastics, which can then be reintegrated into production chains, reducing the country's dependence on imported raw materials and strengthening domestic supply resilience.

Beyond material recovery, CE contributes significantly to pollution mitigation and public health protection. Transitioning away from informal practices such as open burning and acid leaching toward environmentally sound recycling methods reduces the release of dioxins, heavy metals, and other hazardous substances, safeguarding both workers and surrounding communities. At the same time, CE fosters employment generation and social upgrading. Integrating informal e-waste workers into formal systems, coupled with training, protective equipment, and fair wages, can create thousands of green jobs and promote social equity across the recycling sector.

Circular economy approaches also drive business innovation and competitiveness. By enabling product-as-a-service models, leasing arrangements, refurbishment markets, and repair-based enterprises, CE creates new revenue streams while meeting the sustainability expectations of global buyers. This is particularly relevant in sectors such as electronics and textiles, where refurbished products and circular design enhance export potential. Finally, adopting CE principles ensures regulatory and international compliance. A structured CE framework supports Pakistan in meeting its obligations under the Basel Convention and achieving SDG 12 on Responsible Consumption and Production, while aligning with the EU's increasing sustainability requirements for imports, positioning the country to compete in environmentally conscious global markets.

Best Practices

International experiences provide valuable insights that can guide Pakistan in developing an effective and inclusive e-waste management system. India's Extended Producer Responsibility (EPR) framework, established under the E-Waste Management Rules (2011, amended 2016 and 2018), legally obligates producers to collect and recycle electronic waste.[51] This system has facilitated the emergence of authorized recyclers and formal collection networks, although enforcement challenges remain. The key lesson for Pakistan is to introduce phased EPR obligations with realistic targets and robust monitoring mechanisms to ensure gradual but sustained compliance. Similarly, the European Union's Waste Electrical and Electronic Equipment (WEEE) Directive offers a strong regulatory model by setting binding collection and recycling targets, enforcing eco-design principles to enhance recyclability, and promoting producer compliance schemes. The EU's experience demonstrates how strict legislation, coupled with market-based mechanisms, can significantly improve material recovery rates.[52]

China's approach to e-waste management emphasizes industrial innovation and efficiency through the development of specialized eco-industrial parks. These "eco-parks" concentrate advanced recycling technologies in designated zones, allowing for economies of scale, strict environmental monitoring, and safe material recovery processes. This model underscores the benefits of clustering technology and infrastructure to optimize recycling performance.[53] Meanwhile, Kenya's Public-Private Partnership (PPP) initiatives highlight the importance of integrating social inclusion into e-waste

[51] https://hspcb.org.in/uploads/laws/Ewaste_Rules.pdf

[52] European Commission (2019). Directive on Waste Electrical and Electronic Equipment (WEEE)

[53] https://www.iisd.org/system/files/publications/development-eco-efficient-industrial-parks-china-review-en.pdf

governance. By training informal recyclers, providing them with protective equipment, and offering financial incentives, Kenya has successfully bridged the gap between informal and formal sectors. Pakistan can draw from this experience by designing a regulatory framework that not only formalizes e-waste management but also ensures the inclusion and protection of informal workers, fostering both environmental sustainability and social equity.[54]

Stakeholder Insights

Consultations with stakeholders highlight the following perspectives:

- Electronics manufacturers and importers emphasize the importance of policy clarity and financial incentives (e.g., tax rebates, subsidies) to establish take-back schemes and comply with recycling obligations.
- Informal waste collectors and recyclers fear losing their livelihoods but express willingness to transition to formal roles if offered training, protective equipment, fair wages, and access to cooperatives.
- Environmental NGOs and civil society organizations highlight the urgent need for awareness campaigns to educate consumers on safe disposal and call for strict enforcement against illegal imports and unsafe recycling practices.
- Regulators and policymakers acknowledge institutional weaknesses in enforcement and data collection. They call for federal-provincial coordination and integration of e-waste policy with broader climate and environmental strategies.
- Consumers and communities often lack awareness but show readiness to participate in recycling programs if accessible collection channels and incentives (such as discounts or deposit-return schemes) are provided.

Organic Waste

Solid Waste Profile of Pakistan

Pakistan is the fifth largest country in the world and home to 241.5 million inhabitants,[55] who generates approximately 49.6 million tons of solid waste a year, which has been increasing more than 2.4 percent annually.[56] Like many developing countries, Pakistan struggles with inadequate waste management infrastructure, which has led to mounting environmental concerns. Most municipal solid waste is either burned, openly dumped, or buried in vacant areas, creating significant risks for public health and community well-being. Official estimates suggest that the country generates nearly 87,000 tons of solid waste each week, with the bulk originating in major urban centres. Karachi alone home to an estimated 20 million people produces more than 16,500 tons of municipal waste every day. Across all major cities, weak urban planning, bureaucratic delays, insufficient equipment and technology, and low levels of public awareness compound the challenge of managing urban waste effectively.[57]

Existing Solid Waste Management System in Pakistan

[54] https://www.climate-kic.org/wp-content/uploads/2024/09/Nairobi-Circular-Economy_Baseline-Study_Climate-KIC-and-Wasafiri-Kenya.pdf
[55] Pakistan Bureau of Statistics, Government of Pakistan https://www.pbs.gov.pk/content/population-census (2023)
[56] https://www.trade.gov
[57] Ibid.

In most major cities of Pakistan, local and municipal governments are tasked with solid waste collection, covering roughly 60-70% of urban garbage. Collection methods vary widely, ranging from open trucks, tractor-trolley systems, and arm-roll containers for secondary transfer, to handcarts and donkey carts for primary collection. Street sweepers and sanitary workers often hired by municipalities use wheelbarrows and brooms to gather waste from small piles and dustbins, depositing it into both formal and informal depots.[58]

Karachi, the country's largest city, operates three sanitary landfill sites, while Lahore, the second-largest city, maintains two. Plans are underway to construct additional landfill facilities in other metropolitan centers. In many regions, however, waste is still dumped beyond city limits without proper treatment. Provincial systems also vary in Punjab, Lahore remains the only city with an integrated solid waste management system, outsourced to Turkish firms Albayrak and OzPak, with similar arrangements planned for secondary cities. In Sindh, the Sindh Solid Waste Management Board (SSWMB) oversees services in 20 cities and regularly issues tenders for new projects. In Khyber Pakhtunkhwa, the Water and Sanitation Services Peshawar (WSSP) is developing a sanitary landfill, while Balochistan despite being the largest province by area with a population of 6.9 million lacks significant waste management infrastructure.[59]

Recycling occurs largely through informal systems. Scavengers recover a considerable share of recyclable material before waste reaches disposal points, meaning much of the country's solid waste never arrives at landfill sites. The composition of municipal solid waste is estimated as: food waste 30%, ash, bricks, and dirt 18%, yard waste 14%, plastic 9%, cardboard 7%, paper 6%, glass 6%, metal 4%, wood 2%, textile 2%, leather 1%, and rubber 1%.[60]

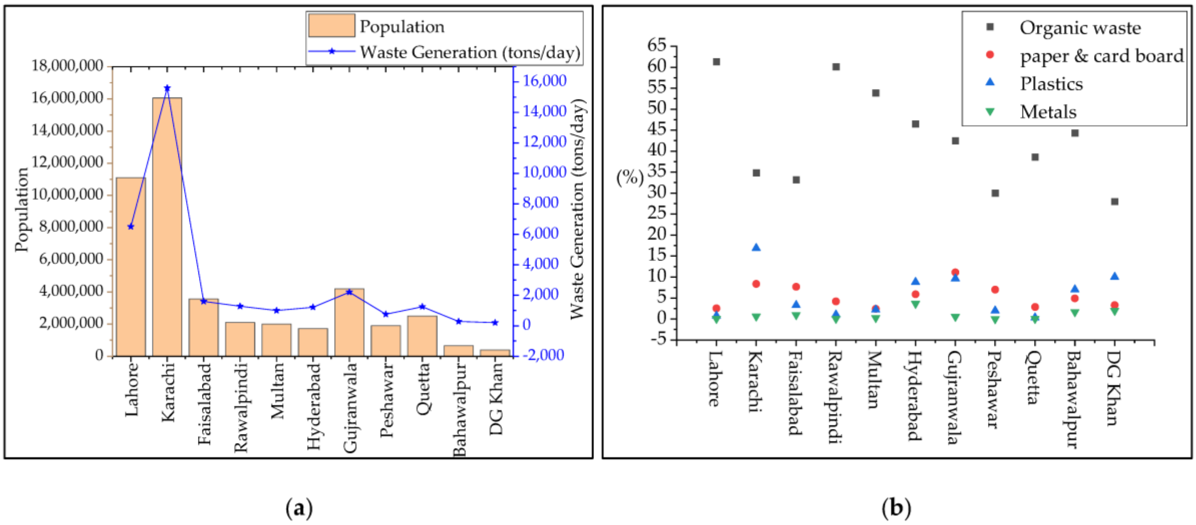

Figure 1: Population, waste generation trend and percentage of recyclables in selected cities (a) Population and waste generation (tons/day) of cities; (b) Percentage of 4 major physical components of 11 cities.

Existing Challenges & Gaps

Pakistan generates over 49.6 million tonnes of solid waste annually, of which nearly 60% is organic in nature, yet less than 10% is recycled or composted.[61] A key challenge lies in the absence of source

[58] Ibid.
[59] Ibid.
[60] Ibid.
[61] Hashim, M., et al. (2022). On-farm composting of agricultural waste materials for sustainable agriculture in Pakistan. Sustainability, 14(19), 12680. MDPI.

segregation, as municipal waste collection typically mixes organic waste with plastics, metals, and hazardous waste, rendering it unsuitable for recycling or energy recovery.[62] The country's reliance on open dumping and poorly engineered landfills leads to uncontrolled methane emissions, leachate seepage, and significant public health risks.[63]

In Pakistan, food loss and waste are substantial problems: approximately 26% of annual food production about 20 million tonnes is wasted, representing an economic value of around USD 4 billion, according to the Ministry of National Food Security & Research. Losses in staple crops such as wheat, rice, and maize alone amount to about USD 1 billion per year, while fruits and vegetables suffer even greater losses. Per capita food waste in Pakistan is estimated at 212 kg per person per year, among the highest globally.[64]

The challenges behind these figures are multi-fold: food loss occurs largely in the post-harvest and supply chain stages due to inadequate storage, processing, transportation and cold chain infrastructure; food waste at retail, restaurant, and household levels is driven by consumer behaviour, lack of awareness, poor planning, and issues with food safety standards (e.g., blemished produce being discarded).

Despite the large share of organics in municipal solid waste, formal composting and biogas facilities are extremely limited. Most initiatives remain small-scale, often donor-driven pilot projects, with little integration into municipal planning or national waste management strategies.[65] In comparison, countries such as Denmark, Sweden, and Japan have developed mandatory frameworks for food waste recycling, yet Pakistan lacks a cohesive regulatory or incentive structure.[66] [67]

Institutionally, there are capacity gaps within municipal corporations, including lack of technical expertise, insufficient budgets, and fragmented responsibilities between local governments, provincial environmental agencies, and private contractors. The informal waste sector, while playing a role in recycling plastics and metals, is largely absent in handling organics due to the absence of economic value in unprocessed food waste. Additionally, there is low public awareness regarding household-level segregation and food waste minimization, further exacerbating the problem.

Negative Economic Costs

Food loss and waste in Pakistan represent one of the most pressing yet under-addressed development challenges, with direct consequences for food security, environmental sustainability, and economic growth. According to the Ministry of National Food Security & Research (MNFSR), nearly 26% of Pakistan's annual food production equivalent to about 20 million tonnes is lost or wasted each year, translating into an economic value of over USD 4 billion.[68] Losses are particularly acute in staple crops such as wheat, rice, and maize, which collectively account for about USD 1 billion annually, while fruits

[62] https://www.emerald.com/jeim/article-abstract/33/4/817/207269/Waste-to-energy-and-circular-economy-the-case-of
[63] Sanjuan-Delmás, D., Taelman, S. E., Arlati, A., Obersteg, A., Vér, C., Óvári, Á., Tonini, D. & Dewulf, J., 2021. Sustainability assessment of organic waste management in three EU Cities: Analysing stakeholder-based solutions. Waste Management, 132, pp.44-55.
[64] https://www.thenews.com.pk/tns/detail/1234804-solutions-to-address-food-loss-and-waste-require-collaboration-and-fundamental-transformation-in-food-systems
[65] Hashim, S., Waqas, M., Rudra, R.P., Khan, A. A., Mirani, A. A., Sultan, T., Ehsan, F., Abid, M. & Saifullah, M., 2022. On-farm composting of agricultural waste materials for sustainable agriculture in Pakistan.
[66] Zhang, D., 2004. Food waste recycling in Japan: From regulatory framework to practical outcomes. Environmental Science and Pollution Research, 11(3), pp.134–140.
[67] Swadhi, R., 2025. Innovative Strategies for Widespread Adoption in a Climate-Smart Future. In: Climate-Smart Innovations for Sustainable Development. Hershey, PA: IGI Global.
[68] Ministry of National Food Security & Research (MNFSR), 2024. Agricultural Statistics of Pakistan 2023-24. Islamabad: Government of Pakistan.

and vegetables incur even higher proportional losses due to their perishability and the absence of robust cold-chain logistics.[69] [70] These inefficiencies not only diminish the country's agricultural productivity but also undermine rural incomes, as nearly 37% of Pakistan's labour force is employed in agriculture and food systems.[71] At the consumer level, UNEP's Food Waste Index Report (2024) estimates that Pakistan generates 212 kg of food waste per capita per year, among the highest globally, reflecting inefficiencies at household, retail, and hospitality levels. This waste amplifies the embedded resource losses of water, energy, land, and fertilizers that were used in food production, thereby intensifying environmental degradation and raising hidden economic costs.

The environmental implications are equally severe. A large proportion of Pakistan's food waste ends up in open dumpsites and poorly engineered landfills, where anaerobic decomposition produces methane a greenhouse gas with 28–34 times the global warming potential of CO_2 over a 100-year period.[72] Without systematic composting or anaerobic digestion infrastructure, the country is missing opportunities to capture this methane for biogas and bioenergy generation, which could reduce reliance on imported fossil fuels and provide decentralized energy solutions.[73] Instead, unmanaged methane emissions contribute to climate change, while landfills impose significant financial and land-use burdens on municipalities, particularly in large urban centres such as Karachi and Lahore.[74]

The cumulative macro-economic impact is substantial: studies suggest that the value of lost food represents between 1.5–2% of Pakistan's GDP, reducing fiscal space for development priorities while simultaneously exacerbating food insecurity.[75] The FAO (2024) stresses that post-harvest losses in Pakistan stem from systemic gaps including inadequate storage, weak transportation infrastructure, limited processing facilities, and poor market connectivity. Meanwhile, urban municipalities highlight challenges of waste segregation and recovery, as most food waste is mixed with municipal solid waste, making recycling or composting unfeasible.[76] Collectively, these figures underline that addressing food loss and waste is not only an environmental and social necessity but an economic imperative: failure to act will continue to drain billions from Pakistan's economy, strain natural resources, intensify methane-driven climate risks, and prevent the harnessing of valuable bioenergy potential.

Why CE is Needed

A circular-economy approach for organic waste prioritizing source segregation, decentralised composting, medium-scale anaerobic digestion (AD), and biogas recovery is the most practical pathway to convert Pakistan's organic liability into energy, nutrients, and climate mitigation benefits.[77] [78] Current literature finds that integrating green-supply-chain practices with municipal waste systems

[69] Ibid.
[70] Food Waste Index Report 2024 — FAO / UNEP collaboration. Tracks global and national food waste across retail, food service and household sectors; provides updated methodology and solutions.
[71] Ibid.
[72] https://www.ipcc.ch/report/ar6/syr/
[73] Hashim, S., Waqas, M., Rudra, R.P., Khan, A. A., Mirani, A. A., Sultan, T., Ehsan, F., Abid, M. & Saifullah, M., 2022. On-farm composting of agricultural waste materials for sustainable agriculture in Pakistan.
[74] United Nations Environment Programme (2024). Food Waste Index Report 2024: Think Eat Save – Tracking Progress to Halve Global Food Waste. UNEP.
[75] https://thedocs.worldbank.org/en/doc/5ee854aff2b120cb30ef910f4e7421f9-0310012023/original/Pakistan-Development-Update-Report-April-2023.pdf?utm_source=chatgpt.com
[76] https://www.thenews.com.pk/tns/detail/1234804-solutions-to-address-food-loss-and-waste-require-collaboration-and-fundamental-transformation-in-food-systems
[77] Adewale, A. M., et al. (2024). Waste-to-energy and circular economy: The case of [article]. Journal of Enterprise Information Management, 33(4), 817–836.
[78] Kumar, S., & Samadder, S. R. (2017). A review on technological options of waste to energy for effective management of municipal solid waste.

and aligning waste-to-energy (WtE) technologies with circular design principles materially improves resource recovery while lowering net greenhouse-gas emissions when implemented with appropriate controls.[79] [80]

Globally, countries that have combined mandatory source separation, regulated extended producer responsibility (EPR), decentralised AD, and strategic WtE investments achieve high organic diversion rates, substantial methane avoidance, and renewable energy generation. Denmark and Sweden, for example, have nearly eliminated landfill dependency by converting organic waste into district heating, electricity, and high-quality compost.[81] Japan's Food Waste Recycling Law has diverted significant food waste into animal feed, fertilizers, and biogas, showing the effectiveness of strong regulatory enforcement.[82] Similarly, the Netherlands has institutionalised mandatory segregation and composting, fostering markets for secondary organic products while sharply reducing methane emissions.[83] These global experiences underline how waste once viewed as a liability can become a resource.

For Pakistan, the rationale is clear and urgent. Official estimates indicate that the country generates nearly 20 million tonnes of food loss and waste annually, representing about 26% of total food production and an economic loss exceeding USD 4 billion.[84] [85] The majority of organic waste comprising 60–65% of municipal solid waste is disposed of in open dumps and poorly engineered landfills, producing methane, a greenhouse gas with 28–34 times the warming potential of CO_2.[86] Without composting and biogas recovery infrastructure, Pakistan is forfeiting opportunities for renewable energy production, landfill cost reduction, and soil nutrient recycling. Composting and biogas technologies can convert organic waste into valuable resources by producing nutrient-rich soil amendments and renewable energy, while simultaneously reducing landfill volumes, mitigating methane emissions, and lowering dependence on imported chemical fertilizers and fossil fuels.[87]

If the 20 million tonnes of organic waste were processed annually through circular technologies, it could generate approximately 2.4 billion m^3 of biogas, equivalent to 12,000 GWh of energy per year, covering almost 8–10% of Pakistan's electricity needs. At the same time, composting could yield around 8 million tonnes of high-quality compost annually, reducing fertilizer import dependency and enhancing soil fertility.[88] [89] These figures highlight the immense untapped potential of organic waste as both a renewable energy source and a soil-health enhancer.

To capture the full potential of organic waste, Pakistan should adopt a phased CE strategy that addresses both material recovery and energy generation. At the municipal level, mandatory source segregation is essential to ensure the quality of feedstock for recycling and energy production. Decentralized, medium-scale anaerobic digestion plants can be established at food markets, large hotels, and agro-processing hubs to generate biogas and digestate, while municipal composting

---

[79] Salmenperä, H., Pitkänen, K., Kautto, P., & Saikku, L. (2021). Circular economy in the Netherlands: Policy and practice. Environmental Science and Pollution Research, 28, 11725–11739.
[80] Makarichi, L., Jutidamrongphan, W., & Techato, K. (2018). The evolution of waste-to-energy incineration: A review. Renewable and Sustainable Energy Reviews, 91, 812–821.
[81] Ayorinde, A., et al. (2024). Sustainability transitions in waste-to-energy systems: Lessons from Denmark and Sweden.
[82] Zhang, 2004
[83] Salmenperä et al., 2021
[84] MNFSR, 2024
[85] UNEP, 2024
[86] https://www.ipcc.ch/report/ar6/syr/
[87] Hashim et al., 2022
[88] UNEP, 2024
[89] MNFSR, 2024

programs can process mixed organic waste, converting digestate into soil amendments that reduce reliance on chemical fertilizers.

Financial and operational barriers can be addressed through blended finance mechanisms and public–private partnerships (PPPs) to de-risk the capital-intensive infrastructure required for anaerobic digestion and waste-to-energy facilities. Simultaneously, market development for compost and digestate should be supported by quality standards and procurement policies from municipal and agricultural bodies, ensuring economic viability and consistent demand. A critical component of this transition is the integration of informal waste workers into formal recycling systems, utilizing micro-enterprise models and providing occupational safeguards to improve livelihoods and social equity.

The co-benefits of this approach are substantial. Methane emissions are reduced, waste diversion from landfills is increased, and renewable energy is generated locally. Municipal costs for waste management decrease, while soil fertility improves and chemical fertilizer imports are curtailed. Moreover, new green jobs are created, stimulating local economies and enhancing social inclusion. For Pakistan, transforming its organic waste management system into a circular model is no longer optional; it represents a necessary step for achieving climate resilience, economic efficiency, and sustainable development.

Best Practices

Global experiences demonstrate that organic waste can be efficiently converted into energy, fertilizers, and other valuable resources when supported by coherent policies, appropriate technologies, and strong public–private partnerships. Countries such as the Netherlands and Germany have shown that source segregation at origin, enforcing mandatory separation of organic waste at both household and commercial levels, significantly improves feedstock quality for composting and anaerobic digestion.[90] This practice not only reduces contamination but also enhances recycling rates and lowers downstream processing costs. In Denmark and Sweden, decentralized and centralized anaerobic digestion (AD) plants successfully convert municipal and agricultural organic waste into biogas, which is then used for electricity generation, district heating, or as a vehicle fuel. The digestate, a nutrient-rich byproduct, is applied as biofertilizer, effectively closing nutrient loops and reducing dependency on chemical fertilizers.[91]

Japan's Food Waste Recycling Law offers another model of circularity, mandating that the food industry recycle unsold and surplus food into animal feed, fertilizers, or energy products. This regulation has created stable recycling markets and promoted industrial symbiosis across the food value chain.[92] Singapore and Austria have demonstrated the benefits of waste-to-energy (WtE) technologies with strict environmental standards, converting non-recyclable organic fractions into electricity while minimizing methane emissions from landfills. Importantly, these high-efficiency WtE systems complement rather than replace composting and recycling infrastructure, ensuring a balanced approach to waste valorisation.[93]

Social inclusion is also a critical pillar of successful waste management systems. In Brazil and India, the integration of informal waste pickers into municipal waste value chains through cooperatives and micro-enterprises has enhanced collection efficiency, improved source segregation, and created dignified livelihood opportunities. These models underscore the importance of coupling

[90] Salmenperä et al., 2021
[91] Ayorinde et al., 2024
[92] Zhang, 2004
[93] Hashim et al., 2022

environmental innovation with social equity, an approach that Pakistan can adopt to foster a just and sustainable transition toward a circular economy in the organic waste sector.[94]

Stakeholder Insights

Stakeholder consultations across municipalities, the food industry, civil society, private-sector waste managers, and informal workers reveal critical insights into the challenges and opportunities for improving Pakistan's organic waste management system.

- Absence of systematic source segregation leads to highly contaminated waste, undermining composting and anaerobic digestion initiatives.
- Organic waste constitutes 60–65% of municipal solid waste, increasing landfill strain, collection costs, and methane emissions.
- Limited budgets and lack of engineered landfill alternatives constrain sustainable waste diversion options.
- High levels of avoidable food waste occur across wholesale markets, supermarkets, restaurants, and hospitality sectors.
- Key drivers include inadequate cold-chain infrastructure, inefficient storage/handling, and lack of formal redistribution channels.
- Large volumes of edible food are discarded due to absence of policies for donation, recycling, or valorisation into feed, fertilizers, or energy.
- Industry expresses willingness to engage in recovery initiatives but emphasizes the need for regulatory incentives, financing mechanisms, and public–private partnerships.
- Public awareness on food waste remains low, with household and cultural practices contributing to unnecessary disposal.
- Behaviour-change campaigns and educational programs are recommended to link household segregation with broader sustainability and climate goals.
- Investment risks exist in composting and biogas plants due to lack of feed-in tariffs, compost/digestate quality standards, and guaranteed offtake agreements.
- Financial viability is challenging without blended finance, public–private partnerships, and long-term contracts.
- Operate at the frontline of organic waste collection and sorting without recognition, safety measures, or integration into municipal planning.
- International examples (e.g., Brazil, India) show formalizing workers into cooperatives or micro-enterprises improves segregation efficiency and secures livelihoods.

[94] Emerald, 2020

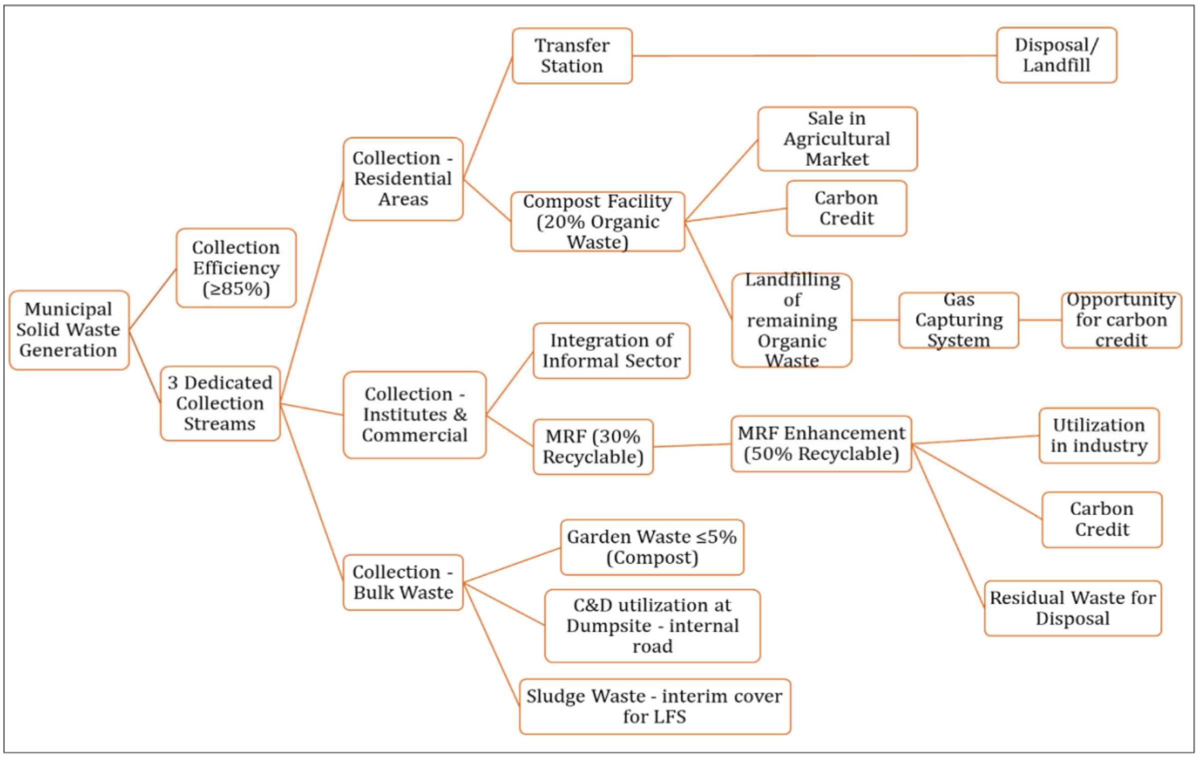

Figure 2: Proposed SWM model

Textiles

Existing Challenges & Gaps:

Pakistan's textile industry is the backbone of its economy, contributing about 8.5% to GDP and ~59–63% of annual exports.[95] [96] Yet this success comes with significant inefficiencies and environmental costs. The sector is highly resource-intensive, with enormous amounts of water and chemical use in cultivation and processing. For example, producing 1 kg of cotton (roughly one pair of jeans) can consume over 20,000 liters of water[97], and globally textiles account for over 20% of industrial water pollution.[98] In Pakistan, textile dyeing and finishing units are major polluters of waterways, as effluent treatment is often lacking or enforcement weak.

The overall water footprint of textile processing is not only driven by cotton cultivation but also by the chemical inputs used during bleaching, dyeing, and finishing. Table 2 highlights the blue water footprint of key non-cotton raw materials involved in Pakistan's cotton textile processing, underscoring the cumulative intensity of water use across the value chain.

[95] Value Extraction from End-of-Life Textile Products in Pakistan https://www.mdpi.com/2313-4321/10/3/101

[96] Pakistan's Circular Culture Is Our Strength: Minister Malik Leads Call For Textile Sustainability At SDPI Policy Dialog-9222-News https://sdpi.org/9222/news_detail

[98] Greening the Textile Industry: An Analysis of the Policy Landscape of Pakistan (Project Paper No. 2) https://unctad.org/system/files/information-document/unda2030d02-pakistan-textile-industry_en.pdf

Table 2: Water footprints of key non-cotton raw materials into cotton textile processing[99]

Raw material	Blue water footprint of raw material (m^3/t)	Quantity of raw material used per tonne of finished fabr ic (tonne)	Raw material BWF per tonne of finished textile (m^3/t)	Data source
Caustic soda	3.2	0.063	0.20	Hong and his colleagues 2014
Sodium silicate	0.069	0.021	0.001	Zah and Hischier, 2007
Soda ash	3.76	0.0025	0.009	Unger and his colleagues 2013
Dyes	4 – 9.5			Wu and Chiu, 2011

Energy use is also high, many mills rely on fossil-fuel power and outdated machinery, contributing to carbon emissions and local air pollution. Fast fashion trends drive large volumes of textile waste, but recycling rates remain low (globally less than 25% of post-consumer textile waste is recycled). Most unused fabric scraps and end-of-life garments historically ended up downcycled or in dumps, indicating lost economic value.

Economic inefficiencies are evident in the form of high production costs due to water and energy waste, and the risk of lost market access if sustainability standards are not met. The EU's new circular textiles strategy and Carbon Border Adjustment Mechanism (CBAM) threaten to penalize "brown" production; Pakistan's 2024 textile exports to the EU (59% of total exports) could face barriers without greener practices. Thus, the current linear model incurs hidden costs: environmental degradation (water contamination, soil damage from chemical runoff, GHG emissions) and foregone opportunities to reclaim waste into value.

Why CE is Needed

Transitioning to circular economy (CE) practices in textiles offers compelling benefits. Resource efficiency is a key motive, recycling fibers and reusing textiles can drastically cut water and energy demand. Life-cycle assessments show products made from recycled post-consumer textile fibers have ~60% lower greenhouse gas emissions than those from virgin cotton. By closing the loop, Pakistan can reduce its reliance on costly inputs (like imported dyes and new cotton) and mitigate environmental harm.

For instance, reusing post-consumer textile waste (PCTW) could return up to 87% of discarded textiles back into the value chain, decreasing landfill load and conserving raw materials. Circular production methods, such as waterless dyeing, closed-loop water recycling, and renewable energy use in factories, can address the sector's heavy footprint. Innovations are already proving the case: in 2023 a major mill introduced supercritical CO_2 dyeing to eliminate water usage and cut energy use by 60%, and another installed a closed-loop system recycling 95% of wastewater, tackling a sector responsible for ~40% of industrial water contamination.[100]

To better understand where major environmental impacts occur, Figure 3 illustrates the key foreground and background processes within a textile product's life cycle. It highlights how raw

[99] Source: WWF-Pakistan (2018), Water Footprint of Cotton Textile Processing Industries – Pakistan, compiled from Hong et al. (2014), Zah & Hischier (2007), Unger et al. (2013), and Wu & Chiu (2011).
[100] Pakistan's Textile Revolution: Leading the Charge in Sustainable Fashion - Fibre2Fashion https://www.fibre2fashion.com/industry-article/10318/pakistan-s-textile-revolution-leading-the-charge-in-sustainable-fashion

material extraction, fiber spinning, weaving, and dyeing (foreground) depend heavily on water, chemicals, and energy production (background), leading to emissions to air and water. Identifying these stages enables targeted circular interventions, such as renewable energy use, closed-loop water systems, and chemical substitution, to reduce overall environmental burdens.

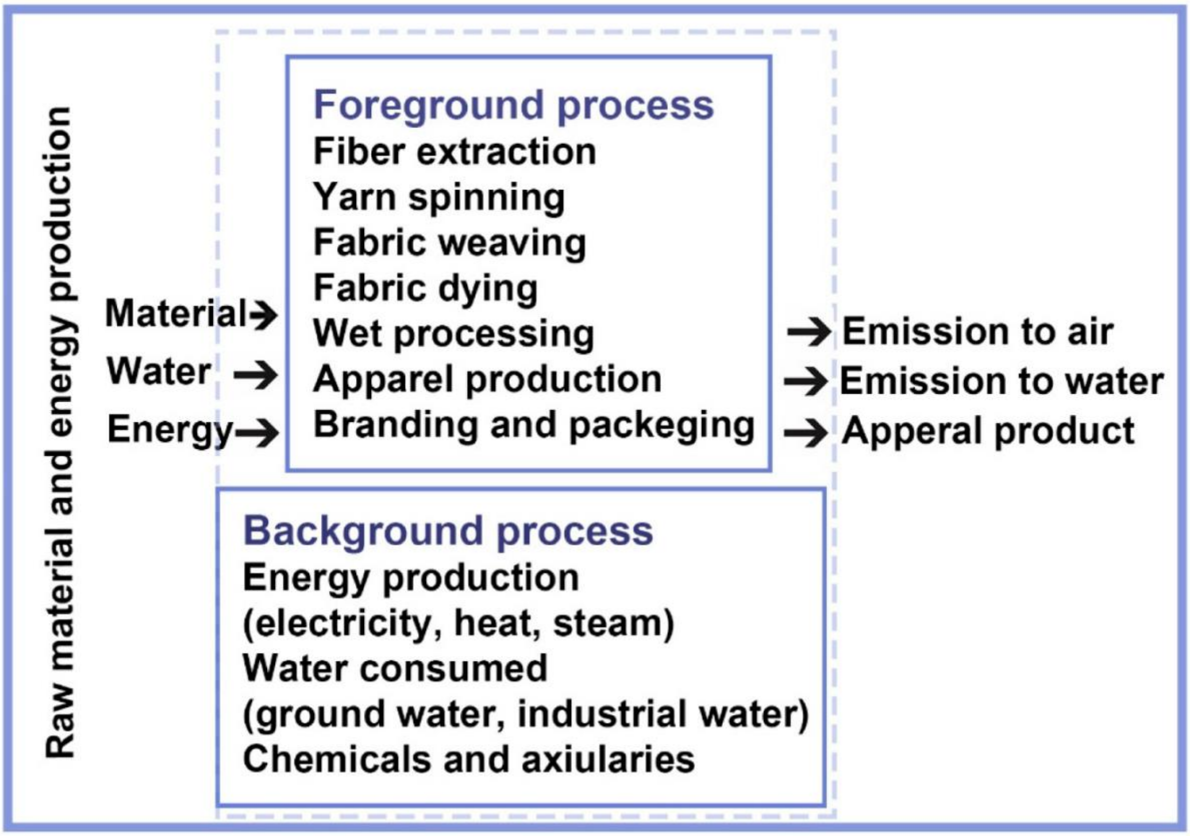

Figure 3: Key elements within foreground and background processes.

These improvements align directly with Pakistan's climate targets under its NDC, since textiles (with its energy use) are a significant source of emissions. Circular practices also enhance competitiveness: global buyers are increasingly demanding sustainable sourcing. By embracing CE, Pakistan's textile sector can safeguard market share, unlock new revenue streams (e.g. recycled yarn exports), and generate green jobs in recycling, repair, and remanufacturing.

Notably, Pakistan's cultural norm of reusing clothing is an asset, extending garment lifecycles and reducing demand for new resources. Leveraging this existing circularity with modern technology and investment will yield environmental gains (lower pollution, less solid waste, reduced CO_2) and economic gains (cost savings, new "green" product lines and investment from conscious brands).

Policy and Regulatory Gaps

Despite some supportive policies, significant gaps impede circular transition in textiles. Pakistan's Textile Policy 2020–2025 has traditionally focused on production and exports, with limited emphasis on sustainability or circularity (it makes no mention of emerging challenges like CBAM). There is *no dedicated national policy on textile circular economy or extended producer responsibility (EPR)* for apparel.

Regulations on industrial effluents and hazardous chemicals exist (e.g. National Environmental Quality Standards), but enforcement at the provincial level remains weak – many small dyeing units lack functional treatment plants, and compliance audits are sporadic. Similarly, while Pakistan has adopted international chemical safety frameworks (like the Stockholm Convention) on paper, implementation in thousands of SME processing units is inadequate.

Provincial and local barriers also persist i.e., water conservation and waste management laws are not aligned with industrial clusters, e.g. Punjab and Sindh have environmental protection acts, but few incentives for factories to invest in water recycling or waste segregation. The thriving *used clothing trade* operates in a policy vacuum; stakeholders note the absence of a national policy recognizing secondhand textiles as a circular industry.

Instead, occasional proposals to ban used garment imports (to protect local textile mills) create uncertainty for circular practices. Another gap is financing and incentives: although the State Bank of Pakistan launched a $500 million Green Financing facility and the new Textile Policy offers tax breaks for eco-friendly upgrades[14], many medium and small enterprises find it hard to access capital for costly technologies (a single modern recycling or waterless dyeing machine can cost $2–3 million).

There is also a fragmentation of governance, multiple agencies (textile ministry, climate ministry, provincial EPAs) have overlapping mandates with little coordination on circular economy goals. Lastly, data and standards are lacking: no unified waste accounting for textile waste streams exists, and standards for recycled fiber quality or “green textile” certification are nascent. These policy gaps and institutional barriers at both national and provincial levels slow down the adoption of CE despite clear interest from the market.

Best Practices

Pakistan’s textile sector presents significant opportunities for advancing circular economy practices, with several ongoing initiatives already demonstrating success. As one of the world’s largest importers of second-hand clothing, receiving over 1.1 million tonnes annually[101], the country has built a robust reuse economy, where an estimated 99% of imported garments are either reused domestically or re-exported, and only around 1% end up in landfills.[102] Informal markets, particularly *Landa Bazaars*, exemplify how large-scale material reutilization can function efficiently, providing both economic value and social livelihood benefits.

At the industrial level, formal textile manufacturers are increasingly embracing circular production models. Examples include Gul Ahmed’s closed-loop wastewater treatment system in Karachi, which achieves 95% water reuse[103], and Nishat Mills’ waterless CO_2 dyeing process, which significantly reduces both water and energy consumption. Leading companies such as Soorty and Interloop have also pioneered the recycling of textile off cuts into new yarn, often through collaborations with international brands committed to sustainability.

Innovation in chemical recycling is advancing as well, with projects such as the *Green Machine*, a partnership between H&M and Rajby Industries, demonstrating cutting-edge recycling of poly-cotton blends. This technology converts garment waste into new fibre, achieving high-value material recovery and setting a precedent for scalable circular manufacturing in Pakistan.

Supportive policy and financial frameworks are reinforcing these industry shifts. Incentives under the State Bank of Pakistan’s concessional green finance schemes and the Textile Policy 2023–28 are

---

101 Pakistan's Second-Hand Clothing Imports Hit Record High https://propakistani.pk/2025/08/15/pakistans-second-hand-clothing-imports-hit-record-high/

102 Pakistan’s Circular Culture Is Our Strength: Minister Malik Leads Call For Textile Sustainability At SDPI Policy Dialog-9222-News https://sdpi.org/9222/news_detail

103 Pakistan’s Textile Revolution: Leading the Charge in Sustainable Fashion - Fibre2Fashion https://www.fibre2fashion.com/industry-article/10318/pakistan-s-textile-revolution-leading-the-charge-in-sustainable-fashion

accelerating investments in resource-efficient technologies and sustainable production models across the sector. On the global front, Pakistan can draw valuable lessons from Bangladesh's centralized effluent treatment plants and fibre-to-fibre recycling factories, the European Union's Strategy for Sustainable and Circular Textiles (2022), and Nordic countries' advanced textile recycling systems, which achieve nearly 50% recycling rates with minimal landfill use.[104]

Additionally, global brand initiatives, such as the take-back, repair, and extended product-life programs of Patagonia and Levi's, illustrate how market-driven circular solutions can reshape consumer behaviour and business models. By integrating similar approaches, Pakistan's textile sector can strengthen its competitive advantage while advancing environmental sustainability and social responsibility within the global value chain.

Stakeholder Insights

A range of stakeholders have voiced both optimism and concerns regarding a circular transition in textiles.

- Industry leaders acknowledge the need for sustainability but cite challenges: many Pakistani textile SMEs operate on thin margins and worry about the *cost of green technologies* and compliance. As one industry assessment noted, high upfront costs and lack of technical know-how are key barriers, even as large firms innovate.[105] Nevertheless, progressive exporters see opportunity – they note that buyers are willing to pay premiums for *"green" apparel*, and initiatives like the EU's Green Deal and CBAM are viewed as catalysts for upgrading.
- Government officials emphasize Pakistan's cultural strength in reuse: *"Only 1% of our secondhand clothing ends up in landfills…Pakistan is already aligned with circularity in spirit; we must match it with technology, policy, and investment,"* stated the Climate Change Minister, highlighting government intent to build on traditional reuse habits with modern infrastructure.[106] Policymakers also stress the importance of meeting international standards to keep exports competitive, especially with EU market shifts.[107]
- Informal sector and civil society stakeholders (including SDPI and NGOs) underscore the significant social dimension, the secondhand clothing trade employs a "massive female workforce" in sorting and refurbishing[108], and any policy changes must protect these livelihoods. They call for formal recognition and support of the used-textile markets instead of punitive measures.
- Environmental groups and local communities, particularly in manufacturing hubs like Faisalabad, voice concerns about untreated wastewater and urge stricter enforcement of pollution controls, they support circular solutions that would reduce community health risks.
- International development partners (UNEP, UNIDO) working on textile initiatives in Pakistan note positive momentum but advocate for better coordination: as presented in a 2025 policy dialogue, stakeholders identified priorities such as improving traceability in the used-clothing value chain, investing in "green skills" training for workers, and introducing a national action plan on textile circularity.

[104] Turning Waste To Energy: Sweden's Recycling Revolution https://www.blueoceanstrategy.com/blog/turning-waste-energy-sweden-recycling-revolution/

[105] [PDF] ECA Energy Efficiency (EE) and Conservation Strategy – neeca https://neeca.gov.pk/SiteImage/Misc/files/NEECA%20Strategic%20Plan%202020-23%20Final%2028%20October%202020(1).pdf

[106] Pakistan's Circular Culture Is Our Strength: Minister Malik Leads Call For Textile Sustainability At SDPI Policy Dialog-9222-News https://sdpi.org/9222/news_detail

[108] Pakistan's Circular Culture Is Our Strength: Minister Malik Leads Call For Textile Sustainability At SDPI Policy Dialog-9222-News https://sdpi.org/9222/news_detail

Construction & Demolition Waste

Existing Challenges & Gaps

Construction and demolition (C&D) waste constitutes an estimated 25–30% of Pakistan's total municipal solid waste, a figure that continues to rise amid rapid and largely unplanned urban expansion.[109] The sector's challenges stem from systemic gaps in policy, technology, and practice, particularly the absence of formal deconstruction protocols and circular construction principles. Mixed debris, comprising concrete, bricks, metals, and timber, is rarely segregated at the source, and Pakistan lacks reverse logistics systems to recover and reintegrate reusable materials into supply chains. As a result, large volumes of debris are informally dumped in peri-urban and low-income settlements, where they contribute to drainage blockages, urban flooding, and serious sanitation problems.

Policy and regulatory frameworks remain underdeveloped. Pakistan does not yet have a National C&D Waste Management Strategy, and while documents such as the Green Building Code (2023) and the Energy Conservation Building Code (ECBC 2023) provide a foundation, they remain voluntary, weakly enforced, and fail to incorporate essential circular economy principles such as design-for-disassembly, lifecycle costing, and recycled-content mandates.[110] Governance is equally fragmented, with overlapping mandates among ministries and provincial departments impeding coherent policy implementation and coordination.

The construction sector also faces technical and human resource limitations. Most workers and engineers are trained in traditional building methods with limited exposure to passive design, lifecycle analysis, or modular construction. Informal labour dominates the industry, making it difficult to institutionalize sustainable practices or enforce safety and environmental standards. Small and medium-sized enterprises (SMEs), which make up a significant portion of the sector, encounter additional barriers, including high upfront costs, limited access to concessional green finance, and inconsistent supply chains for recycled materials. Moreover, data and monitoring gaps persist, there are no standardized testing protocols for recycled aggregates, nor reliable material flow data to inform regulation or build market confidence. Addressing these gaps through targeted policies, training programs, and financing mechanisms is critical to transitioning Pakistan's construction industry toward a resource-efficient and circular model.

[109] https://iips.com.pk/construction-waste-and-moving-towards-a-circular-economy-reduce-recycle-and-reuse/
[110] https://sdpi.org/redesigning-resilience-through-circularity-a-circular-construction-blueprint-for-pakistans-built-environment/publication_detail

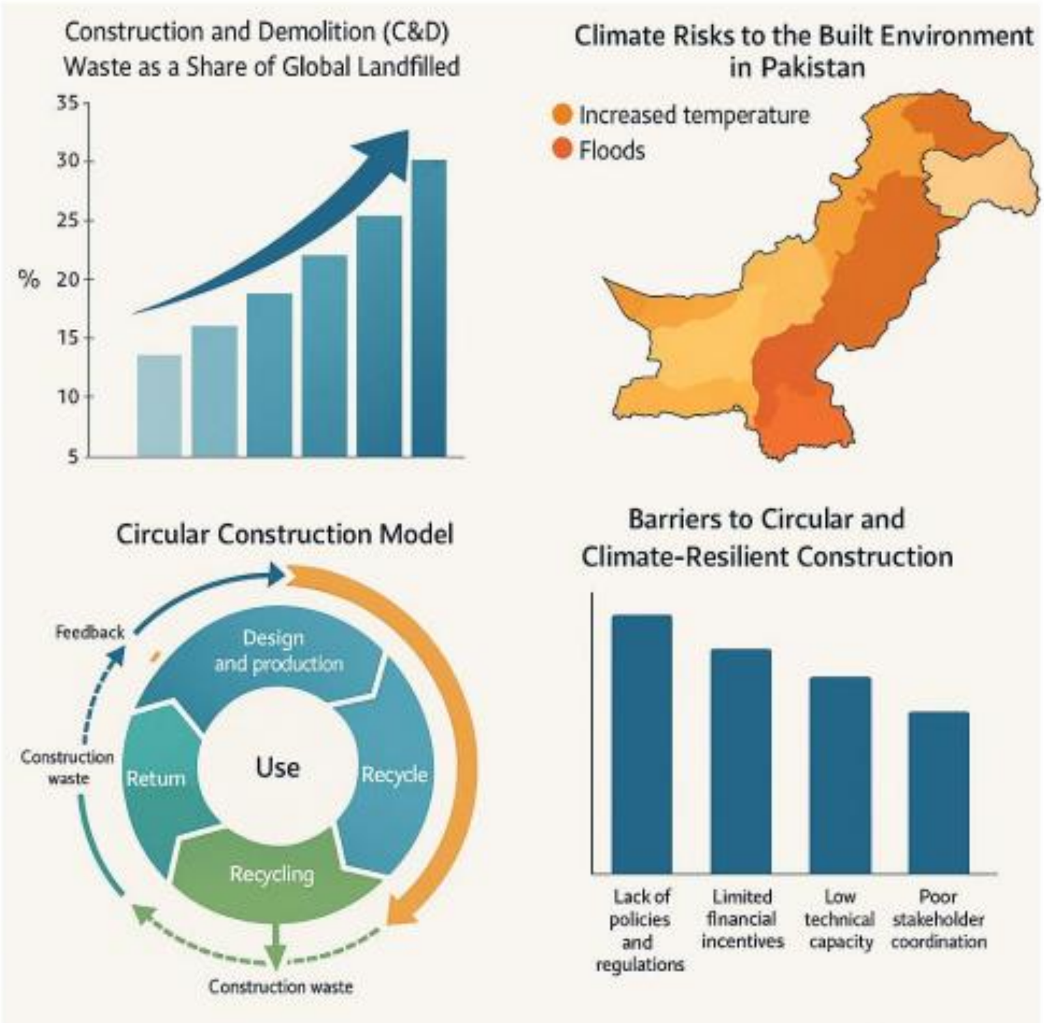

Figure 4: Circular Construction and Climate Risk mitigation- A summary.

Negative Economic Costs

The mismanagement of construction and demolition (C&D) waste imposes considerable economic, environmental, and social costs on Pakistan. The disposal of such waste carries direct landfill fees and opportunity costs estimated at around USD 10 per tonne, translating into approximately USD 30 million in annual expenditures.[111] In addition, the country's heavy reliance on virgin construction materials, such as quarried aggregates and newly produced bricks, has increased construction costs by nearly 15%, while markets for reclaimed and recycled materials remain largely underdeveloped.[112] Uncollected rubble often clogs urban drainage networks, worsening flood risks and placing additional strain on municipal infrastructure and maintenance budgets.

Beyond these immediate losses, Pakistan is also forfeiting substantial economic potential by not embracing circular construction practices. According to the SDPI Cost-Benefit Analysis (CBA), transitioning to circular approaches in the construction sector could generate a net benefit of USD 615 million annually, with a Benefit-Cost Ratio (BCR) of 4.08, indicating that every dollar invested would

111 https://www.researchgate.net/publication/362751191_An_Analysis_of_the_Impact_of_the_Circular_Economy_Application_on_Construction_and_Demolition_Waste_in_the_United_States_of_America

112 https://www.diva-portal.org/smash/get/diva2:1766727/FULLTEXT02

yield over four dollars in economic and environmental returns.[113] Furthermore, the pollution and environmental degradation caused by unmanaged C&D waste contribute to rising public health expenditures. By contrast, implementing circular construction techniques and proper waste management could save an estimated USD 75 million annually in health-related costs, underscoring the urgent need for policy action and investment in sustainable infrastructure systems.[114]

In parallel with addressing economic losses, embedding circularity provisions into Pakistan's building codes and standards is critical to institutionalize material reuse, recycling, and sustainable design compliance. Recent reforms, including the July 2025 Federal Cabinet approval of green building by-laws under PEC, extend mandatory compliance to multi-storey projects and introduce explicit circular measures.[115] [116] These provisions require life-cycle analyses at the design stage, modular and standardized components to enable disassembly, and material inventories to facilitate selective demolition. During construction, mandatory Waste Management Plans (WMPs) enforce on-site segregation, stockpiling, and routing to Material Recovery Facilities (MRFs). Post-construction protocols mandate pre-demolition audits and selective demolition methods to ensure at least 70% diversion of materials from landfill.[117] Recycled-content thresholds for aggregates, steel, and gypsum are also being introduced[118], alongside BIM-based monitoring, quarterly diversion reporting to PEC, and training requirements for professional licensure. Together, these measures position building codes as the enforcement backbone of circular construction, ensuring waste minimization at every stage of the project lifecycle.

Cost-Benefit Analysis (CBA) for Circular Construction in Pakistan

The integration of circular construction practices in Pakistan presents a compelling case not only from an environmental and resilience perspective but also from a socio-economic and fiscal standpoint. A Cost-Benefit Analysis (CBA) was conducted to evaluate the economic viability of transitioning from a linear construction model to a circular one. This section outlines the methodology, assumptions, formulae, and resulting insights from this analysis. The CBA was performed by identifying and monetizing both the quantifiable benefits and associated costs of adopting circular construction practices at scale. Benefits were derived from a combination of environmental, economic, and social gains, while costs reflected the investments necessary for policy reform, workforce development, and infrastructure for circularity. Primary data was drawn from SDPI's stakeholder webinar (March 2025), while secondary estimates were based on global literature and successful case studies from Singapore, Germany, and UNOPS's GHAR Project. Assumptions were also guided by data from the World Bank, WHO, and Pakistan Bureau of Statistics. Key benefits identified include:

- Reduction in landfill-bound Construction and Demolition (C&D) waste.
- Energy savings through passive and modular designs.
- Creation of green jobs in recycling and material recovery.
- Reduced import costs for construction materials.
- Lower public health costs due to pollution mitigation.
- Monetized carbon emission reductions based on global carbon pricing.

---

[113] https://sdpi.org/redesigning-resilience-through-circularity-a-circular-construction-blueprint-for-pakistans-built-environment/publication_detail
[114] Ibid.
[115] https://unhabitat.org.pk/wp-content/uploads/2021/07/Policy-Guidelines-Green-Building-Code.pdf
[116] https://profit.pakistantoday.com.pk/2025/07/31/federal-cabinet-approves-green-building-code-and-rainwater-harvesting-provisions/
[117] https://www.switch-asia.eu/site/assets/files/3619/model_green_building_code_pakistan.pdf
[118] https://unhabitat.org.pk/wp-content/uploads/2021/07/Policy-Guidelines-Green-Building-Code.pdf

Costs primarily included initial investments in skills training, infrastructure development (like reverse logistics), and regulatory enforcement for circular building codes. Formulae Used

Net Benefit = ∑ Annual Benefit - ∑ Annual Costs

Benefit-Cost Ratio (BCR): $\boldsymbol{Total\ Annual\ Benefits\ /\ Total\ Annual\ Costs}$ = $\mathbf{815\ /\ 200}$ = 4.08

A BCR greater than 1.0 indicates a favourable return on investment. Here, a BCR of 4.08 demonstrates that every USD 1 invested would return USD 4.08 in value to the economy and environment, underlining the economic feasibility of circular construction reforms.

Table 3: Cost-Benefit Analysis of Circular Construction in Pakistan.

Category	Estimated Annual Benefit (Million USD)	Estimated Annual Cost (Million USD)	Net Benefit (Million USD)
Reduction in C&D Waste (30%)	250	0	250
Energy Savings from Passive Design & Modular Construction	180	0	180
Job Creation in Recycling and Material Recovery	100	0	100
Savings from Reduced Material Import	120	0	120
Reduced Health Costs due to Pollution Reduction	75	0	75
GHG Emissions Reduction (Carbon Credit Potential)	90	0	90
Initial Investment in Training & Infrastructure	0	150	-150
Cost of Policy Reform & Regulation Enforcement	0	50	-50
Total	**815**	**200**	**615**

The net annual benefit of USD 615 million, alongside a BCR of 4.08, suggests strong economic justification for investing in circular construction systems. These findings indicate that adopting circularity not only advances climate and sustainability goals but also generates significant economic gains, reduces public sector burdens (health, waste management), and fosters inclusive green job creation.

Why Circular Economy is Needed

A circular economy approach provides a pathway to simultaneously reduce environmental pressures and realize economic gains. By closing material loops, reclaimed bricks and crushed concrete can substitute for virgin aggregates, reducing aggregate imports by up to 20% and cutting CO_2 emissions from material production by approximately 30%. Recycling C&D waste into construction products can also save around USD 2.5 per tonne of waste processed, as demonstrated by pilot plants in Lahore[119], while generating direct employment opportunities, estimated at 5,000 jobs in sorting, processing, and product manufacturing.

CE strategies also deliver significant environmental benefits. By diverting 25–30% of C&D waste from landfills and open dumps, circular practices help reduce methane emissions and urban pollution, improving air and soil quality in peri-urban and urban areas. Integrating CE principles into building design through modular construction and deconstruction planning further facilitates end-of-life material recovery, fostering sustainable construction practices and reducing reliance on virgin raw materials.

From a climate and policy perspective, CE approaches align closely with Pakistan's Nationally Determined Contributions (NDCs), the National Adaptation Plan, and the Sustainable Development Goals (SDGs). By reducing resource consumption, greenhouse gas emissions, and vulnerability to climate-related disasters, these practices contribute to broader climate adaptation and mitigation goals. Additionally, CE enhances urban resilience by supporting passive cooling, water efficiency, and improved flood resistance, critical interventions in the face of Pakistan's increasing heatwaves, floods, and water scarcity challenges.

In sum, adopting a circular economy for C&D waste not only improves cost efficiency and environmental outcomes but also strengthens social and economic resilience, creating a more sustainable and climate-aligned construction sector in Pakistan. Integrating circularity into building design and codes reinforces these benefits. Recent provisions mandate life-cycle analyses in project submissions, modular dimensions for prefabrication and future disassembly, and material inventories for selective demolition. By embedding waste minimization into design, construction, and demolition phases, Pakistan's building codes can institutionalize material reuse and recycling while aligning compliance with climate targets.[120]

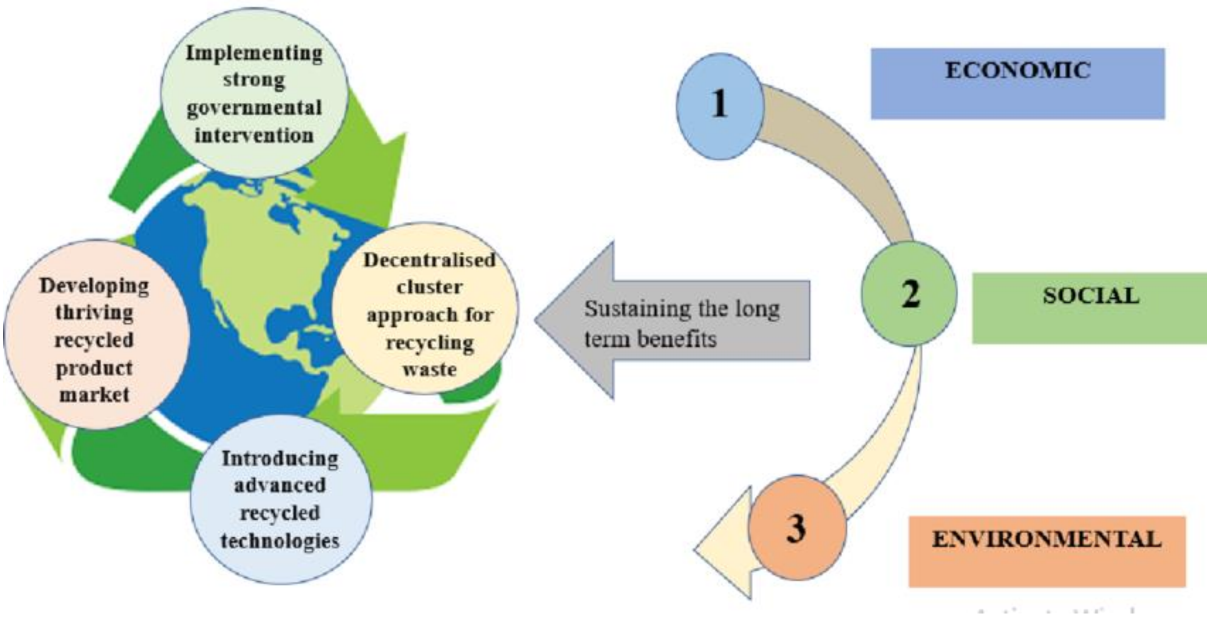

Figure 5: Integration of circular economy concept in C&D waste management

[119] https://ideas.repec.org/a/gam/jsusta/v17y2025i11p4882-d1664780.html
[120] https://www.switch-asia.eu/site/assets/files/3619/model_green_building_code_pakistan.pdf

Best Practices

Several global and local best practices highlight the potential for effective construction and demolition (C&D) waste management. Manual salvage of bricks from deconstruction sites allows to produce high-quality construction materials that comply with green-building standards and support Triple Bottom Line objectives.[121] Centralized public-private C&D recycling plants, which integrate crushing, screening, and grading operations, provide a consistent supply of recycled aggregates and enable scalable, reliable market integration.[122] Policy innovations, such as Singapore's BCA Green Mark and Germany's KfW loans, demonstrate how green finance mechanisms and mandatory recycled-content thresholds can drive the adoption of sustainable construction practices. Additionally, vernacular low-tech approaches, such as mud bricks, passive cooling designs, and indigenous construction techniques practiced in regions like Sindh and Gilgit-Baltistan, showcase culturally adapted, low-carbon solutions that can complement modern recycling and reclamation strategies.

Stakeholder Insights

Stakeholder consultations provide valuable operational and policy perspectives:

- Construction materials and methods are largely outdated and inefficient, with minimal adoption of reuse or recycling practices.
- Pakistan lacks a dedicated framework or national policy for circularity in construction; existing building codes remain poorly enforced.
- Investors and builders remain reluctant to adopt sustainable alternatives, preferring conventional materials and approaches.
- Financial mechanisms such as tax breaks, subsidies, green bonds, and low-interest loans are seen as essential to incentivize circular construction.
- Regulatory enforcement needs to be strengthened by embedding material certification and sustainability criteria in building codes.
- Global models like developer subsidies and low-interest green loans offer replicable pathways for Pakistan's transition.
- The financial sector plays a pivotal role, as banks and housing finance institutions can link lending to sustainability requirements.
- Promotion of recycled aggregates, low-carbon concrete, modular design, and alternative cements can reduce both waste and emissions.
- Energy-efficient designs, water recycling, and rainwater harvesting are critical to reduce resource pressure.
- Training and capacity building for masons, architects, and engineers in sustainable practices is vital for scaling impact.
- Informal sector contributions in repurposing waste are valuable but remain fragmented and unstructured, requiring integration into formal systems.
- The profit-driven growth model of the construction industry may conflict with circular economy principles, requiring careful trade-offs.
- Construction contributes heavily to solid waste, water consumption, and carbon emissions, making the sector a priority for reforms.
- Integrating climate commitments (NDCs and SDGs) with construction practices is essential for long-term sustainability.

[121] https://www.diva-portal.org/smash/get/diva2:1766727/FULLTEXT02
[122] https://ideas.repec.org/a/gam/jsusta/v17y2025i11p4882-d1664780.html

Operational recommendations emerging from stakeholders include:

- Integrate CE principles into urban planning and municipal policies to reduce environmental impact and enhance economic efficiency.
- Enact a National Circular Construction Policy with sectoral waste reduction targets (25–30%).
- Establish a National C&D Waste Management Strategy, mandating waste audits and lifecycle assessments for major projects.
- Revise Green Building Code 2023 and ECBC 2023 to include enforceable recycled-content quotas, passive cooling benchmarks, and certification systems. Building Code reforms should also mandate:
- Waste Management Plans (WMPs) for all projects, with third-party verification and on-site segregation protocols.
- Material Recovery Facilities (MRFs) within 100 km of major urban centres, backed by provincial authorities.
- Compliance systems requiring quarterly diversion reporting to PEC and corrective actions for underperforming projects.
- Scale public-private recycling hubs and incentivize green procurement.
- Expand green finance instruments (green bonds, concessional loans, VAT exemptions) for SMEs and developers.
- Integrate circular economy curricula in TVET and engineering education; revive vernacular skills in rural housing.
- Support SMEs with financial incentives, technical training, and access to low-interest loans to scale recycling operations.
- Standardize testing and certification of recycled aggregates to build confidence among contractors and regulators.
- Promote modular construction and deconstruction planning to facilitate end-of-life material recovery.
- Strengthen local governments with financial resources and monitoring tools.
- Align CE with urban resilience policies, mandating rainwater harvesting, modular design, and energy-efficient systems in approvals.
- Invest in R&D and innovation hubs for recycled aggregates, fly ash cement, bamboo, and digital tools (BIM, material passports).
- Build multi-stakeholder platforms for coordination, PPPs, and knowledge exchange.

Water in Industry and Agriculture

Pakistan is facing a severe and escalating water crisis, driven by over-extraction, population growth, climate change, and inefficient water management. The country's renewable freshwater availability is estimated at only 1,000 cubic meters per capita per year, which is well below the 1,700 cubic meters threshold for water scarcity as defined by the UN.[123] [124] With a population exceeding 240 million in 2025 and growing at approximately 2% per year, per capita water availability has been declining sharply, down from 5,000 cubic meters in the 1950s.

[123] Qureshi, R.H., 2019. Water Security Issues of Agriculture in Pakistan. Pakistan Academy of Sciences.
[124] Shah, T., 2024. Groundwater and Surface Water Challenges in Indus Basin Irrigation System, Pakistan.

Water withdrawal in Pakistan is extremely high, with over 90% of available freshwater allocated to agriculture, 5–7% to industry, and 3–5% for domestic and municipal use.[125] [126] Groundwater is being extracted at unsustainable rates, exceeding natural recharge by about 20–30 billion cubic meters annually, leading to a drop in water tables by 0.5–1 meter per year in critical regions such as Punjab and Sindh.[127] [128] Climate change exacerbates the crisis, causing irregular monsoons, glacial melt, and frequent droughts, which collectively threaten both agricultural productivity and industrial water supply. Experts warn that if current trends continue, Pakistan could face absolute water scarcity by 2040, endangering food security, livelihoods, and industrial growth.[129] [130]

Existing Challenges & Gaps

Agriculture Sector

Pakistan's agriculture sector consumes over 90% of national water resources, amounting to roughly 230–240 billion cubic meters annually.[131] The country relies heavily on the Indus Basin Irrigation System, which serves approximately 16 million hectares of cropland.[132] Flood irrigation remains the dominant practice, causing 60–70% of applied water to be lost as runoff and evaporation, with water-use efficiency for major crops like wheat, rice, and sugarcane ranging between 35–40%.[133]

Groundwater extraction has reached critical levels; in Punjab, 70% of aquifers are over-exploited, and water tables in cities like Lahore and Faisalabad are declining at rates of 0.5–1 m per year.[134] For high-water-demand crops, rice consumes 3,000–5,000 litres per kg, sugarcane 1,500–2,500 litres per kg, and wheat 1,000–1,500 litres per kg, making these crops major contributors to water stress.[135]

The sector also suffers from low adoption of efficient irrigation technologies. Drip and sprinkler irrigation, which can reduce water use by 30–50%, are used on less than 5% of total cultivated land.[136] Barriers include high installation costs ($500–$1,200 per hectare), limited access to financing, and inadequate farmer training programs.

Climate variability further aggravates the situation: monsoon rainfall shows inter-annual variability of 20–25%, while glacial melt contributes around 10–15% of the total irrigation supply, both of which are increasingly unpredictable due to climate change.[137]

Industrial Sector

Industries consume about 5–7% of total freshwater, equivalent to 12–15 billion cubic meters annually, but water use is highly inefficient.[138] The textile sector alone consumes about 1,500–2,000 litres of water per kg of fabric, while leather processing uses 35–50 litres per kg of raw hide (Irfan, 2009;

[125] Ahmad, S., 2023. Water Resources and Their Management in Pakistan.
[126] Siyal, A.W., 2022. Water Resources and Industry.
[127] Khan, M.A., 2024. Advanced Agricultural Water Management in Pakistan.
[128] Faraz, A., 2025. Groundwater Depletion in Pakistan Puts Millions at Risk of Water Scarcity.
[129] Ougahi, J.H., 2025. Water Resource Vulnerabilities from Climate-Induced Tipping Points in Pakistan.
[130] Sameer, M., 2025. The Impact of Climate Variability on Water Resource Management in Skardu.
[131] Qureshi, 2019; Ahmad, 2023
[132] Shah, 2024
[133] Janjua, 2021; Sameer, 2025
[134] Khan, 2024
[135] Ahmad, 2023
[136] Janjua, 2021
[137] Sameer, 2025; Ougahi, 2025
[138] Siyal, 2022; Ahmad, 2023

Ortolano, 2007).[139] [140]Sugar mills use 2–3 m^3 of water per ton of sugarcane, and beverage industries consume 1.5–2 m^3 per ton of product.

Less than 5% of industrial effluents are treated before discharge, releasing 8–10 billion cubic meters of polluted water annually into rivers and canals. The contamination includes high levels of Biochemical Oxygen Demand (BOD 200–500 mg/L), Chemical Oxygen Demand (COD 400–900 mg/L), and heavy metals like chromium, lead, and cadmium, which severely impact downstream ecosystems.

Industrial water pricing is largely subsidized, with groundwater tariffs as low as $0.02–0.03 per m^3, promoting over-extraction and unsustainable practices.[141] Combined with weak enforcement of provincial EPA regulations and lack of real-time monitoring, the sector's water efficiency remains critically low.

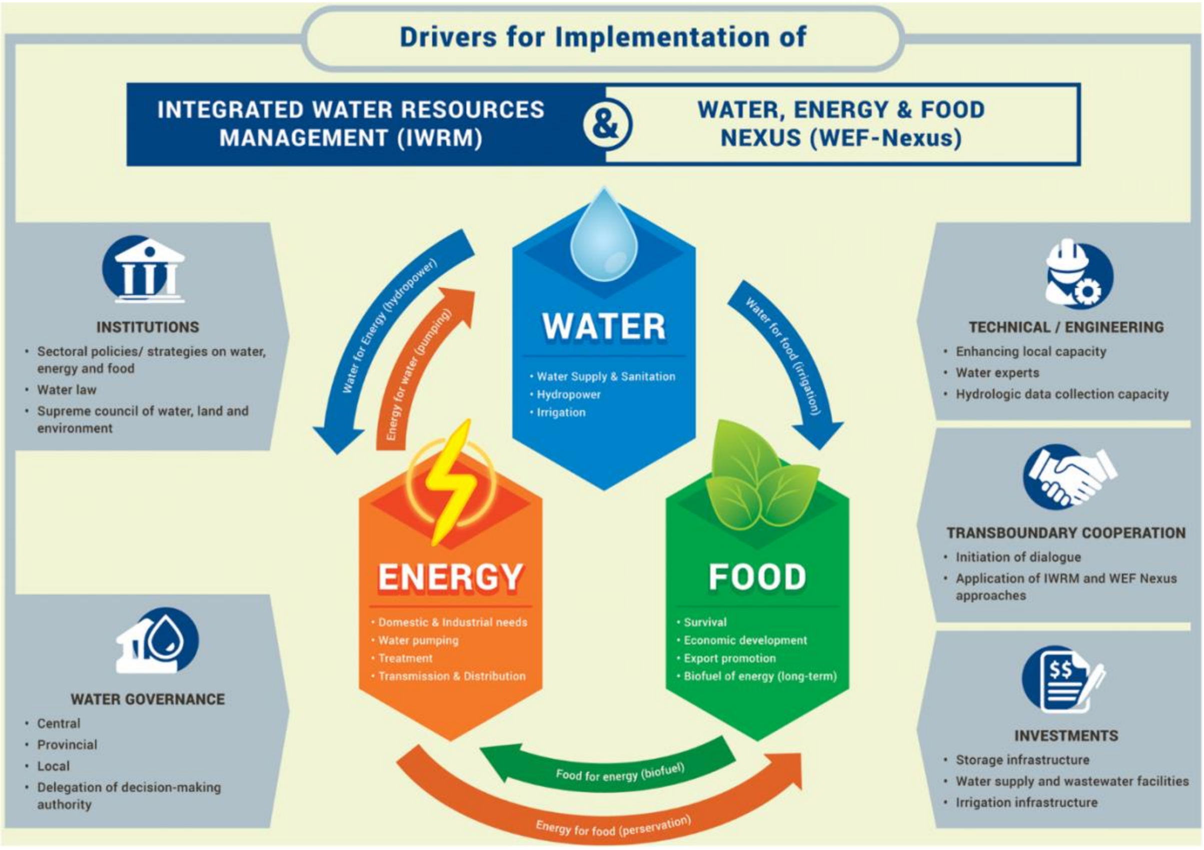

Figure 6: Drivers of implementation of IWRM & WEF-Nexus

Negative Economic Costs

Pakistan is facing a severe and escalating water crisis that imposes substantial economic costs on the country. Per capita renewable freshwater availability has dropped to approximately 655 cubic meters per year, well below the UN threshold for water scarcity, primarily due to over-extraction, inefficient irrigation, and climate-induced variability.[142] Agriculture, which consumes over 90% of national water withdrawals, is particularly vulnerable; water shortages are projected to reduce Pakistan's GDP by more than 4.6%, with overall economic losses potentially reaching 18–20% annually by 2050 under

[139] Irfan, M., 2009. Wastewater Treatment in Textile, Tanneries and Other Industries.
[140] Ortolano, L., 2007. Cleaner Production in Pakistan's Leather and Textile Sectors. World Bank.
[141] CDPR, 2025. An Empirical Analysis of Pricing Strategies for Water in Agricultural Punjab.
[142] World Bank, 2018. Pakistan: Getting More from Water.

pessimistic climate scenarios. These losses are attributed to decreased agricultural productivity, infrastructure damage from floods, and increased health costs due to waterborne diseases.[143]

Groundwater resources, especially in the Indus Basin, are being extracted at unsustainable rates, exceeding natural recharge by around 1 billion cubic meters annually, causing declining water tables, rising pumping costs, and risks of soil salinization, which further threaten agricultural productivity and the livelihoods of millions.[144]

The declining groundwater levels necessitate deeper wells and more energy-intensive pumping systems, leading to increased operational expenses and high-water treatment and extraction costs, which add a substantial economic burden for both agricultural and industrial users. Climate change exacerbates these pressures through erratic rainfall patterns, accelerated glacial melt, and increased frequency of droughts and floods, which further stress the country's water resources and increase the economic costs associated with scarcity and disaster management.[145]

The industrial sector also contributes to the economic costs of water stress, as industries such as textiles and tanneries discharge untreated wastewater into rivers and canals, degrading water quality, harming aquatic ecosystems, and increasing public health expenditures, while also reducing productivity in fisheries and other dependent sectors.[146] Collectively, these factors highlight that Pakistan's water crisis is not only an environmental challenge but also a critical economic threat, with far-reaching implications for national growth, food security, and public health.

Why CE is Needed

Pakistan's escalating water crisis necessitates a paradigm shift towards Circular Economy (CE) principles, particularly in agriculture and industry, to mitigate the adverse economic impacts of water scarcity. Globally, the water recycling and reuse market was valued at approximately USD 17.6 billion in 2024 and is projected to reach USD 30.6 billion by 2030, growing at a compound annual growth rate (CAGR) of 9.7%.[147] This trend underscores the increasing adoption of CE strategies worldwide.

In agriculture, less than 5% of Pakistan's cultivated land employs water-efficient technologies such as drip or sprinkler irrigation, leading to significant water losses exceeding 60% due to traditional flood irrigation methods.[148] [149] Implementing CE practices such as wastewater recycling and nutrient recovery can substantially reduce freshwater consumption and enhance soil fertility.[150] For instance, the integration of treated wastewater for irrigation has been shown to improve crop yields and reduce dependency on freshwater resources.[151] These measures also reduce the high extraction and pumping costs associated with declining groundwater levels in key agricultural areas (World Bank, 2019; ADB, 2021).

In the industrial sector, the discharge of untreated wastewater contributes to environmental degradation and economic losses. A case study in Quincy, Washington, demonstrated that recycling

---

143 World Bank, 2021. Pakistan@100: Environmental Sustainability.
144 World Bank, 2019. Groundwater in Pakistan's Indus Basin: Present and Future Prospects.
145 Asian Development Bank, 2021. Climate Risk Country Profile: Pakistan
146 World Bank, 2013. The Indus Basin of Pakistan: The Impacts of Climate Risks on Water and Agriculture.
147 Grand View Research, 2024. Water Recycling and Reuse Market Size, Share & Trends Analysis Report.
148 Ahmad, S., 2022. Efficient Irrigation Techniques in Pakistan's Agriculture. Journal of Water Resources Management, 36(4), pp.123–138.
149 Mustafa, A., Qureshi, R. and Shah, T., 2024. Smart Irrigation and Water Conservation in the Indus Basin. International Journal of Agricultural Water Management, 270, p.108643.
150 Anwar, F., Khan, R. and Javed, T., 2022. Industrial Wastewater Recycling in South Asia: Lessons for Pakistan. Environmental Science and Policy, 135, pp.45–58.
151 Mustafa et al., 2024

cooling water from a data centre reduced reliance on local potable groundwater and improved water quality for industrial processes.[152] Adopting similar water reuse and closed-loop practices in Pakistan's textile, tannery, and sugar industries could conserve billions of cubic meters of water annually, lower operational costs, and mitigate environmental impacts.[153]

The adoption of CE principles in water management aligns with global efforts to achieve sustainable development goals, particularly in regions facing acute water scarcity. By embracing water reuse, smart irrigation, and resource recovery, Pakistan can enhance water security, promote economic resilience, and contribute to environmental sustainability, while reducing the negative economic costs associated with high treatment and extraction of water.[154]

Best Practices

International experiences provide valuable lessons for Pakistan in sustainable water management. In Spain, reclaimed municipal wastewater is used to irrigate crops such as citrus, vineyards, and vegetables, offering both nutrient benefits and freshwater conservation.[155] In India, integrated rainwater harvesting initiatives in Rajasthan and Tamil Nadu supplement irrigation, replenish groundwater, and reduce reliance on canal water.[156] The Netherlands has implemented aquaponics and closed-loop systems, where fish farming and crop irrigation are combined in controlled environments to efficiently recycle water and nutrients.[157] In the United States, precision agriculture leverages sensors and automated irrigation systems to optimize water application based on soil moisture, achieving reductions in water use of 20–40% while boosting productivity.[158] Germany demonstrates industrial effluent bioremediation, using microbial and enzymatic treatments to allow safe reuse of water in cooling systems or irrigation.[159] Meanwhile, Japan's manufacturing sector reduces water consumption per unit of production through efficiency audits, recycling, and closed-loop water circuits, highlighting practical strategies for minimizing water footprints.[160]

Stakeholder Insights

Stakeholders across the agriculture and industrial sectors highlight the critical water challenges Pakistan faces and the opportunities offered by Circular Economy (CE) practices.

- Over 95% of industrial wastewater in textile, tannery, sugar, and beverage sectors is discharged untreated, causing river and canal pollution, soil contamination, and health impacts on downstream communities.
- High upfront investment costs, lack of subsidies, and limited technical capacity are major barriers to adopting closed-loop water systems.
- Global best practices show industrial water recycling can reduce freshwater demand by 30–80%, depending on technology applied.
- Stakeholders suggest integrating CE approaches such as on-site wastewater treatment, reuse in cooling and process operations, and centralized shared treatment facilities to reduce costs and environmental impacts, while aligning with international water efficiency standards.

---

152 EPA, 2023. Water Reuse Case Study: Quincy, Washington.
153 Anwar et al., 2022; World Bank, 2018
154 World Bank, 2021; ADB, 2021
155 FAO, 2021. Wastewater Use in Agriculture: Global Practices and Guidelines. Rome: Food and Agriculture Organization.
156 Kumar, P., Singh, R. and Sharma, S., 2022. Rainwater Harvesting and Sustainable Agriculture in India. Journal of Environmental Management, 310, p.114748.
157 van der Heijden, M., Janssen, H. and de Groot, J., 2023. Aquaponics as Circular Economy Practice in Netherlands.
158 USDA, 2021. Precision Agriculture for Water Efficiency in the United States.
159 Schneider, F., Müller, S. and Braun, R., 2021. Industrial Effluent Bioremediation Technologies in Germany.
160 OECD, 2022. Water Management in Industry: Best Practices from Japan.

- Traditional flood irrigation dominates over 90% of Pakistan's cultivated area, causing water losses exceeding 60% and accelerating groundwater depletion in Punjab, Sindh, and Balochistan.
- Adoption of drip and sprinkler systems remains below 5%, limited by low awareness, insufficient technical training, and lack of affordable financing.
- Introducing treated wastewater for irrigation can reduce freshwater withdrawal by 20–30%, improve soil fertility, and increase crop productivity by up to 25% for high-value crops.
- Smart irrigation, rainwater harvesting, and precision agriculture can mitigate economic and environmental costs from declining groundwater, reduce pumping energy expenses, and improve climate resilience.
- Fragmented governance, weak industrial effluent monitoring, and poor enforcement of water quality standards allow unsustainable practices to persist.
- Integrated water resource management frameworks are needed to coordinate agriculture, industry, and water authorities.
- Adoption of CE measures should be incentivized through subsidies, tax benefits, or technical support.
- Public–private partnerships, stakeholder capacity-building, and alignment with global CE best practices are essential for sustainable water use and long-term economic efficiency.

Energy Sector

Existing Challenges & Gaps

Pakistan's energy transition is still largely linear focused on installing assets rather than managing them across their full life cycles. Fossil fuels continue to dominate electricity generation (≈59–60% thermal in recent years), locking in high emissions and local air pollution; the energy sector (power, transport, industry) contributes roughly ~46% of national GHGs. At the same time, non-hydro renewables remain a small share (~5–7% of generation in 2023), despite policy targets. Structural inefficiencies persist, T&D losses ~17–18%, weak O&M practices, and the build-up of power-sector circular debt (≈PKR 2.3 trillion+), all of which erode financial sustainability.[161]

The structure of Pakistan's final energy consumption highlights the dominance of industrial and transport sectors, both of which are heavily dependent on fossil fuels. As shown in Figure 5, total final energy demand has risen steadily since 2006, with industrial and transport sectors together accounting for over 60% of total consumption by 2020, illustrating both the scale of dependence and the potential impact of efficiency and circular interventions.

[161] Achieving energy sustainability of Pakistan's power sector through ...
https://www.sciencedirect.com/science/article/pii/S0360544225021917

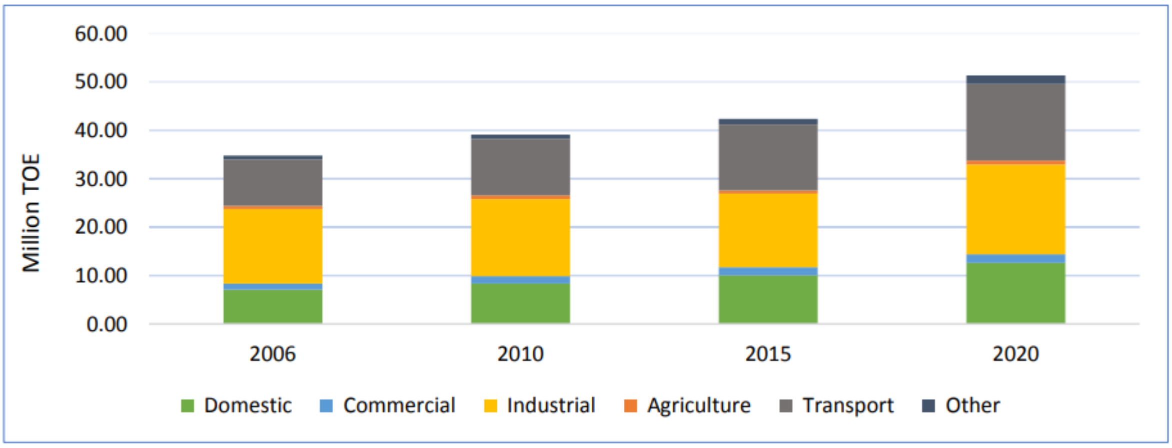

Figure 7: Pakistan's Final Energy Consumption by Sector (Source: Integrated Energy Planning (IEP) Database, Planning Commission of Pakistan, 2006–2020; extracted from Pakistan Energy Outlook 2021–2030

Critically for circularity, rapid rooftop/distributed solar adoption has outpaced lifecycle planning. Most systems are consumer-owned (CAPEX model), with uneven maintenance and no formal end-of-life pathways for PV modules or batteries. Pakistan is already seeing a surge in solar-battery uptake (net-metering and off-grid), yet no dedicated PV recycling facility exists, and formal Li-ion battery recycling capacity is absent; end-of-life lead-acid battery recycling remains largely informal, creating toxic exposures. Without policy action, a "solar e-waste" wave will emerge as the 2010s cohort of panels/batteries ages.[162]

On the waste side, ~49.6 million tonnes of MSW are generated annually; open burning and landfilling persist, with only nascent WtE initiatives. Lahore's planned 40 MW plant (≈2,000 t/day feedstock) illustrates potential, but scaling requires bankable feedstock contracts and emissions controls.[163] [164] [165] So, the circularity gap is that assets are installed but not serviced as circular systems, no performance-based O&M, minimal refurbishment/reuse, and missing reverse logistics for PV modules and batteries.

Why CE is Needed

A circular energy approach integrates lifecycle thinking and aligns incentives across the entire value chain. Energy-as-a-Service (EaaS) shifts the model from owning equipment to purchasing energy outcomes (kWh or availability). Under EaaS or RESCO models, a specialist provider owns, operates, maintains, upgrades, and ultimately retrieves solar and storage assets, embedding lifecycle stewardship—including refurbishment, redeployment, and certified recycling—into the contract. This approach enhances performance through professional operations and maintenance, extends asset life, reduces material throughput, and guarantees responsible end-of-life take-back. In Pakistan, RESCO/OPEX models are already permitted for commercial and industrial rooftop solar via private

[162] The Future of Net-Metered Solar Power in Pakistan https://ieefa.org/sites/default/files/2024-08/IEEFA%20-%20The%20Future%20of%20Net-metered%20Solar%20Power%20in%20Pakistan_August%202024.pdf?utm_
[163] Waste Management https://www.trade.gov/country-commercial-guides/pakistan-waste-management?utm_
[164] Waste To Energy https://www.lwmc.com.pk/waste-to-energy.php?utm_
[165] Lahore to get a 40MW waste-to-energy plant within 22 months https://www.thenews.com.pk/print/397511-lahore-to-get-a-40mw-waste-to-energy-plant-within-22-months?utm_

PPAs and net metering; scaling these arrangements can transform the current CAPEX-driven expansion into managed circular energy fleets.[166]

Renewable energy deployment with storage, executed circularly, is critical to meeting the Alternative and Renewable Energy Policy 2019 targets of 20% capacity by 2025 and 30% by 2030, supporting both energy security and Nationally Determined Contributions. Ensuring panel and battery lifecycle systems, through reuse, second-life applications, and recycling, is essential to prevent shifting environmental burdens downstream. Waste-to-energy initiatives and biomass utilization, such as bagasse cogeneration, serve as additional circular levers alongside efficiency measures and industrial symbiosis.[167] Quantifiable gains emerge from using municipal solid waste and agricultural residues for energy, reducing transmission and distribution losses, and cutting industrial waste, all while displacing fuel imports and emissions, with EaaS guaranteeing that assets remain properly maintained, upgraded, and responsibly decommissioned.[168]

Policy and Regulatory Gaps

While Pakistan has formulated energy policies and climate strategies, gaps remain in effectively enabling a circular energy transition. The national renewable energy policy sets targets (20% renewable electricity by 2025, 30% by 2030)[169], but implementation has lagged due to regulatory and infrastructure hurdles. For instance, dozens of ready-to-build wind and solar projects are stalled awaiting grid capacity or administrative approvals.[170]

Inadequate investment in transmission infrastructure and bureaucratic delays in power purchase agreements have slowed renewable scale-up. There is also a lack of integration between waste management and energy planning, historically, municipal solid waste fell under local government with no mandate to explore energy recovery. Only recently have provincial authorities (e.g. Punjab) begun tendering WtE projects, and while NEPRA (the power regulator) has now approved feed-in tariffs for WtE, these are on a case-by-case basis rather than a robust nationwide program. Provincial-federal coordination is a barrier: electricity is largely a federal subject, whereas waste and agriculture are provincial, meaning a biomass or waste power project requires multi-level coordination (often cumbersome). Regulatory support for biomass energy (besides bagasse) is minimal, there are no streamlined incentives for power producers to use crop residues or manure. Pakistan also lacks strong energy efficiency regulations enforcement.

The National Energy Efficiency & Conservation Act (2016) established NEECA and set efficiency standards, but compliance (e.g. energy audits for industries, building codes enforcement) remains low. Building codes (such as the Energy Conservation Building Code 2023) exist on paper but are not mandatory nationwide; industries face no binding requirements to recover waste heat or meet efficiency benchmarks.

Moreover, subsidies and pricing structures have historically favored the status quo: until recently, gas and electricity prices were kept artificially low for certain sectors, discouraging investment in efficiency

[166]Different investment models for rooftop solar projects in Pakistan factsheet https://asiagarmenthub.net/resources/2022/different-investment-models-for-rooftop-solar-projects-in-pakistan-factsheet?utm_

[167]POWER POLICY ALTERNATIVE and RENEWABLE ENERGY https://cdn.climatepolicyradar.org/navigator/PAK/2019/alternative-and-renewable-energy-policy-2019_8c2ca91631c8bd78c70458de1eb25e15.pdf?utm_

[168] Waste Management https://www.trade.gov/country-commercial-guides/pakistan-waste-management?utm_

[169] Greening the Textile Industry: An Analysis of the Policy Landscape of Pakistan (Project Paper No. 2) https://unctad.org/system/files/information-document/unda2030d02-pakistan-textile-industry_en.pdf

[170] Can waste-to-energy projects help Pakistan meet its climate goals? https://www.thenews.com.pk/magazine/money-matters/1239726-can-waste-to-energy-projects-help-pakistan-meet-its-climate-goals

(the ongoing subsidy reform aims to change this[171]). Another gap is financial and institutional support: while the government launched the "Clean Green Pakistan" initiative and some green financing lines, there is no dedicated fund or tax incentive for circular energy projects (for example, WtE plants often require high upfront capital and face uncertain returns under current tariff structures).

At the city level, waste collection systems need overhauling to supply feedstock to WtE plants, without improving segregation and steady feedstock contracts, WtE investors remain hesitant. Finally, Pakistan's continued investment in coal power (installed most of its coal capacity in the last decade[172]) reveals a policy disconnect: despite climate commitments, energy planning until recently did not fully prioritize circular or low-carbon options. Bridging these policy gaps, by enforcing renewable targets, integrating waste-to-energy into waste policies, tightening efficiency standards, and providing clear incentives, is crucial for removing implementation barriers.

Pakistan's ARE Policy 2019 sets ambitious shares but does not yet hard-wire lifecycle obligations (e.g., mandatory decommissioning and recycling plans for PV/storage). NEECA/ESCO frameworks exist but need stronger instruments (standardized performance contracts, guarantees) to mainstream EaaS/RESCO across public and private sectors. Proposed net-metering reforms should be calibrated so they do not stall service-based solar models that deliver professional O&M and end-of-life management.[173]

On waste governance, there is no explicit EPR for PV modules and high-capacity batteries; no PV recycling plants; and Li-ion recycling capacity is effectively nil. Lead-acid battery recycling remains heavily informal, with proven public-health risks. Aligning MoCC/EPAs rules with AEDB/NEPRA approvals (e.g., requiring EPR registration and take-back plans in generation licenses and public procurements) is urgent.[174] Also, municipal-provincial-federal coordination for WtE is still patchy; Lahore's 40 MW case shows the need for stable feedstock agreements and emissions compliance, not just tariffs or ad-hoc tenders.

Best Practices

Despite existing gaps, several promising practices in Pakistan demonstrate the potential of a circular energy approach. Dozens of sugar mills convert bagasse, a biomass residue, into electricity, with some exporting surplus power to the grid. Facilitated by NEPRA's bagasse tariffs, this public-private synergy has tapped over 2,000 MW during harvest seasons, reducing reliance on fossil fuels and showcasing effective industrial circularity. The telecom sector provides an example of Energy-Storage-as-a-Service (ESaaS). In 2025, Infralectric commissioned 25 MWh of AI-managed batteries at mobile towers, financed via Pakistan's first Green Sukuk (~PKR 3 billion). The provider owns and operates the batteries, cutting roughly 5 million liters of diesel and 13,500 tCO_2 annually, while ensuring full lifecycle management—demonstrating a clear EaaS model in practice.

Industrial solar combined with battery energy storage systems (BESS) is gaining traction. Lucky Cement partnered with a local cleantech firm to deploy 20.7 MW of solar capacity and 22.7 MWh of BESS, managed with performance software and service contracts.[175] This aligns incentives for uptime and longevity, acting as a stepping-stone toward full EaaS adoption. Similarly, commercial and industrial

[171] The Economics of Circular Debt -6747-News https://sdpi.org/the-economics-of-circular-debt-/news_detail
[172] Greening the Textile Industry: An Analysis of the Policy Landscape of Pakistan (Project Paper No. 2) https://unctad.org/system/files/information-document/unda2030d02-pakistan-textile-industry_en.pdf
[173] Net metering reforms and grid challenges amid Pakistan's solar rise https://ieefa.org/resources/net-metering-reforms-and-grid-challenges-amid-pakistans-solar-rise?utm_
[174] Recycle solar https://www.thenews.com.pk/print/1327450-recycle-solar?utm_
[175] Pakistan's largest battery energy storage project edges closer to operation for cement giant https://www.ess-news.com/2025/07/10/pakistans-largest-battery-energy-storage-project-edges-closer-to-operation-for-cement-giant/?utm_

rooftop solar through RESCO/OPEX contracts shifts ownership and operations to service companies, often paired with net metering and long-term PPAs, enabling professional maintenance, upgrades, and end-of-life take-back obligations.

Municipal waste-to-energy (WtE) initiatives further illustrate circular solutions. Punjab's first large-scale WtE plant in Lahore, a 40 MW facility processing 2,000 tons of waste daily, demonstrates government partnerships with international consortia to manage waste while generating electricity. Planned expansions and similar projects in Karachi, digesting 4,200 tons of cattle manure and food waste daily into 22–30 MW of biogas, highlight the scalability of urban organic waste-to-energy solutions.[176] Industrial symbiosis is also emerging in Pakistan. Cement plants, such as DG Khan Cement in Lahore, use approximately 1,000 tons of city garbage daily as refuse-derived fuel (RDF) for co-firing kilns. This reduces coal consumption, lowers emissions, and diverts waste from landfills, with similar adoption expanding across Punjab and KPK.[177]

International experiences offer additional lessons. Sweden achieves near-circular waste management by recycling 47% of household waste, incinerating 52% for energy, and sending less than 1% to landfills, driven by landfill bans, high taxes, and district heating from WtE plants.[178] Denmark's Kalundborg industrial symbiosis exchanges waste heat, refinery gas, and by-products between industries and the city, improving overall resource efficiency. Germany and China demonstrate how stable feed-in tariffs and mandatory renewable purchase policies support large-scale solar and wind deployment, providing guidance for unlocking Pakistan's 50,000 MW potential in the Gharo-Keti Bandar wind corridor.[179]

Finally, distributed generation and net metering are already widespread in Pakistan, with thousands of households and businesses feeding surplus solar electricity back to the grid. Expanding distributed generation and micro-grid programs, as seen in India and Bangladesh, can enhance energy access, resilience, and decentralized circular energy adoption.

Stakeholder Insights

Transitioning to a circular energy model has garnered strong interest among stakeholders in Pakistan, each bringing unique perspectives:

- Policymakers recognize the need to reform Pakistan's energy mix due to high costs and fuel price vulnerability. NDC (2021) commitments and Clean Green Pakistan initiatives highlight renewable energy and WtE as dual solutions, though financing and technical capacity remain challenges. Grid modernization is needed to accommodate intermittent renewables.
- Energy-intensive industries (textile, cement, fertilizer) are investing in on-site solar and wind to reduce costs and meet sustainability goals, advocating for clearer net metering policies. Conventional power incumbents express reliability concerns.
- Investors cite circular debt and regulatory uncertainty as risks, stressing consistent policy implementation to build confidence for circular energy projects.

[176] Two biogas projects under development in Middle East https://biodieselmagazine.com/articles/two-biogas-projects-under-development-in-middle-east-9217
[177] Lahore stands tall by generating green fuel from waste https://tribune.com.pk/story/1966466/lahore-stands-tall-generating-green-fuel-waste
[178] Turning Waste To Energy: Sweden's Recycling Revolution https://www.blueoceanstrategy.com/blog/turning-waste-energy-sweden-recycling-revolution/
[179] Can waste-to-energy projects help Pakistan meet its climate goals? https://www.thenews.com.pk/magazine/money-matters/1239726-can-waste-to-energy-projects-help-pakistan-meet-its-climate-goals

- City administrators see WtE as a solution to landfill overflow, but communities and environmental groups demand strict emissions controls. Public support for solar adoption and cleaner air is growing.
- Waste pickers and recyclers emphasize that WtE must complement recycling, ensuring materials are recovered before incineration.
- Development partners (World Bank, ADB, GIZ) advocate capacity-building, integrated planning, feed-in tariffs, and subsidy improvements, showing benefits via pilot projects.
- Stakeholders agree on a sustainable energy future, with government focused on policy, industry on cost, civil society on environmental safeguards, and financiers on risk. Alignment through dialogue, incentives, and enforcement is key for a circular energy transition.

4. Economic and Social Implications of Circular Economy Transition

The transition towards a circular economy (CE) in Pakistan has profound economic and social implications, offering pathways to improve resource efficiency, reduce waste, generate employment, and strengthen social equity. Unlike the linear "take-make-dispose" model, CE prioritizes extending product lifecycles, promoting reuse, recycling, and repair, and creating systems that capture value from waste streams. This transformation is not merely an environmental imperative but also an opportunity to stimulate sustainable growth, attract green investments, and improve quality of life for citizens.

Job Creation Potential

One of the most immediate and visible benefits of a circular economy (CE) is its potential to generate green and inclusive jobs across multiple sectors. In waste management, expanding recycling infrastructure and introducing formal collection networks can absorb thousands of workers currently engaged in informal waste picking. Employment opportunities arise across collection, sorting, repair, refurbishment, and advanced recycling operations. The International Labour Organization[180] projects that CE transitions could create millions of jobs globally, particularly in developing economies. In Pakistan, where an estimated 60,000–70,000 people work in informal waste collection, formalizing this workforce could transform precarious livelihoods into decent employment opportunities.

In water conservation, the adoption of smart irrigation systems, wastewater recycling, and industrial water-efficiency measures creates jobs for technicians, engineers, and service providers. Community-led water stewardship programs further empower local groups, especially women in rural areas, providing both employment and capacity-building opportunities.

The energy efficiency and renewable energy sector also benefits from CE approaches. Waste-to-energy projects, bioenergy initiatives, and renewable energy deployment generate jobs in manufacturing, installation, operations, and maintenance. Additionally, retrofitting industries and buildings for energy efficiency opens professional avenues for contractors, auditors, and technology suppliers.

Case Insight: In the European Union, CE-related policies are projected to create 700,000 new jobs by 2030.[181] If adapted proportionally, Pakistan could generate tens of thousands of green jobs, especially in recycling and water conservation.

Economic Benefits from Resource Efficiency and Reduced Waste Management Costs

Circular economy (CE) practices generate measurable economic benefits by improving efficiency, reducing costs, and enhancing competitiveness. In terms of resource efficiency, Pakistan's heavy reliance on imported raw materials, such as metals and petroleum-based products, can be mitigated by recovering resources from waste streams, including metals from e-waste, fibres from textiles, and compost from organic waste. Such measures reduce import dependence and strengthen domestic industries. A World Bank study (2021) highlights that resource efficiency initiatives in developing countries can lower material costs by up to 25%, thereby improving industrial competitiveness.[182]

[180] ILO (2018). Greening with Jobs: World Employment and Social Outlook.
[181] European Commission (2019). Directive on Waste Electrical and Electronic Equipment (WEEE).
[182] World Bank (2021). Resource Efficiency and Waste Management in Developing Economies.

CE also reduces waste management costs. Landfilling and mismanaged waste impose substantial fiscal burdens on municipalities, while CE practices such as recycling and composting decrease landfill volumes, saving public funds. For example, community-based composting of organic waste in Karachi could reduce landfill demand by nearly 30%, cutting municipal costs and producing marketable fertilizer.

Adoption of CE practices also boosts competitiveness and exports. International buyers, particularly in the textiles and apparel sector, increasingly require sustainability compliance. Implementing measures like water recycling in textile mills, chemical reuse, and fabric recycling enhances Pakistan's global export competitiveness. In construction, recycling demolition waste into secondary raw materials lowers the costs of new materials and reduces project budgets.

Finally, CE fosters innovation and opens new markets. It encourages entrepreneurship in repair services, refurbished goods, sustainable packaging, and recycling technologies. SMEs and startups can leverage green financing, microcredit, and climate-linked funds to develop circular initiatives, creating opportunities for economic growth and sustainable business models.

Case Insight: China's eco-industrial parks demonstrate the cost-saving potential of CE. By reusing industrial by-products, companies cut input costs, improved competitiveness, and reduced environmental fines. Pakistan's industrial zones could replicate this model.

Social Equity Aspects, Including Formalizing the Informal Waste Sector

The transition to a circular economy (CE) carries significant social justice benefits, particularly in a country like Pakistan, where labour markets are characterized by high inequality and informality. One key area is the formalization of the informal waste sector. Approximately 90% of Pakistan's e-waste and municipal waste is currently managed informally, with workers facing hazardous conditions, lacking protective equipment, and excluded from labour protections. CE provides an avenue to formalize this workforce, offering training, safety gear, and integration into organized recycling enterprises. Cooperative models, successfully implemented in Brazil and India, demonstrate how waste pickers can gain stable wages, social security, and bargaining power while maintaining their livelihoods.

CE also improves health and safety outcomes. Formalized systems reduce exposure to toxic materials, lowering rates of respiratory illnesses, lead poisoning, and other chronic conditions among workers and surrounding communities. These health improvements not only reduce public health burdens but also enhance workforce productivity. Gender inclusion is another critical dimension. Women are disproportionately engaged in low-paid, unsafe roles within waste collection. By formalizing and professionalizing CE sectors, safer and better-paying jobs for women can be created, contributing to gender equality. Finally, community empowerment is strengthened through localized CE initiatives. Programs such as community composting, water recycling, and repair hubs promote civic participation and awareness, fostering collective responsibility for sustainable resource management and long-term social resilience.

Case Insight: In India, organizations like *Chintan Environmental Research and Action Group* have successfully integrated waste pickers into formal systems, improving livelihoods while reducing environmental impacts. Pakistan could replicate such models through municipal–NGO partnerships.

Stakeholder Perspectives on Financing Opportunities and Social Impact

Successful adoption of a circular economy (CE) requires mobilizing financing and aligning incentives across diverse stakeholders. From the industry and private sector perspective, businesses acknowledge the long-term cost savings of CE but often cite upfront capital costs as a barrier. They call for government support through tax rebates, concessional loans, and public procurement of circular products. Large manufacturers in textiles, electronics, and packaging see CE as an opportunity to access global markets that increasingly demand higher sustainability standards.

Financial institutions also play a critical role. Development banks such as the ADB and World Bank, along with domestic banks, consider CE projects eligible for green financing instruments, including green bonds, climate funds, and blended finance. Microfinance institutions have the potential to support small-scale circular activities, such as household-level recycling businesses or women-led repair shops, expanding access to capital at the community level. Government and regulatory bodies emphasize CE as a pathway to achieving Pakistan's climate goals and SDGs, while noting the need for cross-sectoral coordination and provincial-level capacity-building. Public–private partnerships are seen as essential for scaling recycling infrastructure, water conservation projects, and renewable energy initiatives.

Civil society organizations and NGOs stress that CE must be inclusive and equitable, ensuring that benefits extend beyond large corporations to marginalized communities. They also emphasize the importance of awareness campaigns to shift consumer behaviour toward sustainable consumption and disposal practices. Communities and informal workers bring another vital perspective. Informal workers, while concerned about potential livelihood losses, are receptive to formalization if it includes training, fair wages, and social protections. Urban communities show willingness to participate in recycling and reuse programs when convenient and incentivized options are available, highlighting the importance of designing user-friendly systems to maximize engagement.

Case Insight: Kenya's PPP model for e-waste financing demonstrates how NGOs, government, and private firms can jointly support informal workers while scaling infrastructure. Pakistan could adapt this model by leveraging both donor support and local financing.

In conclusion, the economic and social implications of a circular economy transition in Pakistan are profound. CE not only reduces waste and environmental degradation but also creates jobs, enhances competitiveness, promotes equity, and mobilizes new financing streams. The challenge lies in ensuring that the transition is inclusive, adequately financed, and embedded in strong policy frameworks. By aligning industry, government, financial institutions, and communities, Pakistan can capture the full spectrum of economic and social benefits that CE offers.

5. Key Barriers to Circular Economy Adoption

Despite growing interest in circular economy (CE) solutions, Pakistan faces several significant barriers that hinder widespread adoption of CE practices. These challenges span financial, infrastructural, regulatory, and societal domains, as identified in the needs assessment:

Financial Constraints and Limited Investment

A lack of financing and high upfront costs pose a major obstacle to CE initiatives. Businesses recognize long-term savings from circular practices but often cannot afford the initial investment without support. Commercial banks currently allocate less than 2% of their green lending portfolio to projects like energy efficiency, indicating limited access to credit for circular projects. Although programs like the State Bank's Green Financing facility have been launched, many small and medium enterprises (SMEs) still struggle to obtain capital for needed technologies. This funding gap curtails the scaling of recycling plants, waste-to-energy projects, and other circular ventures.

Lack of Infrastructure and Technology

Insufficient infrastructure for waste processing, recycling, and water treatment is a critical barrier. Pakistan generates about 49.6 million tonnes of solid waste annually yet lacks a unified waste management system or widespread sorting and recycling facilities. For example, of ~2 million tons of plastic waste produced each year, less than 15% is recycled and over 85% is mismanaged through landfills or dumping. Only about 3% of plastic waste is processed by formal recycling, due to limited collection, segregation, and recycling capacity. Similarly, wastewater treatment infrastructure is inadequate – a large share of industrial and municipal wastewater is discharged untreated, since many industries lack treatment plants. High costs and technical limitations prevent adoption of closed-loop water systems, as many firms cite expensive equipment and scarce technical know-how as barriers. Overall, the dearth of modern recycling centres, composting facilities, waste-to-energy plants, and water treatment facilities severely constrains Pakistan's ability to circulate materials and recover resources.

Regulatory and Policy Enforcement Gaps

Gaps in policies and weak enforcement undermine CE progress. While environmental laws and standards exist (e.g. waste management rules, National Environmental Quality Standards for effluents), enforcement at provincial and local levels remains inconsistent. Many regulations are "on paper" but not implemented rigorously for instance, numerous small industrial units operate without functional pollution controls or waste treatment despite legal requirements. There is also fragmented governance and poor coordination across agencies: responsibilities for waste, water, and energy are split among federal, provincial, and municipal authorities, leading to siloed efforts. A lack of alignment (e.g. electricity is federally regulated while waste management is provincial) makes integrated projects like waste-to-energy cumbersome to execute. Moreover, Pakistan has yet to develop a dedicated national policy on circular economy or robust extended producer responsibility (EPR) frameworks for products like plastics or electronics. Existing policies (e.g. on renewable energy or water conservation) have not fully incorporated circular principles, and incentives for circular practices (such as tax breaks or mandates for recycled content) are limited. This regulatory uncertainty and weak enforcement discourage businesses from investing in CE and allow linear, polluting practices to continue unchecked.

Public Awareness and Skill Development Challenges

Low public awareness and a skills gap in green industries present another hurdle. The public and many businesses have limited understanding of circular economy concepts, resulting in low participation in recycling or resource-saving programs. For example, household waste is rarely sorted at source, and consumer behaviour does not yet strongly favour recycled or sustainable products. Changing this mindset requires widespread education and awareness campaigns. Additionally, there is a shortage of skilled professionals and technical experts needed to drive a circular transition. Pakistan lacks enough trained waste management professionals, recycling technicians, and energy auditors to implement and manage advanced CE solutions. Many companies report a lack of technical know-how for adopting innovations like industrial symbiosis or efficient resource use. Furthermore, workers in the informal recycling sector (e.g. waste pickers, scrap dealers) often have little formal training and operate in unsafe conditions. Without investments in capacity building – from vocational training in recycling techniques to university programs in sustainable design – the workforce is ill-prepared to support new circular business models. NGOs have emphasized the need for public awareness campaigns and "green skills" training so that consumers, workers, and entrepreneurs can actively participate in the circular economy.

Stakeholder Recommendations for Overcoming Barriers

Stakeholders from across sectors have proposed solutions to address these challenges. Financial actors recommend creating targeted incentives such as tax rebates, low-interest loans, or grants to ease the burden of upfront costs. Expanding green credit lines, climate funds, and public–private partnerships (PPPs) could mobilize much-needed investment for circular projects**.** Infrastructure gaps could be tackled by leveraging PPP models, for instance, a case study from Kenya's e-waste sector shows that collaboration between government, NGOs, and firms can fund recycling facilities while empowering informal workers. Adapting such models in Pakistan (with support from international donors and local industry) can help build modern waste processing and water treatment plants. To close regulatory gaps**,** stakeholders urge stronger government action: establishing clearer mandates and one-window permitting for environmental approvals to reduce bureaucratic hurdles and aligning national and provincial policies so that rules and incentives are consistent across the country. They also call for better enforcement through capacity-building of regulators, e.g. training environmental inspectors and using digital monitoring tools for waste and emissions. In the area of awareness and skills**,** stakeholders highlight education and inclusion: launching nationwide awareness campaigns to instill a "reduce, reuse, recycle" culture, and investing in skill development programs in collaboration with industries and educational institutions. Public–private initiatives can train workers in recycling techniques, safe e-waste handling, sustainable product design, and other green skills, ensuring that human capital is ready for a circular transition. Importantly, all groups emphasize that overcoming these barriers will require collaboration, government, industry, civil society, and communities must work together so that policies are informed by on-ground realities and everyone's incentives are aligned. These stakeholder insights form the basis for the strategic recommendations and roadmap outlined in the next section.

6. Recommendations & Roadmap

Building on the identified barriers, this chapter presents a strategic roadmap to facilitate Pakistan's transition towards a circular economy. The recommendations focus on reforming policies, enabling circular business models, adopting innovative technologies, building capacity, and fostering collaboration among stakeholders. Together, these steps provide a comprehensive pathway for Pakistan to move from awareness to action on circular economy:

- ***Policy Reforms:*** Strengthen and refine the regulatory framework to incentivize circular practices. This includes developing a National Circular Economy Policy or action plan that sets clear targets (e.g. recycling rates, waste reduction, resource productivity) and assigns responsibilities across agencies. Existing environmental and waste management laws should be better enforced and updated to close loopholes for example, making waste segregation at source and extended producer responsibility for products (like plastics, electronics, and packaging) mandatory. Incentive mechanisms are crucial: the government can introduce tax credits, subsidies, or feed-in tariffs to promote recycling, waste-to-energy, and use of recycled materials. Aligning provincial and federal regulations will reduce fragmentation; a one-window clearance system for environmental approvals could streamline investments in circular projects. Additionally, policy reforms should mandate greater transparency and data reporting (e.g. requiring companies and municipalities to report waste generation and resource use), which can help track progress and identify gaps. By embedding circular economy priorities into national development plans, climate strategies, and sectoral policies, Pakistan can create an enabling environment where businesses find it profitable and obligatory to adopt circular practices.
- ***Business Models and Support for Enterprises:*** Foster innovative business models by supporting startups and SMEs engaged in circular economy sectors. The government and financial institutions should extend dedicated support (financial and technical) to enterprises focusing on recycling, repair/refurbishment, product-life extension, and resource recovery. This can be done through incubator programs, challenge funds, and easier access to credit for green entrepreneurs. For instance, microfinance and green financing avenues can be expanded to fund small-scale recycling businesses, composting initiatives, or women-led repair shops. Large industries should also be encouraged to pivot to circular models. for example, textile and apparel manufacturers could invest in take-back schemes and upcycling of fabric waste, while agri-businesses can explore composting and bioenergy from residues. Public procurement can play a role too: government agencies might prioritize purchasing recycled or remanufactured products, which would create market demand for circular goods. Moreover, integrating the informal sector into formal value chains will strengthen circular business models; waste pickers and scrap dealers can be organized into cooperatives or social enterprises that are given contracts for municipal recycling, improving livelihoods and efficiency. By promoting entrepreneurship and new market opportunities in areas like packaging-free retail, sharing economy platforms, and product-as-service models, Pakistan can unleash private sector creativity to drive the circular transition.
- ***Technology Adoption:*** Invest in and scale up innovative technologies for recycling, waste processing, water treatment, and renewable energy. Modernizing the technological base is critical for improving resource efficiency. The roadmap calls for promoting advanced recycling technologies for example, plastic recycling can be enhanced by introducing waste-to-oil pyrolysis or chemical recycling for hard-to-recycle plastics, alongside boosting mechanical recycling capacity. Waste-to-energy (WtE) solutions should be piloted and expanded: projects that convert municipal solid waste, agricultural biomass, or livestock waste into electricity or biofuels can simultaneously address waste disposal and energy shortages. Pakistan has begun exploring such

projects (e.g. a 40 MW waste-to-energy plant in Lahore is underway), and these efforts should be multiplied with supportive policies and private investment. In the water sector, proven technologies like wastewater treatment and recycling systems must be adopted in both industry and urban utilities, installing effluent treatment plants, water recycling units, and rainwater harvesting can significantly cut freshwater demand. The government can facilitate technology transfer by partnering with countries and organizations that have expertise in CE technologies, as well as incentivizing local R&D and manufacturing of green tech (such as biogas digesters, solar panels, efficient irrigation systems). Digital technologies also form part of the roadmap: tools like waste-tracking apps, smart bins, and blockchain for supply chain transparency can improve efficiency and accountability. By embracing innovation, whether it's converting textile waste into new fibres with modern methods, or using AI for smart energy management, Pakistan can leapfrog to more circular and sustainable production systems.

- ***Capacity Building and Awareness:*** Develop human capital and public awareness to support the circular transition. A concerted capacity-building effort is needed to equip both the workforce and institutions with the necessary skills and knowledge. This should start with education and training programs: integrating circular economy concepts into curricula at universities, technical institutes, and vocational training centres will prepare the next generation of engineers, entrepreneurs, and policymakers. Specialized training (often through public-private partnerships) can be offered for roles like waste management professionals, recycling plant technicians, resource auditors, and repair/refurbishment specialists. At the governmental level, training programs for regulators and local officials (for example, environmental inspectors, municipal waste managers) will improve enforcement and implementation of CE initiatives. In parallel, nationwide awareness campaigns are recommended to change mindsets and behaviours among the public. These campaigns can educate citizens about waste segregation, recycling practices, water conservation, and the benefits of a circular economy for community well-being. NGOs and community organizations should be engaged to reach households and schools with messages to "reduce, reuse, recycle," as stakeholder consultations highlighted the importance of public engagement. Additionally, empowering the informal sector workforce through training and formal recognition is key – for example, offering certification and safety training to waste pickers can help integrate them into the formal economy with better income opportunities. Ultimately, building a culture of sustainability in Pakistan – where skills development and public awareness go hand in hand, will create a strong social foundation for the circular economy.
- ***Stakeholder Collaboration:*** Establish robust collaboration mechanisms among government, industry, academia, and civil society to drive the circular economy agenda. The complexity of the transition requires that all stakeholders work in concert, breaking out of silos. A top recommendation is to create multi-stakeholder platforms or councils on circular economy at national and provincial levels. These platforms would institutionalize regular dialogue, allowing industry representatives, policymakers, scientists, and community leaders to share insights, monitor progress, and coordinate initiatives. Such forums can help align regulations with on-ground realities and ensure continuous feedback loops for policy improvement. Strengthening federal-provincial coordination is also critical, since environmental management in Pakistan is decentralized, a clear delineation of roles and cooperative frameworks (perhaps through MoUs or joint task forces) will help implement projects that cut across jurisdictions (e.g. a national recycling program that local governments execute uniformly). Public-private partnerships should be expanded beyond infrastructure to include co-development of solutions: for example, companies and cities can collaborate on pilot projects for zero-waste cities or circular supply chains, with academia providing research support. Community engagement is equally important; local communities and civil society groups need to be partners in initiatives like community recycling

centres, repair cafés, and sustainable consumption campaigns. The roadmap encourages transparent information-sharing and data availability (such as open data on waste streams, pollution levels, recycling rates) so that all actors can make informed decisions and track progress. By fostering a spirit of cooperation and shared responsibility, Pakistan can accelerate innovation and overcome bottlenecks more effectively than any sector acting alone. In essence, a whole-of-society approach, where government provides vision and incentives, businesses innovate, researchers guide with evidence, and citizens participate actively is essential for the circular economy to flourish.

7. Conclusion

Pakistan's journey towards a circular economy, as examined in this needs assessment, highlights both significant challenges and promising opportunities. In recap, the study finds that the country's current linear practices are economically and environmentally untenable from millions of tons of unmanaged waste to inefficient water and energy use but that there is immense potential to reclaim value from these inefficiencies through circular strategies. Key insights from the analysis underscore that improving waste management (e.g. increasing recycling beyond the current ~15% of plastics), promoting resource efficiency in industries, and closing loops in sectors like agriculture and textiles can yield multi-faceted benefits. These benefits include reduced pollution and greenhouse gas emissions, improved resource security (less dependency on raw material imports), and substantial economic gains such as cost savings and job creation. Notably, the social dimension of a circular economy was highlighted: a transition to CE can foster green jobs and healthier communities for instance, formalizing recycling activities can improve livelihoods for thousands of informal workers, and better waste and water management will mitigate public health risks. The assessment also documented pockets of progress and inherent strengths that Pakistan can build upon, such as the nearly 99% reuse rate in the second-hand clothing sector, emerging renewable energy projects, and a cultural ethos of repair and reuse in many communities. These positive elements, combined with the urgency of addressing climate and waste crises, form the rationale for Pakistan to earnestly pursue a circular economy pathway.

Looking ahead, several strategic priorities for policymakers and industries emerge from this study. First and foremost is the strengthening of the policy and institutional framework government must provide clear direction by updating regulations, enforcing standards, and introducing incentives that encourage circular business practices. For example, implementing extended producer responsibility laws for waste, tightening enforcement of pollution controls, and investing in infrastructure (recycling facilities, composting sites, wastewater treatment plants) are high impact moves for policymakers. Another priority is financial and technical support for industry: businesses should be incentivized and assisted to adopt cleaner production and circular design, whether through tax breaks, low-interest green loans, or technical advisory services. Industries, for their part, need to integrate circular principles into their operations and supply chains designing products for durability and recyclability, reducing waste in production, and finding ways to turn by-products into value streams**.** Building capacity is also critical: from government agencies training staff to better regulate and facilitate CE, to companies training employees in new processes, to educational institutions producing skilled graduates in environmental sciences and sustainable engineering. Collaboration between research institutions and industry can drive innovation in locally appropriate circular solutions (such as converting crop residues to bioenergy or developing indigenous recycling technologies). Moreover, aligning Pakistan's efforts with international best practices and commitments will be important; for instance, meeting the rising sustainability criteria of export markets (like the EU's circular economy policies) will require both government and industry to prioritize eco-friendly initiatives. In summary, the strategic agenda calls for a mix of regulatory reform, investment in infrastructure and innovation, capacity building, and integration of circular economy goals into all levels of decision-making for both public and private sectors.

Finally, a strong call to action for collaborative efforts is warranted. Transitioning to a circular economy is not the mandate of a single entity, it demands an all-hands-on-deck approach**.** The government, businesses, civil society, and citizens each have a role to play in this collective endeavour. The findings of this assessment serve as a clarion call for unity of purpose: policymakers must show leadership and vision, private sector actors must demonstrate responsibility and creativity, and the public must embrace behavioural change toward sustainability. Establishing formal mechanisms for this collaboration (such as the multi-stakeholder forums and partnerships suggested) should be an immediate step. Time is of the essence with mounting environmental pressures and economic constraints, delaying action will only increase the costs and risks for Pakistan. By contrast, early movers in circular economy practices stand to gain competitive advantages, resilience against resource shocks, and international goodwill. By aligning industry, government, financial institutions, and communities, Pakistan can capture the full spectrum of economic and social benefits that a circular economy offers. In conclusion, this report emphasizes that a circular economy in Pakistan is not just an environmental imperative but an opportunity to catalyse sustainable growth. The road ahead will require dedication, innovation, and cooperation, but the reward is a more prosperous, inclusive, and resilient Pakistan. The time to act is now, a collective push towards circular economy adoption will help secure the country's economic future and the well-being of its people and environment for generations to come.