PLASTIC WASTE:

A JOURNEY DOWN THE INDUS RIVER BASIN IN PAKISTAN

JUNE 2022

THE WORLD BANK

SAWI SOUTH ASIA WATER INITIATIVE

PLASTIC WASTE:

A JOURNEY DOWN THE INDUS RIVER BASIN IN PAKISTAN

JUNE 2022

THE WORLD BANK

SAWI SOUTH ASIA WATER INITIATIVE

June 2022
SAR ENB

Report design and layout: ShahRukh, SmarTek, Islamabad, Pakistan.

Table of Contents

Acknowledgements ... v

Abbreviations ... vii

Executive Summary ... 1

1 Rising to the Challenge of Plastic Pollution in the Indus River Basin in Pakistan

The Indus River Basin ... 7
Pollution along the Indus River and its Tributaries ... 8
Solid Waste and Plastics ... 10
Purpose and Structure of the Report ... 13
World Bank Engagement on Plastics in Pakistan ... 14

2 Identifying Institutional and Policy Gaps in Riverine Management in Pakistan

Institutional and Policy Gaps ... 17
Effectiveness of Laws and Policies to Manage Plastic Pollution in Pakistan ... 19
Stakeholder Mapping ... 20
Role of the Informal Sector in Solid Waste Management in Pakistan ... 25

3 Assessing the Impacts of Plastic Waste on Riverine Environments

The Plastics Problem ... 27
Plastics in Riverine Environments ... 29
Assessing Plastics in Riverine Environments ... 31

4 Quantifying Plastic Waste in the Indus River Basin

Site Selection ... 35
Methodology ... 37
Results ... 39

5 Key Findings and Recommendations

Focus Area 1: Solid Waste Management Systems and Capacity Building ... 50
Focus Area 2: Data Collection, Monitoring, and Reporting ... 52
Focus Area 3: Planning, Policy, and Institutional Frameworks ... 54

Appendices

1: Summary of Relevant Policies, Laws, and Legislation at Federal, Provincial, and Local Levels ... 57
2: Waste Collected during Field Survey ... 63
3: Calculation of Plastic Load at Sampling Sites ... 67
4: Stakeholder Consultation Summaries ... 69

References

References ... 77

Boxes

1.1: Impacts of Plastic Waste on the Indus River ... 9
1.2: The South Asia Water Initiative ... 13
1.3: Related World Bank Initiatives in Pakistan and South Asia ... 15
4.1: Limitations of the Field Survey ... 40
4.2: Limitations of Plastic Modeling ... 47
A4.1: Khyber Pakhtunkhwa Irrigation Department ... 69
A4.2: Peshawar Water and Sanitation Services Company, Khyber Pakhtunkhwa ... 70
A4.3: Mingora Water and Sanitation Services Company, Khyber Pakhtunkhwa ... 71
A4.4: Punjab Irrigation Department ... 72
A4.5: Punjab Department of Forests, Wildlife, and Fisheries ... 72
A4.6: Punjab Environmental Protection Department ... 73
A4.7: Lahore Waste Management Company, Punjab ... 74
A4.8: Deputy Commissioner Office, Kashmore, Sindh ... 74
A4.9: Irrigation Department, Guddu Barrage, Sindh ... 75
A4.10: Assistant Commissioner Office, Sukkur, Sindh ... 75
A4.11: Hyderabad Municipal Corporation, Sindh ... 75
A4.12: Other Stakeholder Consultations during the Field Survey ... 76

Figures

ES.1.: Types and proportions of waste surveyed in this study ... 3
ES.2: Amount of waste collected by active sampling at survey sites ... 3
ES.3: Average quantity of plastic waste collected by active and passive sampling at survey sites ... 4
ES.4: Summary of key findings from the field survey ... 5
B1.1: Summary of impacts of plastic waste in waterbodies ... 10
1.1: MSW generated in urban and rural areas of Pakistan (2016) ... 11
1.2: Waste treatment and disposal in Pakistan (2016) ... 12
2.1: Waste management governance structure in Pakistan ... 19
2.2: Schematic of the informal waste sector in Pakistan ... 25
3.1: Disposal of plastics since the 1950s ... 28
3.2: Impacts of plastics on the environment, human health, and economy ... 28
3.3: Plastic input from rivers into the world's oceans ... 30
4.1: Sampling site locations along the Indus River Basin ... 36
4.2: Summary of methodologies used in this study ... 37
4.3: Steps in the field survey for this study ... 37
4.4: Composition of waste from active and passive sampling ... 41
4.5: Field survey results by site location ... 42
4.6: Plastic concentration and annual discharge at sampling sites along the Indus River system ... 44
4.7: Monthly plastic load in the Upper Indus Basin ... 46
4.8: Annual plastic load at sampling sites along the Indus River system ... 46
5.1: Key focus areas for reducing plastic pollution in the Indus River ... 50
5.2: Summary of key findings from this study related to SWM ... 51
5.3: Summary of key findings from this study related to data collection, monitoring, and reporting ... 53
5.4: Summary of key findings from this study related to planning, policy, and institutional frameworks ... 54
A1.1: Timeline of federal-level policies, laws, and rules ... 57
A1.2: Timeline of provincial-level policies, laws, and rules ... 59

Tables

2.1: Effectiveness of existing policies and laws to manage plastic pollution 20
2.2: Analysis of supporting stakeholders 21
2.3: Analysis of enabling stakeholders 21
3.1: Advantages and limitations of various sampling methods for plastic litter in rivers 33
4.1: Sampling sites and criteria for selection 35
4.2: Summary of field survey methodologies for this study 38
4.3: Summary of key findings from active and passive sampling 39
4.4: Plastic polymer by share collected (percent), ease of recycling, and status of recycling in Pakistan 43
5.1: Suggested recommendations for planning, policy, and institutions 56
A1.1: Federal-level policies, laws, and rules 58
A1.2: Provincial-level policies, laws, and rules 60
A1.3: Local-level policies, laws, and rules 61
A2.1: Categories and types of waste collected during field survey 63
A2.2: Waste quantities collected during field survey (kg) 64
A2.3: Average waste quantities collected during field survey 65
A3.1: Calculation of plastic load at sampling sites 67

Acknowledgements

This report was prepared by a World Bank team co-led by Rahat Jabeen *(Environment Specialist),* Basharat Saeed *(Water Resources Specialist*), Suhaib Rasheed *(Urban Development Specialist),* and Sachiko Kondo *(Natural Resource Management Specialist),* with contributions from Lisbet Kugler *(Senior Environmental Specialist),* Perinaz Bhada-Tata *(Solid Waste Consultant),* and Zahid Shakeel Ahmad *(Environment Consultant).*

This report is part of a larger series of stocktaking and analytical reports on plastic pollution in South Asia. This research is undertaken as part of the World Bank's South Asia Marine Plastics Pollution Platform, which aims to promote circular plastic economy solutions, advance country-level policy dialogue, promote investments in solid waste management, and raise public awareness of the deleterious impacts of marine plastics pollution on people's lives and livelihoods. The Platform reflects the Bank's strong commitment to support the countries of South Asia to pursue and scale-up policies and programs that help the countries of South Asia move toward a circular plastic economy and, in partnership with civil society and the private sector, harnesses the power of innovation to bring viable and sustainable solutions for plastic waste reduction and management across the region.

This research was funded by the South Asia Water Initiative (SAWI), a trust fund supported by the United Kingdom's Foreign, Commonwealth and Development Office; Australia's Department of Foreign Affairs and Trade; and Norway's Ministry of Foreign Affairs. The trust fund was designed to build a shared understanding of transboundary river pollution flows in South Asia, especially plastics pollution.

The field work for this diagnostic study was conducted by a consortium of Otium Services, 3Drivers, and Ghulam Hussain & Sons.

The contribution of various government officials and experts is gratefully acknowledged, particularly Naheed Shah Durrani *(Secretary, Ministry of Climate Change (MoCC)),* Dr. Muhammad Irfan Tariq *(Director General, Environment and Climate Change Wing, MoCC),* Farzana Shah *(Director General, Federal Environmental Protection Agency),* and Dr. Saima Shafique *(Program Manager-WASH, WASH Unit, MoCC),* for showing keen interest in this ground-breaking study and for providing necessary administrative support.

Valuable consultations helped with data collection and information to develop local scenarios. The team thanks the Ministry of Climate Change, Ministry of Water Resources, environment protection departments and environment protection agencies, provincial irrigation departments, forest, wildlife and fisheries departments, waste management companies, water and sanitation companies, and local communities for their insights. The report benefited positively from these discussions.

For technical guidance and many engaging discussions, the team thanks Karin Shepardson *(Lead Environmental Specialist),* Pawan Patil *(Senior Economist),* and Monika Kumar *(Environmental Specialist).* The report benefitted from editing support provided by Farahnaz Zahidi Moazzam, and administrative support from Poonam Rohatgi, Muhammad Naeem, and Juliette Makandi Guantai.

The team gratefully acknowledges the insightful comments provided by World Bank peer reviewer Kanako Hasegawa *(Environmental Specialist)*, and advice provided by Christina Leb *(Senior Counsel)*, Amena Raja *(Senior Operations Officer)*, and Mariam Sara Altaf *(External Affairs Officer)*.

The study was prepared under the guidance of Christophe Crepin *(Practice Manager, South Asia Environment, Natural Resources and Blue Economy)*, Abedalrazq F. Khalil *(Sector Leader, SAR Regional Director)*, and Najy Benhassine *(Country Director for Pakistan)* of the World Bank.

Abbreviations

ABS	Acrylonitrile-butadiene-styrene
ADB	Asian Development Bank
ASA	Advisory Services and Analytics
BOD	Biochemical oxygen demand
BPA	Bisphenol A
CBO	Community-based organization
CD	Compact disk
CDA	Capital Development Authority
CDG	City district government
CEO	Chief Executive Officer
cm	Centimeter
COD	Chemical oxygen demand
DG	Director General
DVD	Digital versatile disk
EIA	Environmental impact assessment
ENB	Environment, Natural Resources and Blue Economy
EPA	Environmental Protection Agency (federal)
EPD	Environmental Protection Department (provincial)
EPR	Extended producer responsibility
EPS	Expanded polystyrene
GDP	Gross domestic product
GEA	General environmental approval
GER	Green Earth Recycling
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global positioning system
HDPE	High-density polyethylene
IBIS	Indus Basin Irrigation System
ICT	Islamabad Capital Territory
IEA	Environmental Impact Assessment
IEE	Initial environmental examination
IFC	International Finance Corporation
IRB	Indus River Basin
IRSA	Indus River System Authority
ISWM	Integrated solid waste management
IUCN	International Union for Conservation of Nature
kg	Kilogram
km	Kilometer

LDPE	Low-density polyethylene
LGO	Local government ordinance
LWMC	Lahore Waste Management Company
m	Meter
MDTF	Multi-donor trust fund
MoCC	Ministry of Climate Change
MSW	Municipal solid waste
NCCP	National Climate Change Policy
NEQS	National environmental quality standards
NGO	Non-governmental organization
O&M	Operation and maintenance
PASA	Programmatic Advisory Services and Analytics
PEPA	Pakistan Environmental Protection Act
PEQS	Punjab Environmental Quality Standards
PET	Polyethylene terephthalate
PLEASE	Plastic-free Rivers and Seas for South Asia
PP	Polypropylene
PPP	Public-private partnership
PRs	Pakistan Rupee
PS	Polystyrene
PVC	Polyvinyl chloride
RDF	Refuse-derived fuel
SACEP	South Asia Cooperative Environment Programme
SAR	South Asia Region
SAWI	South Asia Water Initiative
SWEEP	Solid Waste Emergency and Efficiency Project
SWM	Solid waste management
TMA	Town/*tehsil* municipal administration
UAV	Unmanned aerial vehicles
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WAA	Water Apportionment Accord (1991)
WAPDA	Water and Power Development Authority
WASA	Water and sanitation agency
WASH	Water, sanitation, and hygiene
WBG	World Bank Group
WMC	Waste management company
WSSC	Water and sanitation services company
WtE	Waste-to-energy
WWF	World Wide Fund for Nature
μm	Micron or micrometer

Currency Units and Exchange Rates

Currency Unit	Exchange Rates (Effective as of May 12, 2022)	
Pakistan Rupee (PRs)	$1 = PRs 190.71	PRs 1 = $0.0052
All dollar amounts are US dollars		

Executive Summary

The perennial presence of plastic waste in the Indus River and its tributaries is a recent addition to the already extensive list of threats to water quality, ecological health, and environmental sustainability in Pakistan. While there is some information available, although insufficient, both on surface water resources as well as on solid waste management (SWM) in Pakistan, the intersection of the two remains grossly under-studied in research circles and underrepresented on policy forums. This study delineates the interface between land-based plastic waste and the Indus River system with the objective of raising plastics-in-rivers as a major policy and developmental issue, and providing a starting point for researchers, policy makers, and development and environmental professionals to expand the agenda of SWM to include protection of rivers. It is the first study of its kind in Pakistan, and uses a combination of active sampling of floating waste at key sites in the Indus River system, passive sampling of waste dumped along the banks at those sites, consultations with key stakeholders in the sector, and a review of relevant policies, laws, and literature.

The Indus is the 12th largest river in the world and the backbone of Pakistan's economy and ecology. It, along with its tributaries, is at the heart of the Indus

Basin Irrigation System (IBIS), the largest contiguous surface water irrigation system in the world. This transboundary river originates in the Hindu Kush Himalayan region from where it receives snow and glacier melt water. As it flows through the Pakistan Indus River Basin, it receives surface water flows from its tributaries—Kabul River in the west and a confluence of five tributaries to the east (Jhelum, Chenab, Ravi, Beas, and Sutlej). Throughout its journey down the Pakistan Indus River Basin, it receives rainfall runoff, return flows, and drainage from Khyber Pakhtunkhwa, Punjab, most of Sindh, and parts of Balochistan. Finally, it enters the Indus Delta before terminating in the Arabian Sea, having completed a journey of about 3,200 kilometers (FAO AQUASTAT 2011). Along with water from various sources, the river also carries large amounts of silt that are picked up from river banks through erosion and transported to vast areas of the basin through the IBIS, with the residual amount flowing into the Indus Delta and the sea. While the movement of water and silt is as old as the river itself, in recent times a number of stowaways have joined this journey down the Indus: Untreated sewage, industrial effluent, and agricultural drainage join the river system at various points, spurring concern about water quality for downstream users and sustainability of ecological sites that depend on flows of freshwater from the Indus. However, **the national conversation on water quality in rivers has, thus far, overlooked an increasingly common cause of pollution in the Indus—unmanaged solid waste, and in particular, plastic waste.**

Internationally, the Indus River has received notoriety for being the second most polluted river in the world in terms of plastic concentration (Lebreton et al. 2017). This raises the first question: **Where does plastic waste in the Indus come from and what does it consist of?** This report studied nine identified solid waste 'hotspots' across the Indus River Basin to quantify and characterize the solid waste that flows in the Indus and its tributaries (through active sampling) and that lays strewn on the banks of the river (through passive sampling), a part of which will inevitably make its way into the river through natural and anthropogenic forces. Analysis and characterization of the waste collected reveals that plastics contribute the most to solid waste in rivers (Figure ES.1), and within plastics, low-value plastics make up the highest proportion.

The Indus River has historically been recognized for being one of the biggest contributors to marine plastic pollution with an estimated 11,977 tonnes of plastic leaking into the ocean every year (Schmidt et al. 2017). However, recent work that uses higher resolution data shows that the contribution of big rivers, such as the Indus, to marine plastic pollution is over-estimated, and that smaller rivers play a much larger role in connecting land-based plastic waste and marine environments (Meijer et al. 2021). The reduced estimate of the Indus' contribution to plastic pollution does not mean the anecdotes and limited research on the plastic load carried by the Indus stand invalidated. In fact, it raises a second question: **Where does plastic waste in the Indus end up?** Through active and passive sampling, this study estimates the amount of waste flowing downstream Kotri Barrage—the last barrage on the Indus River before it meets the Arabian Sea—to account for leakages to the sea. In addition, the report infers the destination of the remaining plastic waste by simply following the water. Water from the Indus and its tributaries is diverted into irrigation canals at barrages that supply the vast network of branch canals, distributary canals, and water courses. Like other materials, plastic waste, too, is diverted and spread across the canal system. Therefore, diversions at barrages act as 'sinks' for plastic waste, serving to remove it from the river(s) and inject it into the canal system. The data analysis in this study supports the existence of such sinks as it shows that there is no linear accumulation of waste from upstream to downstream sites (Figure ES.2). While these sinks reduce the plastic load in the Indus and its tributaries, thereby decreasing leakage to the sea, it merely directs the problem towards a different landscape with its own set of consequences. For example, macroplastics tend to degrade into microplastics through wave action in rivers and canals, and the presence of microplastics in the irrigation supply system can introduce plastic into the agricultural/food supply chain, creating potential health and nutrition challenges.

Figure ES.1: Types and proportions of waste surveyed in this study

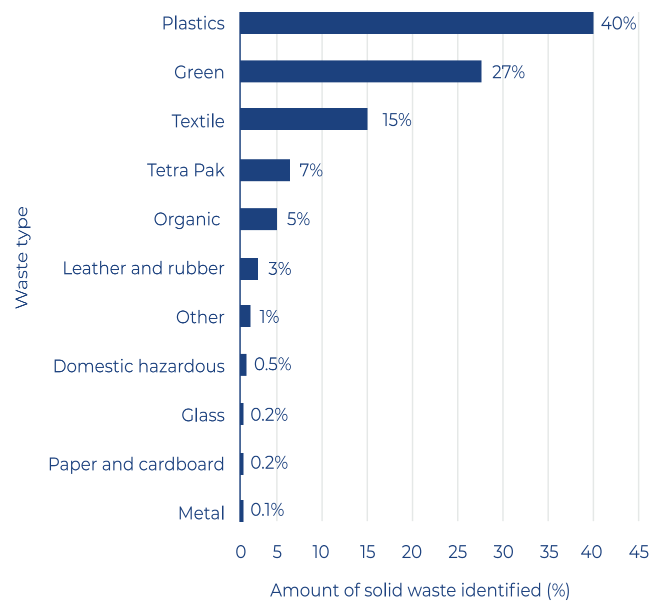
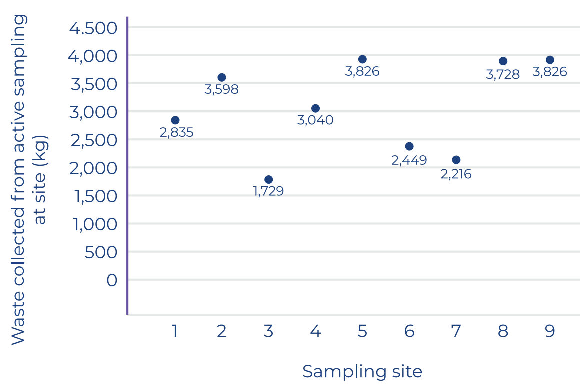
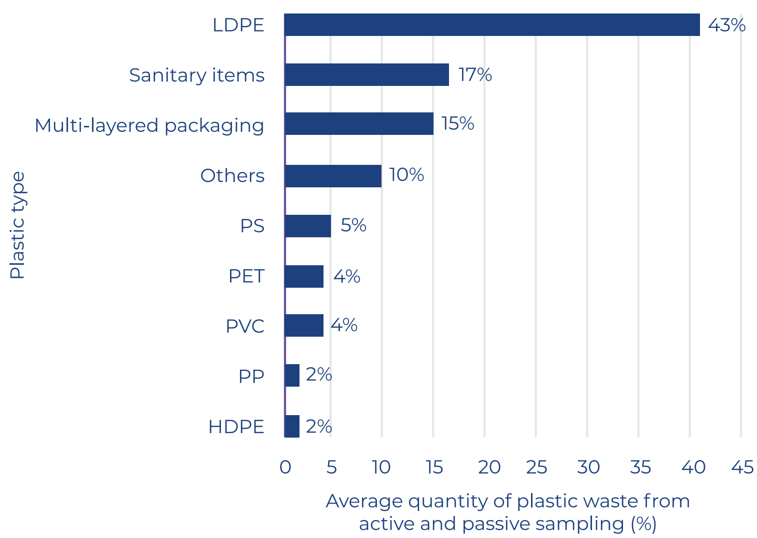


Figure ES.2: Amount of waste collected by active sampling at survey sites



The third question is **what drives the high plastic load carried by the Indus?** The answer to this question lies in understanding the SWM sector itself: The quality and coverage of waste management services, the legal architecture and enabling environment, and the role of formal and informal actors. This study explores the SWM sector in detail, using a combination of data from stakeholder consultations and secondary sources to uncover determinants of solid waste being dumped in Pakistan's rivers or on their banks. Some drivers of the large quantum of waste that finds its way into the Indus River system include: Low solid waste collection rates, with only about 50 percent of municipal solid waste (MSW) collected; lack of solid waste treatment and disposal facilities; inadequate legal framework to ensure accountability for SWM services; poor enforcement of environmental laws regarding discharge of waste into waterbodies and insufficient end-of-pipe solutions; and dependence on informal solid waste collectors who exist outside any regulatory framework. In particular, the high proportion of plastic waste, especially low-quality plastics, found in active and passive samples indicates that existing waste management practices (mostly informal) are filtering out high-value plastics and other materials that have reuse or resale value. The high proportion of sanitary products and the extremely low presence of metals, glass, and cardboard further reinforce this inference (Figure ES.3).

Figure ES.3: Average quantity of plastic waste collected by active and passive sampling at survey sites



Finally, **to what extent can questions about plastic pollution in the Indus River Basin, including the ones above, be answered?** Unfortunately, the study finds glaring gaps in the data and monitoring architecture of the SWM sector, and that information on plastic pollution in rivers is virtually non-existent, except for isolated one-off studies such as this one. Narratives—and images—of solid waste dotting riverine landscapes abound, and stakeholders consulted for this study testify to it being a major environmental issue, but the data required to determine entry points, prioritize actions, and design programs remains elusive.

Figure ES.4 below sheds light in detail on the conclusive findings of the field survey.

Based on the insights generated by this study, **a number of recommendations are proposed for stakeholders**. Given the current lack of investment and policy attention to plastic pollution in the Indus River Basin, these recommendations represent a starting point towards integrated land-water plastic waste management. This move is urgently required, given that economic growth, urbanization, and rise in living standards are likely to both increase consumption as well as change consumption patterns with a consequential rapid rise in plastic waste generation, at least in the short-to medium-term. Existing structures and practices are inadequate to cope with the current solid waste management scenario.

Figure ES.4: Summary of key findings from the field survey

MUNICIPAL WASTE COMPOSITION	PLASTIC WASTE COMPOSITION	PLASTIC CONCENTRATION & ANNUAL WATER DISCHARGE	PLASTIC LOAD
Plastic constitutes 40 percent of the waste collected from the Indus River	No significant variation in composition of plastics from active and passive sampling, except for LDPE fraction	The annual discharge, or flow rate of the river, at Hyderabad is significantly lower than was expected from upstream measurement points	The Indus River delivers around 10,000 tonnes of macroplastics to the Arabian Sea each year
Macroplastic pollution does not accumulate in a linear way from upstream to downstream	Low-value plastics, such as LDPE, make up a major proportion of waste found	Plastic concentration in the Indus River increases significantly in the Upper Indus Basin, Balloki, and Hyderabad as annual discharge drops substantially	More than 90 percent of plastic waste from the Upper Indus Basin ends up in the Indus River
Textile waste and Tetra Pak are the third and fourth most significant waste types found, of which the latter also contributes to plastic pollution in the Indus River	High-value plastics, such as HDPE and PET, make up a small fraction of plastics found	Most macroplastic waste entering the Indus River system does not reach the Arabian Sea	Around 27 percent of the total plastic waste generated in Hyderabad ends up in the Indus River
Proportion of high-value recyclables (e.g., metal, glass, paper and cardboard) is low	Hard-to-recycle plastics like sanitary waste and multi-layered packaging are the second and third most dominant type of plastic waste	It is likely that plastics accumulate in various canals and other sinks throughout the IRB irrigation network	This is similar to the values reported by Schmidt et al. (2017) in their seminal study on riverine plastic pollution

- **Improvement and capacity building of waste management systems** with the aim of expanding waste collection, treatment, and disposal. This includes infrastructure and capacity building to improve service provision by local government bodies (or waste management companies, as the case may be) in each province, with guidance from a national or at least basin-level waste management strategy developed and monitored by the federal government. The improvement of waste management systems also requires close coordination with two key players: (1) informal waste collectors, as they are already providing services that account for a large proportion of waste collection, reuse, and resale; and (2) provincial irrigation departments, as they manage the barrage and canal infrastructure which serves as a major sink, and also provide the service of removal of plastic waste along with silt and debris from canals.
- Invest in **data collection, monitoring, and reporting,** with a long-term objective of having a single integrated basin-scale monitoring platform/dashboard that can help identify major concentrations and movements of plastic pollution towards rivers, within rivers, and from the rivers to canals and to the sea. A prerequisite for this is to establish and agree on national data collection and data sharing protocols, and to build capacity of existing waste institutions to collect data.

- Resolve overlaps and fill gaps in **planning, policy, and legal frameworks**, with the objective of assigning responsibility for specific tasks to specific institutions and holding them accountable for it. The toughest but most impactful long-term policy change would be one that creates a functional relationship between federal, provincial, and local government waste management actors and between key waste management and water management institutions. There is also a need to update or create provincial laws and regulations governing plastic production and disposal, as well as to develop a national strategy and plan for plastic waste management across sectors and industries, focusing on the intersection between plastics management and water resources management.

Chapter 1: Rising to the Challenge of Plastic Pollution in the Indus River Basin in Pakistan

The Indus River Basin

Geographically and hydrologically, the Indus River Basin is perhaps one of Pakistan's defining features, covering about two-thirds of Pakistan's surface area and accounting for 95 percent of its total annual renewable water resource (Young et al. 2019). The Indus River, with a length of some 3,200 kilometers, is the 12th largest river in the world (FAO AQUASTAT 2011). The river's annual flow is about 243 cubic kilometers—twice that of the Nile River and three times that of the Tigris and Euphrates rivers combined (Ahmad and Lodrick 2021). It is known as the great trans-Himalayan river of South Asia, as it traverses through the Himalayas, Hindu Kush, and Karakoram ranges, originating in China and crossing through India and Afghanistan before finally entering Pakistan. The Indus River has two main tributaries: Kabul River in the west and Panjnad in the east. Panjnad is the flow resulting from five main rivers: Jhelum, Chenab, Ravi, Sutlej, and Beas (a tributary of the Sutlej).

In Pakistan, the Indus River Basin covers around 520,000 square kilometers, comprising the entire provinces of Khyber Pakhtunkhwa and Punjab, most of the territory of Sindh, and the eastern part of Balochistan (FAO AQUASTAT 2011). The Indus exits through an extensive delta system into the Arabian Sea. The delta itself covers an area of 7,800 square kilometers (Ahmad and Lodrick 2021).

Thus, the importance of the Indus River to Pakistan's economy and way of life cannot be underestimated. It is a crucial resource for Pakistan's agricultural and industrial sectors, as well as for the country's potable water requirements. The Indus River system is fed by snow and glacial melt, along with rainfall in the catchment areas, making it a perennial river system. Nevertheless, this results in varied river flow throughout the year: Discharge is at a minimum during the winter months of December to February, followed by a rise in water level in the spring and early summer from March to June. The highest flow occurs in the monsoon season between July and September. The river flow then falls rapidly until the beginning of October, when the water level begins to subside gradually (Ahmad and Lodrick 2021).

Importantly, the Indus River and its tributaries make up the world's largest contiguous surface water irrigation system. The Indus River provides irrigation to 83 percent of the total irrigable area, the equivalent of the country of Tajikistan (Qureshi 2011). This is important because the Indus River system receives most, if not all, of its water from the headwaters in the mountainous northern part of the country, with rapidly decreasing surface flow in the plains. The agriculture sector thus relies heavily on the connected system of three reservoirs (Tarbela, Mangla, and Chashma), 23 barrages/headworks/siphons, 12 inter-river link canals, and 45 canals extending 60,800 kilometers.[1] Together with communal watercourses, farm channels, and field ditches, the system covers an additional 1.6 million kilometers, serving tens of thousands of farmers and supporting the country's breadbasket (FAO AQUASTAT 2011). The Indus River system has been identified as one of the world's most vulnerable water resources based on future climate and socio-economic projections, primarily because of its importance to lowland and downstream communities as well as the vulnerability of people and ecosystems dependent on the river (Ghai 2019).

Pollution along the Indus River and its Tributaries

Deteriorating water quality is a major threat to the ecological resources of the Indus River and is a key driver of poor environmental outcomes from water use in Pakistan. Water quality issues in the Indus River are typically attributed to three main sources: municipal wastewater discharges, which consist primarily of untreated sewage; industrial wastewater discharges consisting primarily of chemicals and heavy metals; and return-agriculture flows, which consist of high concentrations of salt and agro-chemical residue. Treatment of wastewater prior to disposal into waterbodies is rare; around 90 percent of municipal wastewater does not receive adequate treatment, with few existing treatment facilities. Almost 99 percent of industrial wastewater in the country has been reported to be discharged without treatment (Dawn 2008; Michel and Sticklor 2013).

A hitherto less scrutinized and under-studied aspect of water quality in the Indus is pollution by unmanaged or poorly managed solid waste management (SWM). In particular, plastic waste is increasingly being highlighted as an area of concern for both the water resources management as well as SWM sectors. Much of the uncollected solid waste is dumped into the river or can be found lying along the banks and bunds near the river (See Box 1.1 for impacts of plastic waste in the Indus River). The accumulation of plastics can be observed in some parts of the river in Sindh province, where the water current and hydrological factors allow the plastic to gather and float on the surface.

1 Barrages are hydraulic structures with gates, having water storage or electricity generation capacity. Headworks are smaller structures, mainly used to divert water from rivers into canals for irrigation purposes. There are numerous barrages and headworks on the Indus River to facilitate irrigation and to control flooding.

The ecological threat posed by plastic pollution in the Indus River and its tributaries is a subset of larger environmental concerns surrounding SWM in Pakistan. It is, thus, important to understand the processes and practices that contribute to the SWM sector in the country.

Box 1.1: Impacts of Plastic Waste on the Indus River

Plastic waste has become one of the main sources of water pollution, and has serious impacts on people and other living organisms in the Indus River Basin. It either finds its way naturally to waterbodies, or is deliberately dumped in them as a means of disposal. The impacts discussed here have been observed not just locally but worldwide as well, as plastic waste gets distributed globally across all oceans due to its buoyancy and durability (Mukheed and Khan 2020). Figure B1.1 presents a summary of these impacts.

Climate change is increasing the frequency, intensity, and unpredictability of riverine floods in the Indus River Basin. Climate change is also increasing variability in precipitation, one manifestation of which is increased frequency and intensity of rain events. In urban areas, the impact of floods and extreme rain events is exacerbated by the clogging of drainage networks by solid waste. This was witnessed most recently in the city of Karachi in August 2020 when record-breaking rainfall was unable to pass through the city's storm water drains due to, among other things, clogged storm water drains. On average, the annual flood damage from 1960 to 2011 was about 1 percent of mean annual GDP (Sobkowiak et al. 2020). Stagnant water in drains is also a source of transmission of water and vector borne-diseases. Plastic waste in waterbodies also lowers the aesthetic appeal of coastal areas, beaches, and green spaces alongside rivers, thereby negatively impacting the tourism industry.

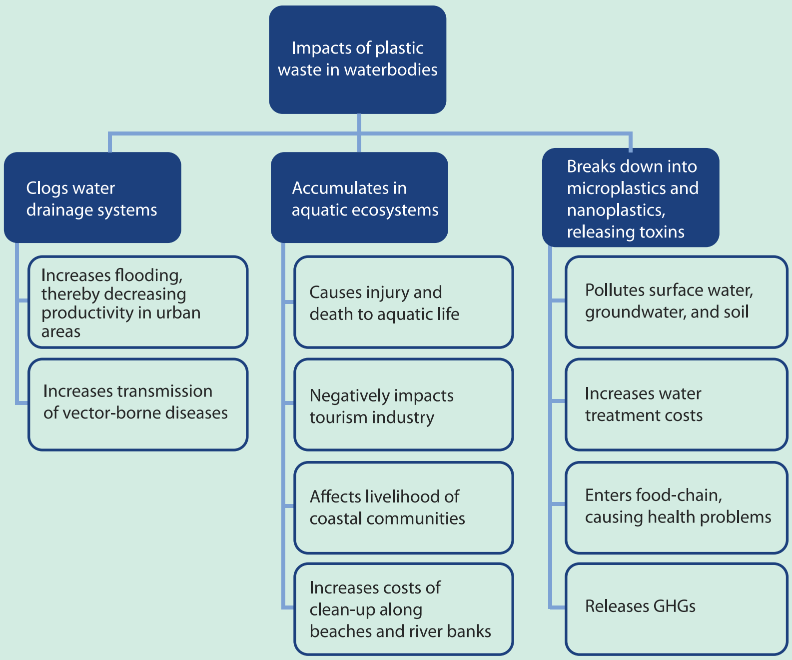
Plastic waste has also been found to shorten aquatic animal lifespans through entanglement and ingestion of plastic debris. Globally, over a million sea birds and mammals die annually from the ingestion of plastic which is mistaken for food by birds, turtles, seals, and whales. This can potentially choke, poison, or impede digestion causing starvation (Our News 2019). The use of over 55 billion plastic bags each year in Pakistan is also a reported cause of death of aquatic life (Qureshi 2019).

Plastic material accumulates in river banks and deltas, breaking down into microplastics (plastic fragments 0.1 μm−5 mm in size) and nanoplastics (0.001–0.1 μm in size) through continuous exposure to sunlight as well as mechanical forces. Microplastics and nanoplastics are almost impossible to recover and release additives and toxins, thereby polluting water, disrupting food chains, and degrading natural habitats. Toxins can limit the quantity of clean water available for consumption and increase treatment costs for drinking water. They can also seep into groundwater and other freshwater reservoirs.

Poor water quality has also impacted fish population and species diversity drastically in the Indus River. High levels of pollutants in the river have been reported to increase fish mortality, affecting the food supply of the endangered Indus River dolphin (WWF 2020). In parts of the lower Indus River, mangroves have almost disappeared due to the toxic effects of polluted water that flow into the ecosystem (Pappas 2011).

With the effects of climate change increasing in the future, more frequent floods from rainfall will likely increase the flux of waste, including plastics, into aquatic environments. Hence, plastic pollution in aquatic ecosystems is a serious environmental risk, as it negatively impacts ecology, endangers aquatic species and public health, and causes economic damage.

Figure B1.1: Summary of impacts of plastic waste in waterbodies

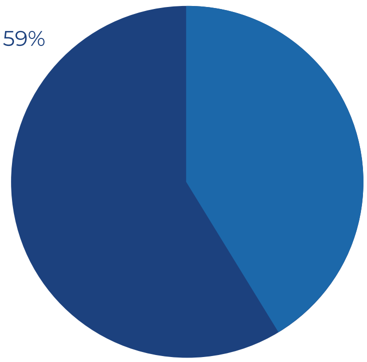


Solid Waste and Plastics

A key challenge to Pakistan's environment and ecology is its burgeoning solid waste management sector. An increasing population and rapid urbanization, coupled with rising and changing consumption patterns are leading to a concomitant increase in generation of municipal solid waste (MSW). This is to be expected in growing economies with increasing urbanization, disposable income, and living standards on the one hand, and weak environmental regulation and low standards of public service delivery on the other. The result is an increase and change in patterns of consumption resulting in a corresponding increase in the amount of waste generated. Particularly, the increased use of plastics is a cause of major concern. Experience in other developing countries shows that as economies develop, so does domestic consumption, and plastic waste is a major by-product. Convenience and affordability make plastics a material of choice, be it in the form of plastic bags used in marketplaces, or disposable food containers made of expanded polystyrene (EPS)—commonly referred to as Styrofoam—and plastic cutlery for take-aways.

In 2017, Pakistan generated 30.76 million tonnes of MSW, or the equivalent of approximately 84,000 tonnes per day and the equivalent of 0.43 kilograms per person per day (Kaza et al. 2018). While solid waste is generally considered an 'urban' issue, a study by Safar et al. (2017) shows that solid waste generation in rural areas of Pakistan amounts to just over 40 percent of total MSW generated (Figure 1.1, Safar et al. 2017).

Figure 1.1: MSW generated in urban and rural areas of Pakistan (2016)



Source: Safar et al. 2017

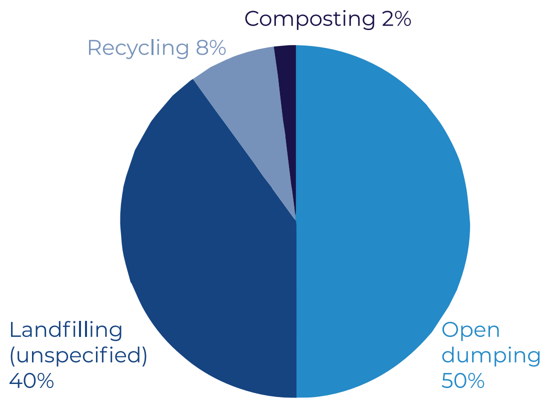
The simultaneous rise in economic growth, population, and urbanization on the one hand, and MSW generation on the other might be well understood, but the consistently poor outcomes from the SWM sector in Pakistan suggest that the country was ill-prepared for this rise. Pakistan has a rudimentary waste collection system with poor waste collection rates in its urban areas. According to the Pakistan Bureau of Statistics, waste collection services in Pakistan are not widely available. Forty-three percent of urban areas have no waste collection service; meanwhile, more than 95 percent of rural areas in Pakistan have no waste collection system at all (PBS 2015). This national average for urban areas in 2015 is reinforced by views from stakeholders from selected urban areas consulted for this study in 2021, who claimed that 40 to 50 percent of waste remains uncollected.

Waste management systems are unable to cope with current waste generation rates due to poor levels of public awareness, insufficient institutional and technical capacity, outdated and inadequate infrastructure, and a shortage of financing. What makes the situation more dire is that with the current system, the gap between generation and collection will rise exponentially against population increase, because urban waste is growing twice as fast as population in Pakistan, as observed in 10 cities between 2009 and 2014 (PBS 2015). The World Bank estimates that MSW in Pakistan will increase by 36 percent between 2016 and 2030 to 42 million tonnes, and by 57 percent between 2030 and 2050 to over 66 million tonnes, based on current urbanization and population growth rates (Kaza et al. 2018). If MSW continues to grow unabated while management systems remain the same, it will result in severe environmental and health-related issues. Already, many countries in the South Asia region—including Pakistan—face negative consequences from poor solid waste management: polluted water bodies, clogged waterways, contaminated land, infectious diseases, and choking smoke, to name a few. These effects also negatively impact economic development.

Typically, MSW collection goes hand-in-hand with waste treatment and disposal: If collection systems are poor, the same can generally be said regarding treatment and disposal. In low- and middle-income countries, governments typically spend most of their SWM budgets on primary collection, which leaves little or no budget remaining for treatment and disposal (Hoornweg and Bhada-Tata 2012). Moreover, having waste collection services remain insufficient if proper treatment and disposal are lacking.

Almost 90 percent of the waste generated in the country is disposed of through open dumping, landfilling, and open burning, while only eight percent is recycled (Figure 1.2, Kaza et al. 2018). A study by the Government of Pakistan in 2015 listed disposal sites in only a handful of cities. It should be noted that none of these listed sites are sanitary landfills (PBS 2015).

Figure 1.2: Waste treatment and disposal in Pakistan (2016)



Source: Kaza et al. 2018

Most of this waste ends up in unmanaged dumpsites or strewn about in open areas and waterbodies. In urban areas, this results in clogging of storm water drains and sewerage systems, which exacerbates flood risks and impacts by increasing retention of storm water. In addition to direct physical damages, this also increases the spread of water-borne and vector-borne diseases such as cholera, diarrhea, malaria, and dengue, especially where blockages in sewerage systems lead to mixing of sewage with flood water. In peri-urban and rural areas, waste is disposed of in open areas or along banks of water channels such as rivers, open drains, and canals. Open burning of waste is common, often to reduce the volume of waste or to retrieve recyclable materials such as metals, which comes at an environmental and public health cost due to air pollution and associated greenhouse gas (GHG) emissions.

Plastics, an increasingly important waste stream, make up roughly one-tenth of MSW in Pakistan. In 2016, it was estimated that approximately 2.8 million tonnes of plastic waste were generated, equivalent to almost 14 kilograms per person each year (calculated based on Kaza et al. 2018). More recent estimates suggest that plastic waste generated per year is closer to 3.12 million tonnes per year (World Bank 2021c). A conservative estimate suggests that approximately 55 billion plastic bags are used in Pakistan annually, but the number could be as high as 112 billion (Constable 2019; Hadid and Sattar 2019). Fifty-five billion plastic bags would be enough to wrap around the earth 425 times (calculated based on Sanchez 2019).

Purpose and Structure of the Report

In addition to the paucity of analytical work on this topic locally, globally the work that features the Indus River has focused on understanding how it contributes to plastic pollution in the Arabian Sea and, ultimately, the Indian Ocean. These studies provide estimates of plastic pollution in the Indus River using basin-scale estimates of solid waste generation and coarse remote-sensed data (for example, Schmidt et al. 2017 and Lebreton et al. 2017), but ultimately focus on leakages to the sea.

A new study claims that the share of mismanaged global plastic waste entering the ocean from Pakistan is 0.09 percent (Ritchie 2021; Meijer et al. 2021). This does not affect the macroplastic load of the Indus River; it just implies that the plastic load of the Indus River does not leak into the ocean.

While pollution from the Indus River, particularly due to plastics, has gained attention in the last few years, there has been little analytical understanding or mapping of the sources and nature of plastic pollution in the river. For the first time, a pathbreaking study was conducted to identify, quantify, and analyze plastic 'hotspots' in the Indus River Basin. This report—funded by the South Asia Water Initiative (SAWI)—presents the findings of this new research, quantifying plastic litter in the Indus River using techniques applied in other parts of the world to quantify riverine plastic waste (See Box 1.2 for a brief description of SAWI). Engaging with stakeholders and using scientific techniques to map the plastic waste trail in the Indus River Basin, this report highlights complex issues surrounding solid waste—particularly plastics—on irrigation, food production, water quality, and other resources which make the Indus River vital for the Pakistani economy and ecology. This report seeks to elevate the management of solid waste, particularly plastics, as a crucial development issue, and one that requires targeted action with intense coordination among various stakeholders determined to make the Indus garbage-free.

While this—the first—chapter of the report explores the challenge of plastic pollution in the Indus River Basin, the focus of the remaining chapters of the report is as follows:

- Chapter 2 describes the plastics management architecture in Pakistan by identifying key federal and provincial policies and the related gaps.

Box 1.2: The South Asia Water Initiative

The South Asia Water Initiative (SAWI) is a multi-donor trust fund (MDTF) supported by the United Kingdom's Foreign, Commonwealth and Development Office, Australia's Department of Foreign Affairs and Trade, and Norway's Ministry of Foreign Affairs. The goal of the MDTF is to increase regional cooperation in managing major Himalayan river systems to deliver sustainable, fair, and inclusive development and climate resilience.

The aims of the MDTF are to:

- Strengthen awareness and knowledge about regional water issues
- Enhance technical and policy capacity
- Support dialogue and participatory decision processes to build trust
- Scope and inform World Bank investments.

SAWI works in three river basins (Indus, Ganges, and Brahmaputra) and one landscape (Sundarbans), spanning seven countries: Afghanistan, Bangladesh, Bhutan, China, India, Nepal, and Pakistan. SAWI is also involved in regional cross-cutting work that supports non-basin specific activities such as groundwater management.

In the context of water resources planning and management, the program seeks to promote poverty alleviation, economic development, gender inclusion, and climate change adaptation.

Source: World Bank 2021b

- Chapter 3 assesses the tools used to measure and quantify riverine plastics pollution.
- Chapter 4 discusses the key findings of the field work undertaken for this study.
- Chapter 5 summarizes the report's key findings and recommends priority areas for reform and investment.

World Bank Engagement on Plastics in Pakistan

As Pakistan's economy steadily grows, it will create a correspondingly larger middle class desirous to improve their standard of living. A larger number of Pakistanis are expected to move out of poverty and, consequently, acquire more purchasing power. As economies grow, inevitably so does environmental degradation, as hypothesized through the environmental Kuznets curve, which purports that economic development initially results in environmental degradation. Population growth, urbanization, and economic growth will, undoubtedly, result in more waste generation across Pakistan.

Higher waste generation needs to be tackled through better collection, treatment, and disposal services. Solid waste management is generally expensive and is often one of the largest budget items of a local government (Hoornweg and Bhada-Tata 2012). However, the costs of inaction of SWM are far higher than the costs of action and have the potential to disrupt the economic, environmental, and social development of economies: It is significantly cheaper for cities to manage their wastes sustainably in the present, rather than to pay for clean-up later. Studies in various developing countries have shown that mismanaged plastics often end up polluting waterbodies. In Pakistan, the Indus River, as the backbone of agriculture and food production, is of vital importance. Citizens, too, need to be made aware of the consequences of plastic consumption and pollution on their health and environment.

In terms of policy, Pakistan is moving in the right direction. The Clean Green Pakistan Program, initiated by Prime Minister Imran Khan in 2018, is a national campaign to bring about behavioral change and strengthen institutions in five key areas: plantation, solid waste management, liquid waste management/hygiene, total sanitation, and safe drinking water (Pakistan MoCC 2021). The Ten Billion Tree Tsunami is another program of the Government of Pakistan to revive forest and wildlife resources and to improve overall conservation of protected areas. With a budget of PRs 125 billion, it aims to afforest 85,000 acres in the Indus Delta, among other targets.

Through various analytical and advisory services, the World Bank Group (WBG) supports the Government of Pakistan in its broader green and clean Pakistan initiatives. In this way, the WBG is contributing to Pakistan's shift towards green growth, curbing the impacts of pollution on health and the environment, building resilience to shocks (for example, pandemics and climate change), and supporting gender-responsive outcomes for the poor and marginalized groups, especially women.

This SAWI-funded study is one of a number of linked advisory services and analytics (ASA) provided by the World Bank in Pakistan and the broader South Asia Region (SAR). These activities are described in further detail in Box 1.3.

Box 1.3: Related World Bank Initiatives in Pakistan and South Asia

In addition to lending, the World Bank undertakes a number of analytical and advisory activities (ASA) to support its clients across the South Asia Region (SAR), including Pakistan. These are non-lending activities that help external clients advance a development objective, such as supporting design or implementation of better policies, strengthening institutions, building capacity, and informing development strategies or operations.

In the context of this SAWI study, there are a number of studies and projects in Pakistan and in South Asia that integrate the environment, including water resources, with improved waste management practices, while promoting circular economy goals. These ongoing activities include:

Plastic Free Rivers and Seas for South Asia (PLEASE): PLEASE aims to strengthen innovation and coordination of circular economy solutions to plastic pollution across South Asia in all regional countries. The project consists of three components that will be implemented over a period of five years and hopes to sharply drive innovation and results for plastic waste and plastic pollution reduction that would lead to cleaner coasts, rivers, and seas in the region. Within PLEASE, the World Bank, Parley for the Oceans, and the South Asia Cooperative Environment Programme (SACEP) have formed a unique partnership to help the region curb its marine plastic pollution. PLEASE will also engage with decision makers from public and private sectors to promote a circular economy for plastics.

Marine Pollution Diagnostics Assessment and Waste Management: This PROBLUE-funded study elaborates on the major sources of marine pollution to provide a strategy and roadmap to mitigate pollution in Pakistan's coastal areas. PROBLUE is a World Bank-administered multi-donor trust fund (MDTF) that supports the sustainable and integrated development of marine and coastal resources in healthy oceans.

Green Clean Pakistan Programmatic ASA (PASA): The objective of this PASA is to provide federal and provincial governments with policy and technical advice to transition to greener growth by rebuilding renewable natural resources, addressing pollution, and building environmental governance. In particular, Pillar 2 of the study on Pollution Management (Air and Water Quality) focuses on outlining low-cost technical options and potential for riverine and watershed restoration. Relevant activities include characterizing current river use and river health, as well as mapping key infrastructure, and designing and identifying low-cost pollution management, among others.

Plastic Circularity in Pakistan—Opportunity and Barriers for the Private Sector: This IFC study aims to inform the private sector and administrative authorities of the barriers to achieving circularity, while simultaneously introducing market opportunities available in plastics.

Sustainable Solid Waste Management in Mountain Areas of India, Nepal, and Pakistan: This activity represents the first attempt by the World Bank to examine solid waste management (SWM) in ecologically sensitive mountain areas that face unique challenges. The study looked at the impact of, and provided recommendations and a menu of options for, solid waste—particularly plastics—in mountain environments in order to prevent waste from leaking into pristine water resources, such as streams and rivers originating in the Himalayas, and into the environment.

Solid Waste Emergency and Efficiency Project (SWEEP): SWEEP in Pakistan is primarily designed to reduce flood risk in Karachi and supports emergency response to flood events during the 2020 monsoon season. The project involves cleaning of water channels and construction of sanitary cells at the existing dumpsite for disposal of medical waste due to COVID-19. By leveraging COVID-19 emergency response interventions, SWEEP tackles institutional and infrastructure changes required to upgrade the SWM system in Karachi.

SWM in South Asia Policy Note: Given the rapidly changing SWM scenario in SAR, this upcoming policy note by the SAR's Environment, Natural Resources and Blue Economy (ENB) Global Practice serves as a call for a paradigm shift in waste management. It provides an assessment of the SWM sector in South Asia, highlighting key areas for investment and financing. It also provides policy recommendations for transitioning from a linear 'take-make-waste' economy to a circular economy.

Chapter 2: Identifying Institutional and Policy Gaps in Riverine Management in Pakistan

Institutional and Policy Gaps

The Indus River flows through three provinces in Pakistan: Khyber Pakhtunkhwa, Punjab, and Sindh. Hence, it falls under several geographical jurisdictions and comes under the administrative purview of various Pakistani institutions and departments. The Indus River System Authority (IRSA) is the nodal body at the federal level, responsible for regulating, apportioning, and monitoring water distribution among the three provinces, according to the Water Apportionment Accord (WAA) of 1991. The Pakistan Water and Power Development Authority (WAPDA) is responsible for developing water and hydroelectric power resources, and provincial irrigation departments are responsible for irrigation water delivery and operations and maintenance of infrastructure including the canal networks and barrages. However, these institutions do not have any monitoring systems in place to analyze levels of plastic pollution in the Indus River Basin. The provincial irrigation departments routinely remove solid waste, including plastic waste, from canals during annual maintenance, and transfer it to formal disposal sites.

Policies, laws, and mechanisms for solid waste management (SWM) in Pakistan are not well integrated and fall under the respective mandates of local governments. The focus on reduction of plastic waste is relatively new, and most existing policies and laws do not specifically mention plastic pollution. Furthermore, there are multiple challenges associated with implementation, monitoring, and enforcement of related legislation and policies at all three levels of governance—federal, provincial, and local. This is a recurring theme that has been identified during policy review and stakeholder consultations. A list of relevant federal and provincial policies and legislation is provided in Appendix 1.

Pakistan is a signatory to various international environmental treaties and agreements. The Government of Pakistan Ministry of Climate Change (MoCC) is responsible for incorporating the terms of these treaties and agreements into effective government policies and for passing national legislation, while also monitoring and reporting adherence to these commitments. Even though climate change is a provincial subject, the MoCC is responsible for drafting laws and legislation on the environment, simply on account of Pakistan's multilateral treaty obligations. However, MoCC and the federal Environmental Protection Agency (EPA) have serious capacity issues in terms of human resources and institutional sovereignty. The same is the case with provincial Environmental Protection Departments (EPDs), which are responsible for implementation of laws and policies at the sub-national level, pertaining to environmental pollution including plastic waste pollution on land and in rivers.

There is a growing trend of plastic waste imports in Pakistan, recording a growth rate of 30 percent in 2018, after many countries, particularly China, banned plastic waste imports. Pakistan imported around 65,000 tonnes of plastic waste from January to April 2020. The imported plastic waste includes hospital waste, end-of-life sewerage pipes, contaminated chemical containers, and other hazardous materials, mainly from Belgium, Canada, Germany, Saudi Arabia, and the United Kingdom. These imports have been reported to be made through formal entry points in violation of the Import Policy Order obligations and commitments made under the Basel Convention. Plastic waste shipments are being permitted into the country without valid documents, such as pre-shipment inspection certificates from exporting countries as defined in the Convention (Abbas 2020).

After the 18th Amendment to the Constitution in 2010, environmental protection and irrigation devolved from the federal level to the provincial level. The responsibility of SWM in Pakistan lies with local governments, and national-level policies and institutions do not deal with the subject directly, except as a part of overall environmental management and policy linkages. Data on provision of waste collection services are widely collected by the Pakistan Bureau of Statistics, which suggests that even in urban areas, 43 percent receive no waste collection (PBS 2015).

SWM is a provincial subject for policy making and legislative purposes. Local governments or their designated utilities are responsible for executing waste collection, disposal, and management of wastes, including plastics. Local governance systems for SWM in the three provinces through which the Indus River traverses also vary. For instance, in Punjab, SWM companies are separate from water supply and sanitation utilities. In Sindh, SWM services fall under the umbrella of the Sindh Solid Waste Management Board and are separate from water supply and sanitation utilities. However, in Khyber Pakhtunkhwa, water and sanitation services companies (WSSCs) are responsible both for solid waste as well as water supply and sanitation services. Municipal corporations, town/*tehsil* municipal administrations (TMAs), and *zila* councils are responsible for SWM in towns and cities. However, separate companies have been formed only in five major cities in Punjab and Khyber Pakhtunkhwa to collect and dispose of waste generated in cities. NGOs, such as WWF and Amal, are increasingly working to improve public awareness on plastic reduction and recycling in Pakistan. Figure 2.1 summarizes the waste management governance structure at the federal, provincial, and local levels in Pakistan.

Figure 2.1: Waste management governance structure in Pakistan

FEDERAL LEVEL	PROVINCIAL LEVEL	LOCAL LEVEL
MoCC (Multilateral environmental agreements; overall guidance on environmental policy making at federal level)	EPDs (Monitoring and implementing agencies for environmental regulations)	TMAs (City councils collect and manage solid waste and other local functions)
Pak-EPA (Environmental law-making body)	Local government departments (Supervisory function of local government agencies)	WMCs/WSSCs (Government-owned specialized companies perform SWM functions on behalf of TMAs)
IRSA (Supervisory role to implement water distribution as per WAA)	Irrigation departments (Water distribution and management through canals and headworks)	WASAs (Provide water and sanitation services in large cities)
WAPDA (Hydropower and water resources development)		

Pakistan introduced its overarching Environmental Protection Act in 1997, yet since then plastic and wider waste management policies and regulations have been largely limited to introduction of state-level bans for thin single-use plastic bags (less than 15 microns), which have now been introduced across the country but are largely ineffective. Guidelines for solid waste management were drafted in 2005 but have not been introduced or implemented. Climate change strategies now exist at the provincial level and include waste management. The federal EPA and provincial EPDs and MoCC are working together under the government's 'Clean Green Pakistan' initiative that is expected to strengthen legislation, including on plastic waste. There is also a need to broaden the monitoring scope of IRSA to include water pollution. This is necessary as water pollution has become an emerging intrastate and interstate issue worldwide in recent times.

Effectiveness of Laws and Policies to Manage Plastic Pollution in Pakistan

Lack of implementation and ineffectiveness of existing policies and laws have resulted in an increase in plastic pollution. Since the adoption of the 18^{th} Constitutional Amendment, provinces are responsible for the development of polices as well as their implementation to manage plastic pollution. However, if current policies are compared to key actions required to control plastic pollution, the result shows limited effectiveness and poor controls (Table 2.1).

Table 2.1: Effectiveness of existing policies and laws to manage plastic pollution

Key action to control plastic pollution	Effectiveness
Ban on single-use plastic bags	*Limited* Periodic spurts of implementation can be seen in main cites (e.g., Islamabad, Lahore, Karachi) but there is negligible implementation in intermediate and small cities.
Ban on open dumping	*None* In every city there are one or more open dumpsites, usually found along river banks.
Ban on dumping of untreated sewage into rivers	*None* Municipal departments (WASAs and TMAs) have failed to develop and manage water treatment plants resulting in dumping of city sewage directly into rivers without treatment. The recently promulgated Punjab Water Act (2019) and Khyber Pakhtunkhwa Water Act (2020) have made it mandatory to procure a disposal license or approval, respectively, for disposal of wastewater into "controlled water". The implementation of both acts by the respective provincial authorities is yet to commence.
Implementation of two-bin system at source (i.e., waste segregation at the household level)	*None* Municipalities are unable to develop and implement systems to collect source segregated waste. Residents habitually dump commingled waste into municipal bins, resulting in low formal recycling rates.
Development of plastic quality standards	*None* No quality standards specific to plastic manufacturing or further utilization into secondary products have been developed.
Extended producer responsibility (EPR)	*None* Producers are not legally bound to work on or invest in recycling/waste disposal of plastics. The exception to this is the Ban on Polythene Bag Regulations 2019, which allows the manufacture or import of flat polythene bags in the ICT for selected and specified uses subject to the submission of a satisfactory "Recycling Plan".

Stakeholder Mapping

For this study, the Ministry of Climate Change, Ministry of Water Resources, and the federal EPA were identified as enabling stakeholders at the federal level, meaning that they provide an enabling environment for behavioral change and benefits to occur as well as to be sustained over time. Provincial irrigation departments, EPDs, and Forest, Wildlife and Fisheries Departments were considered as enabling stakeholders at the provincial level. At least 10 municipalities and waste management companies (WMCs) were identified along the sampling routes as stakeholders. Consultations carried out within Khyber Pakhtunkhwa included the Peshawar WSSC, Mingora WSSC, and the Khyber Pakhtunkhwa Irrigation Department. Similarly, stakeholders in Punjab included the Irrigation and Forests, Wildlife and Fisheries Departments, and the Lahore WMC. The summaries of the various stakeholder consultations are provided in Appendix 4.

In addition to the above stakeholders, NGOs, private businesses, and trade associations dealing with plastic recycling were considered as supporting stakeholders. These stakeholders contribute to the amount of plastic pollution leaking into riverine and marine environments, and whose behavioral change is directly targeted. While NGOs do not contribute to plastic leakage and as such are not part of the problem, they can be part of the solution, and are thus considered important stakeholders. The analysis of supporting and enabling stakeholders is provided in Tables 2.2 and 2.3, respectively.

Table 2.2: Analysis of supporting stakeholders

Relevant initiatives/programmatic areas	Gaps in programs/project design and implementation
NGOs working in the fields of plastic pollution, biodiversity, and environmental conservation (e.g, IUCN, WWF-Pakistan)	• Focus mainly on raising awareness and knowledge for conservation purposes • Lack capacity to run sustainable projects and finance infrastructure development • Programs are limited in size and scope
Recycling companies and associations	Operations are limited in size and scope, thereby constraining efforts to promote recycling and to reduce plastic pollution
Private sector manufacturers	

Table 2.3: Analysis of enabling stakeholders

Primary stakeholders	Governance level	Relevant organizational mandate (Roles and responsibilities)	Gaps in programs, policies, and laws	Gaps in capacity and resources
MoCC	Federal	• Formulates and implements climate change and other environmental policies and programs at the national level, including plastic bans • Monitors adherence to Pakistan's international environmental commitments	• After 18th Constitutional Amendment, primary responsibility shifted to provinces • NCCP and subsequent frameworks do not mention SWM or plastic pollution reduction as a core policy measure	• Limited capacity and resources to monitor implementation of laws and regulations, especially after devolution of responsibility to provinces
Ministry of Water Resources	Federal	• Responsible for development of water resources, Indus Basin works, and IRSA • Processes development programs/projects related to water • Provides inputs in preparation of annual plans • Coordinates with federal ministries, provincial irrigation, and agriculture departments • Monitors water resource development projects	• Water pollution not addressed under its responsibilities	• Multiple authorities with varying jurisdictions working on water resource management, particularly in rivers

Table 2.3: Analysis of enabling stakeholders (contd.)

Primary stakeholders	Governance level	Relevant organizational mandate (Roles and responsibilities)	Gaps in programs, policies, and laws	Gaps in capacity and resources
Federal EPA	Federal	• Department affiliated with MoCC, responsible for implementing PEPA and enforcing environmental laws, regulations, and guidelines • Provides technical assistance to MoCC • Drafts laws and guidelines for EPDs to follow	• New legislation on environment and water pollution needed with updating of PEPA (1997) and NEQS (2001)	• Limited enforcement capacity
Irrigation departments	Provincial	• Monitor and regulate water quality of groundwater and surface water sources • Manage water distribution through canals and non-perennial drains	• Responsibility restricted to irrigation network • New legislation and enforcement mechanisms needed to improve water pollution in irrigation canals in big cities, such as Peshawar and Lahore	• Lack of monitoring equipment on barrages and irrigation canals to record pollution • Lack of capacity to remove and manage plastic waste from irrigation networks
Local government departments	Provincial	• Formulate policies, update laws, and provide guidelines to local governments • Manage and improve municipal infrastructure and services • Enforce municipal laws and regulations • Frame by-laws to regulate municipal services	• Numerous changes to the system in recent decades due to new local government acts • Local laws not amended to meet current ISWM needs • Different institutional frameworks exist in different provinces, and in urban and rural areas	• Funding and capacity improvement programs carried out through development projects, such as the Punjab Intermediate Cities Improvement Program and Khyber Pakhtunkhwa Cities Improvement Program • Limited sustainable development schemes for large areas, especially small towns and rural areas, are limited

Table 2.3: Analysis of enabling stakeholders (contd.)

Primary stakeholders	Governance level	Relevant organizational mandate (Roles and responsibilities)	Gaps in programs, policies, and laws	Gaps in capacity and resources
Forest, Wildlife and Fisheries Departments	Provincial	• Prepare and implement policies and programs in the forestry sector • Implement forestry laws • Protect, conserve, preserve, and manage wildlife • Manage protected areas, wildlife parks, safaris, and zoos • Provide services related to fish farming/aquaculture development • Produce fish seed under controlled conditions	• Lack of programs and mechanisms to monitor and control water pollution for sustainable development of fisheries	• Lack of skilled manpower and technological resources to monitor and implement laws and regulations
EPDs	Provincial	• Administer and implement provisions of PEPA • Prepare and establish PEQS (by Punjab EPD) • Identify needs and initiate legislation related to various sectors of the environment • Provide information and guidance to the public on environmental matters • Specify safeguards to prevent and control pollution	• Environmental laws to be updated to include plastic pollution, including amending and enforcing NEQS	• Limited monitoring and human resource capacity
Urban Policy Units (Punjab, Khyber Pakhtunkhwa, Sindh)	Provincial	• Policy wings for SWM and other urban services	• SWM a core area for policy development, but little progress made in drafting and creating new policies and legislation on ISWM, especially plastics	• Mandate restricted to policy advice • Capacity development units, such as Al Jazari Academy, established in Punjab Province • Policy units in other provinces to be set up

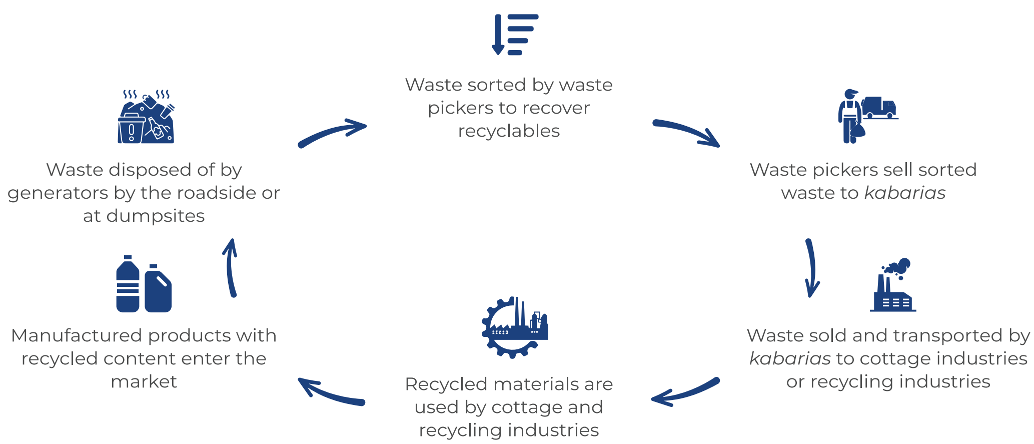
Table 2.3: Analysis of enabling stakeholders (contd.)

Primary stakeholders	Governance level	Relevant organizational mandate (Roles and responsibilities)	Gaps in programs, policies, and laws	Gaps in capacity and resources
Municipal corporations/ Town committees	Local/City level	• Approve master plans, zoning, and land use plans • Implement rules and by-laws for the above • Develop integrated system of water reservoirs, treatment plants, drainage, liquid and solid waste disposal, and sanitation • Enforce municipal laws, rules, and by-laws • Manage municipal infrastructure and services, including water supply and control, sewage, and sewage treatment • Control air, water, and soil pollution in accordance with federal and provincial laws and standards	• Frequent changes in local governance and administration	• Revenue generated not sufficient to cover O&M costs for efficient SWM • Lack of funds and skilled resources hinder adoption of ISWM systems • Lack of infrastructure and capacity for waste-to-energy projects • Sanitary landfills to be developed • Culture of recycling lacking • Villages and small areas yet to be provided SWM services
WMCs	Local/City level	• Deal with SWM in major cities of Lahore, Rawalpindi, Multan, Faisalabad, and Gujranwala, including mobilization for proper disposal of waste at the community level	• Recycling and other waste management options not included in scope	
WASAs	Local/City level	• Responsible for planning, design, and construction related to water supply, sewerage, and drainage facilities in cities	• Monitoring and collection of solid waste (including plastics) from waterbodies not included in scope	

Role of the Informal Sector in Solid Waste Management in Pakistan

The informal sector plays a major role in SWM in Pakistan, comprising individuals (waste pickers) and small businesses *(kabarias)* involved in waste collection, sorting, and recycling dry waste (Figure 2.2). The approximate revenue from the informal waste sector is estimated to be around $1.1 billion (Ashraf et al. 2016). Since formal recycling is very limited in Pakistan, even in the largest cities, the informal sector has numerous complex interlinkages with the public and private formal sectors that require a large bulk of these services. However, these key stakeholders are not represented nor consulted at the time of framing crucial waste management decisions. Although the role of the informal sector is often disregarded, they make vital contributions to waste collection and recycling and help reduce waste management costs in the municipalities they work in. For instance, in Karachi SWM is largely managed by the informal sector, which provides livelihood to over 55,000 families and comprises a trading volume of more than PRs 1.2 billion (Dawn 2003). In Lahore, given the absence of a formal recycling system, the informal recycling sector recovers an estimated 21 percent of all recyclable waste. A study carried out in 2015 estimated that the quantity of recyclable material recovered by junkyards in Shalimar Town, Lahore is about 15.3 tonnes per day (Kamran et al. 2015).

Figure 2.2: Schematic of the informal waste sector in Pakistan



Source: Adapted from World Bank 2021a

Since recycling is primarily being carried out only by the informal sector in Pakistan, it is essential to integrate this sector with the formal sector (Masood and Barlow 2013). The process of formalization would benefit the informal sector by providing access to fair compensation, health benefits, safe working conditions, and social inclusion, while also significantly benefitting the formal waste sector by providing access to valuable recyclables. A study carried out in Bahawalpur City in 2016 assessed the economic contribution of the informal waste sector by analyzing recycling trends and roles of key stakeholders involved in recycling. The study found that recovery activity is profitable for key stakeholders and generates a revenue of approximately PRs 6.05 billion annually (Majeed et al. 2016). Hence, the overall impact of integration will be positive, providing socio-economic, health, and environmental benefits.

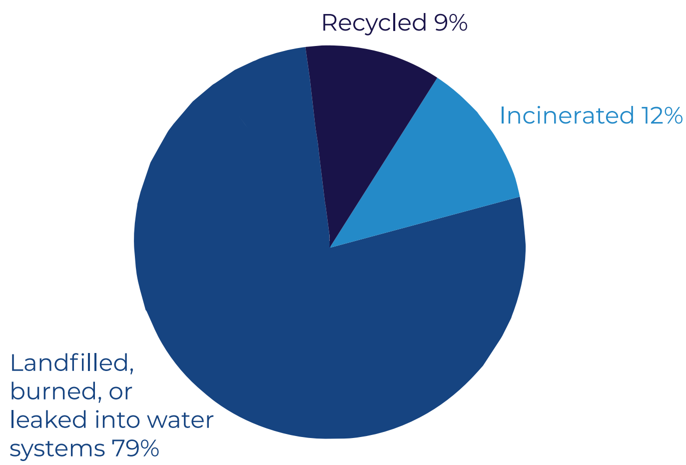
So far, there is no formal integration nor support from the government. Initiatives to encourage recycling and support waste picker communities have been implemented mostly at small scale, often by grassroots organizations. For example, an NGO ‘Faces Pakistan’ has supported the Afghan waste picker community in the Saggian area and opened a school. The ‘Aabroo Educational Welfare Organization’, a non-profit initiative in Eastern Lahore founded in 2003, has set-up a waste collection system for 8,000 households, and covered educational expenses for about 8,000 underprivileged children with revenue earned from recycling (EJ Atlas 2020).

Chapter 3: Assessing the Impacts of Plastic Waste on Riverine Environments

The Plastics Problem

Plastics are so pervasive in modern-day living that it is impossible to imagine a world without them. Since the 1950s when commercial plastics were first introduced, their production has increased exponentially. The properties of plastics that make them suitable for a wide range of applications and increase their durability also make plastic waste a ubiquitous problem. As a result, plastics are found everywhere—on every continent and in every ocean. Plastic production has shifted significantly from reusable plastics towards single-use plastics, such as bags, straws, and bottles. About one-third of the plastic produced worldwide is used for packaging. Roughly 368 million tonnes of plastics are generated globally each year, and it is estimated that since the 1950s, over nine billion tonnes of plastics have been produced globally, of which only nine percent has been recycled, 12 percent incinerated, and the remaining landfilled, burned, or leaked into freshwater and marine ecosystems (Figure 3.1, Tiseo 2021; Hamblyn 2019; Jambeck et al. 2015).

Figure 3.1: Disposal of plastics since the 1950s



Sources: Hamblyn 2019; Jambeck et al. 2015

Plastics pose a peculiar problem in terms of waste management. Unlike other types of waste, plastics have a lifespan extending hundreds of years. Some scientists are of the opinion that plastics never fully disappear (unless burned or incinerated), but break down into smaller and smaller particles called nanoplastics (0.001–0.1 μm in size), thus posing a long-term threat to the environment, ecosystems, and human health (Derraik 2002; Thompson et al. 2004; Rochman et al. 2015; Conchubhair et al. 2019).[2] The prolonged life of plastics and their ever-increasing production means that plastic pollution is likely to grow, unless concerted effort and funding are directed towards solid waste management (SWM) sector reform (Figure 3.2).

Figure 3.2: Impacts of plastics on the environment, human health, and economy

ENVIRONMENTAL IMPACTS	HUMAN HEALTH IMPACTS	ECONOMIC IMPACTS
Creates riverine and marine litter	Chemical additives such as BPA and phthalates leach into the water, causing serious health effects	Clearing of blocked sewerage and drainage systems is expensive for city administrations
Contributes to climate change	Chemicals in plastics migrate from packaging into foods	Negatively impacts tourism industry
Causes injury and death to aquatic life	Toxins pollute drinking water in surface and groundwater reservoirs	Negative impact on fisheries and blue economy in general
Microplastics are injested by fish, thus entering food chain	Microplastics enter the body via direct exposure to plastics through contact, ingestion, or inhalation	Increase in water treatment costs

2 A micron or micrometer, denoted by the symbol μm, is a unit of measure for length equivalent to 0.001 mm.

Unfortunately, Pakistan is not an exception to the plastics conundrum. The problem of plastic waste, particularly in low- and middle-income countries, is directly linked to poor SWM systems. Inadequate or irregular collection of waste, coupled with poor treatment and disposal practices results in plastic litter everywhere—open and abandoned areas, drainage systems, river banks, canals and rivers, beaches, and mountains. Thus, this waste has a high probability of leaking into the environment and reaching the ocean through waterways. In addition, it has been estimated that Pakistan's contribution to mismanaged plastic waste globally in 2019 was 2.18 percent (Meijer et al. 2021).

Plastic waste management has been gaining a lot of attention in Pakistan in recent years, with consumption of plastics growing rapidly and contributing significantly to land-to-water pollution. This has led the government to take certain actions, such as the ban on single-use plastic bags in Islamabad issued in August 2019 (Dawn 2020); however, enforcement of the ban is weak. According to WWF-Pakistan, 65 percent of waste that was found along river banks included water bottles, plastic caps, plastic bags, and packaging materials (WWF-Pakistan 2021). In this way, plastics have become a prime source of water and land-based pollution in the country.

Plastics in Riverine Environments

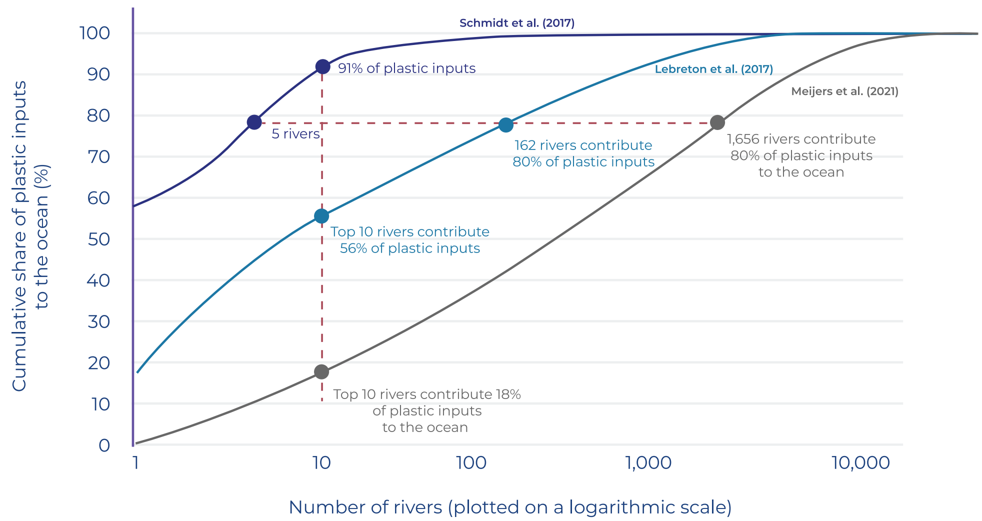
It is well documented that over 80 percent of plastics in the oceans originate from land-based sources, while less than 20 percent of leakage originates from ocean-based sources like fishing vessels (McKinsey Center for Business and Environment 2015). A staggering 8-10 million tonnes of plastics end up in the world's oceans every year (Jambeck et al. 2015; Boucher and Billard 2019). How much of this comes from rivers is debatable. Research shows that rivers are responsible for 1.15 million to 2.41 million tonnes per year of plastic waste in the oceans globally (Lebreton et al. 2017). Previous studies suggest that most plastics in the oceans come from a handful of rivers: 10 rivers alone carry 90 percent of the plastic waste that ends up in the oceans (Jambeck et al. 2015).

New research, however, challenges these assumptions. Meijer et al. (2021) suggest that smaller rivers play a much larger role than previously thought. They propose that emissions of river plastic waste into marine environments are a much more distributed problem than previously thought, and many urban drainage systems and smaller rivers emit several orders of magnitude of plastic waste into the oceans. Figure 3.3 compares this new research with two previous studies. The top 10 rivers (in which the Indus River ranked second) contribute a much smaller amount than previously thought: just 18 percent of plastics compared to 56 percent and 91 percent from previous studies (Ritchie 2021). On the other hand, 80 percent of marine litter originating from river sources come from 1,656 rivers (Meijer et al. 2021). The reason for this deviation in estimates is the use of higher-resolution data, modeling how plastic is transported using wind and precipitation patterns, river discharge data, proximity of populations to the river, distance to the ocean, the slope of the terrain, and types of land use (Tramoy et al. 2019).

It is well understood that the main source of plastic in riverine and marine environments is from human activity and land-based sources. Plastics in rivers show high correlation with population density, urbanization, wastewater treatment, and solid waste management (van Emmerik and Schwarz 2020). Plastic waste enters rivers through three avenues:

- *Natural transport:* This includes processes such as wind and rainfall-induced surface runoff

Figure 3.3: Plastic input from rivers into the world's oceans



Source: Adopted from Ritchie 2021

- *Direct dumping:* This includes dumping of solid waste on river banks or directly in the river and littering in recreational areas along river banks
- *Indirect dumping:* This includes transport of plastic to rivers through municipal wastewater and industrial wastewater discharges as well as agricultural return-flows through drainage structures.

The transport of plastic debris in rivers is influenced by several hydrological factors such as water level, flow rate, discharge, turbulence, direction, and velocity. These factors affect the mobility of plastic waste in a number of ways, such as:

- Where flow velocity tends to be high, most plastic is found to be afloat
- High water flow rate has the potential to dilute plastic concentration in rivers (Tramoy et al. 2019)
- Plastics tend to accumulate in estuaries and deltas, where the river meets the sea, owing to bidirectional flow due to the influence of tides and winds
- Floods, extreme rainfall, and other extreme natural events transport significant quantities of submerged plastic debris (UNEP 2020).

All these factors play an important role in transporting plastic waste that normally accumulates on river banks, neighboring freshwater bodies (for example, lakes), man-made infrastructure (for example, dams and barrages), and areas with significant aquatic vegetation (for example, mangrove forests) (van Emmerik and Schwarz 2020).

It is important to note that that not all plastic waste found in rivers makes its way to seas and oceans. Almost 99 percent of plastic in rivers is reported to be 'lost' and is not found in the ocean. Hence, the driving mechanisms for transport of plastics from upstream to downstream of a river need to be considered to accurately evaluate plastic transfer into marine environments (van Emmerik and Schwarz 2020).

The fate of plastic waste also depends on its properties. Likelihood of dispersion, accumulation, sedimentation, and degradation of plastics mainly depend upon polymer type, shape, size, composition, and other characteristics of plastic materials (UNEP 2020). Hence, identifying the plastic polymer is crucial to predict the fate and effect of particular plastics on the environment. For instance, high-density plastics tend to sink more easily than low-density plastics; thin plastics, with larger surface areas, tend to accumulate mud and growth of microorganisms, thus becoming heavier; and floating and beached plastics tend to degrade faster in the presence of sunlight compared to submerged plastics (Tramoy et al. 2019).

While plastic waste in rivers is one of the largest contributors to marine pollution, its impacts on local riverine environments themselves must not be underestimated. Research on the impacts of plastics in waterbodies primarily focus on marine ecosystems and oceans, while research on plastics in riverine environments is comparatively limited, despite its many impacts on human health and climate resilience, for example, through clogging of urban drains upstream of rivers, leaching of toxins into drinking water sources, and degradation into microplastics and nanoplastics. Of course, the impacts on aquatic health are equally concerning, similar to concerns around marine plastic pollution. A few studies on plastic pollution in rivers indicate ingestion rates by fish and other aquatic species of up to 33 percent in Brazil's Goiana River. In France and Switzerland, plastic has been found in birds and fish with ingestion rates amounting to 12.5 percent (van Emmerik and Schwarz 2020). The impacts of ingestion include gut obstruction leading to starvation and other digestive issues, changes in behavior, impaired growth, and effects on reproduction. As with ingestion in marine environments, toxic contaminants in plastics can move up the food chain in riverine environments as well.

Assessing Plastics in Riverine Environments

The study of river pollution assessment is still nascent and evolving. The United Nations Development Programme (UNDP) has recently published guidelines on harmonizing guidelines on assessing macroplastic debris in freshwater systems, that is, rivers and lakes (UNEP 2020). Studies on quantification of riverine plastic pollution reveal six broad methodologies, combinations of which are used widely around the world: (1) Active sampling through the use of a litter boom in the river or canal, (2) passive sampling, by collecting waste on foot, (3) visual observation, (4) remote sensing using drone technology, (5) plastic tracking, and (6) using existing municipal data. Each approach has its advantages and limitations, which are summarized in Table 3.1.

Active sampling: This is the most direct technique to monitor macroplastic pollution in waterbodies and quantifies moving—mainly floating or superficially suspended—plastics in rivers. Common sampling techniques include deploying net trawls or booms from bridges or boats and sampling sediments. These techniques have been used in various studies to conduct both quantitative as well as qualitative analysis of plastic debris. Small nets released from bridges or boats have been commonly used to monitor plastic debris in rivers. For larger sample sizes and to collect debris during high discharge conditions, nets have also been deployed from bridges using cranes; however, this tends to be more resource-intensive.

Passive sampling: This refers to sampling river banks by foot, in which all the waste in a selected area is collected, weighed, and segregated to understand the characteristics of the waste deposited along the river. This can also be used to study the occurrence of illegal dumpsites.

Visual observation: This sampling method is used to quantify plastic flux or stock in rivers, usually carried out by visually counting the amount of floating and superficially submerged plastic litter for a specific period of time, often from a bridge. The results can be used to quantify the plastic transported by the entire river at a given moment in time and its distribution over the width of the river.

Remote sensing using drone technology: In this method, unmanned aerial vehicles (UAV) or drones mounted with cameras are used to measure plastic flux and stock in a river as well as to identify plastic hotspots. Machine learning algorithms have been developed to automatically detect, categorize, and quantify marine plastic debris from images, as in the case of Cambodia, where aerial surveys were conducted in Phnom Penh, Sihanoukville, and Siem Reap (Wolf et al. 2020). Camera technology based on near-infrared imagery and particle tracking software have also been used to identify and track floating plastic debris in rivers.

Plastic tracking: In this method, global positioning system (GPS) is used to track the travel path of tagged plastic items in rivers. It enables monitoring of pathways taken by floating and submerged plastic debris. While it provides accurate data regarding flow path, plastic retention time, and remobilization based on various hydro-meteorological conditions, it is time consuming.

Existing municipal data: In this method, plastic debris is quantified using existing municipal waste generation and disposal data. Urbanization rate and population density, combined with solid and liquid waste management practices in the area, influence levels of plastic pollution in rivers. Most models generally use mismanaged plastic waste data to estimate plastic transport and discharge into waterbodies.

Table 3.1: Advantages and limitations of various sampling methods for plastic litter in rivers

Sampling Method	Advantages	Limitations
Active sampling (Litter boom)	• Cost effective • Equipment is easy to transport • Allows frequent and flexible measurements at different locations across the river width	• Easily influenced by external factors such as weather conditions • Difficult with heavy boat traffic • Can only be used effectively between certain flow velocities[3] • When sampling is done using net trawls, results can vary based on mesh sizes
Passive sampling (Foot survey)	• No technical equipment required • Inexpensive	• Laborious and time consuming
Visual observation	• No equipment required • Allows frequent and consistent measurements over time • Cost effective	• Time consuming • Expertise and experience of observers might affect how observations are recorded and uncertainties are introduced through possible observer bias • Location choices are limited, particularly for wide rivers • Bridge height and turbidity of river affects affect counting
Remote sensing using drone technology	• Provide measurements on a higher spatial and temporal scale • Easy to carry out the study on the field • Less time consuming	• Technical skill and expertise required • Expensive compared to some other technologies • Permissions may be required • May not be suitable for sensitive areas such as near military installations and private areas
Plastic tracking	• Provides accurate data on a number of parameters • Precise measurement • Monitors both floating and submerged plastics	• Expensive compared to some other technologies • Technical skill required in setting up and monitoring GPS trackers • Long duration required
Existing municipal data	• No equipment required • Cost effective • No scientific knowledge required	• Only reliable if data collection is quality assured and trusted • Laborious

Sources: van Emmerik and Schwarz 2020; Tramoy et al. 2019; Meijer et al. 2021

3 For higher flow velocities (>1 meter per second), the forces can become too high, and for low flow velocities, the forces are too low to keep the net horizontal and to collect plastic.

Chapter 4: Quantifying Plastic Waste in the Indus River Basin

Despite the global concern of plastic pollution being a threat to aquatic ecosystems, useful and reliable data on plastic litter in freshwater environments is limited. This report presents the first-of-its-kind field survey undertaken along the Indus River Basin to quantify the amount of waste, particularly plastics, leaking into the river system. Nine sampling sites were studied using a combination of methodologies described in Chapter 3. This chapter describes the sites selected for the survey, methodology used, key findings, and analysis of the results. Detailed information regarding the survey methodology and data are provided in Appendices 2 and 3 of this report.

Site Selection

Nine sampling sites were selected for the study based on multiple criteria including geographical location, population dependent on the river, tourism or industrial activity, and transboundary importance. Sites were selected along the tributaries of the Indus River as well as on the Indus itself (Figure 4.1), encompassing the entire Indus River Basin. Table 4.1 summarizes the sampling sites and criteria for selection.

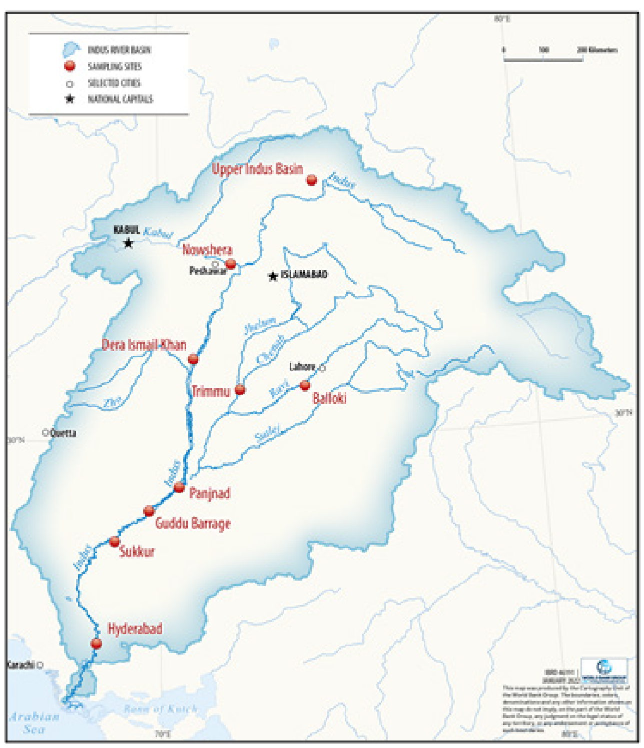
Table 4.1: Sampling sites and criteria for selection

Sampling site	Province/Area	River/Barrage	Criteria for selection
Sampling site	**Upper Indus Basin**	• Confluence of Ghizer and Indus rivers • No barrage	• Major population center in the area • Tourism hotspot
Nowshera	**Khyber Pakhtunkhwa**	• Kabul River • No barrage	• Kabul River is a major Western tributary of the Indus River and carries pollution load from major cities of the province before its confluence with the Indus downstream of this site • Transboundary and interprovincial significance for potential water-sharing treaty with Afghanistan • Tourism hubs of Chitral and Swat are located upstream of this site
Dera Ismail Khan	**Khyber Pakhtunkhwa**	• Indus River • No barrage	• The last major city of Khyber Pakhtunkhwa Province on the banks of the Indus River before the river passes through Punjab Province • Important in terms of data on plastic pollution carried from Khyber Pakhtunkhwa into Punjab • Western tributaries from Bannu and Karak join the Indus River upstream of this site
Trimmu	**Punjab**	• Confluence of Chenab and Jhelum rivers • Barrage	• Point of confluence of Jhelum and Chenab, two largest tributaries of the Indus River • Located near important towns for trade, industrial, and agricultural activities draining into Indus tributaries

Table 4.1: Sampling sites and criteria for selection (contd.)

Sampling site	Province/Area	River/Barrage	Criteria for selection
Balloki	**Punjab**	• Ravi River	• Heavily-polluted transboundary Hadiara Drain and Ravi River are located upstream of this site • Lahore, the second most populated city in Pakistan, drains its wastewater into Ravi River that is carried to Balloki
Uch Sharif (Panjnad)	**Punjab**	• Confluence of eastern tributaries (Sutlej and Ravi rivers) • Barrage	• Large cities of Bahawalpur and Multan located upstream of this site • Transboundary significance as water from Ravi and Sutlej Rivers are allocated to India • Important in terms of plastic pollution data for Punjab Province
Guddu Barrage	**Sindh**	• Panjnad confluence • Barrage	• Situated at Punjab-Sindh boundary, providing insight into each province's share of plastic pollution entering the Indus • All major cities and tourism hubs along the Indus and its tributaries are upstream of this location
Sukkur Barrage	**Sindh**	• Indus River • Barrage	• Major tourist hub along an important trade and transportation route
Hyderabad	**Sindh**	• Indus River • Barrage	• Second most populated city in Sindh Province • Tourist areas of Sehwan and Manchar Lake drain into the Indus River at this point • Situated at the point before Indus River forms a delta and divides into distributaries; hence, important to obtain accumulated pollution data flowing to the Arabian Sea • Major tourist hub, important for industry and trade

Figure 4.1: Sampling site locations along the Indus River Basin



Methodology

The objective of this study is to quantify the amount of solid waste, particularly plastics, found in and around the Indus River system in order to determine the quantity of plastics that are transported to the Arabian Sea or carried through the vast irrigation network to other parts of the country.

In order to accomplish this, a two-step process was followed (Figure 4.2). Firstly, primary and secondary data was collected through a field survey on the amounts of plastics found at various points along the river system. This was followed by an effort to calculate and quantify the plastic load in the river, using both primary data for plastic concentration, as well as hydrological data collected for each site through stakeholder consultations. Each of these processes is described in further detail below (Table 4.2).

Data collection during the field survey included the following steps: Drone imagery, active sampling, passive sampling, and segregation and quantification of wastes (Figure 4.3).

Figure 4.2: Summary of methodologies used in this study

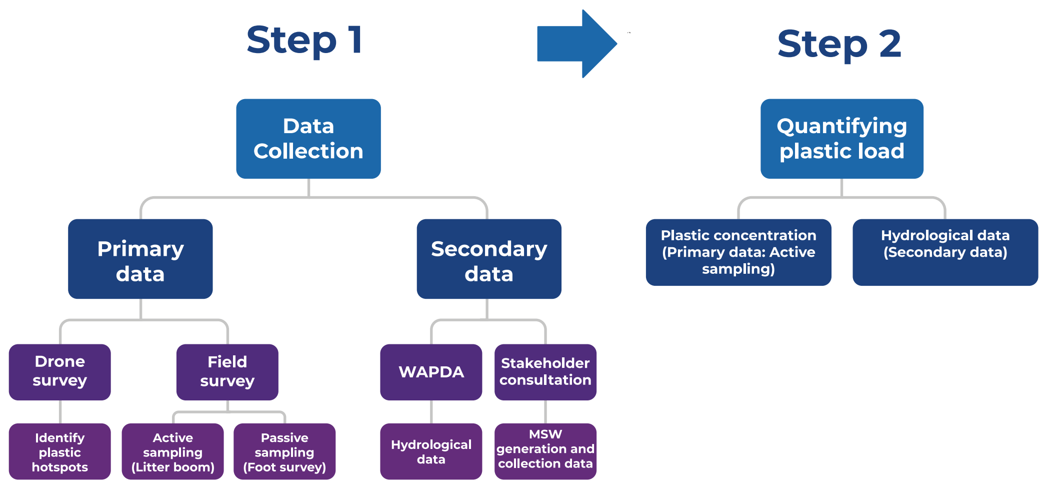


Figure 4.3: Steps in the field survey for this study

Table 4.2: Summary of field survey methodologies for this study

Drone survey	Active sampling	Passive sampling
• Used to identify plastic pollution 'hotspots' at selected sampling locations • Enabled targeting of particular sampling sites based on criteria such as accessibility	• Use of floating litter boom to capture waste flowing downstream • Litter boom was designed to capture litter greater than 2.5 cm in size • Litter boom was used for three consecutive days, for eight hours per day, at all locations • Waste collected was separated into various categories (Appendix 2), and quantified by type • Plastics were further separated and quantified by type of polymer (Appendix 2)	• Conducted on the banks of the river, 20 m inland of the river, 1 km upstream and 1 km downstream • Waste collected was separated into various categories (Appendix 2), and quantified by type • Plastics were further separated and quantified by type of polymer (Appendix 2)

Data Collection

The field survey was conducted across nine locations along the Indus River and its tributaries, spanning 2,032 kilometers. Sampling sites ranged from the Upper Indus Basin, to the southernmost point in Hyderabad, Sindh Province (Figure 4.1).

The field survey adopted a mixed method approach for data collection, initially using drones to identify plastic pollution 'hotspots', followed by active and passive sampling at the selected sites. Active sampling, which involves the use of a floating litter boom, captures the culmination of waste from multiple point and non-point sources upstream. Significantly, the waste represents the quantity of leakage only from the previous sampling site and not an accumulation of waste from the first sampled site (except for the northernmost sampling site in the Upper Indus Basin). This is crucial because it also signifies that there are a number of 'sinks' along the Indus River system, most notably barrages where water is diverted into canals. All rivers in the Indus River system are transboundary, originating in neighboring countries before joining the Indus River and eventually ending at the Arabian Sea. It was beyond the scope of this study to investigate whether the waste in rivers originated from within the borders of Pakistan or its neighboring countries. While there may be waste from transboundary areas, it is not possible to determine what is domestic and what is not.

Passive sampling at the sites represents the local waste generated at a particular place. During high flow season, it is possible that a portion of this dumped waste along the banks of the river escapes into the river and becomes part of active sampling further downstream.

Importantly, this mixed method approach of employing both active and passive sampling provides an important glimpse at a particular point in time of the litter along this riverine system: Active sampling shows the amount of solid waste pollution that has already found its way into the river, whereas passive sampling tells us about local pollution ending up along the banks that may potentially enter the river system.

Quantifying Plastic Load

The next step of the study involved quantifying the estimated plastic output from the Indus River and its tributaries, based on the data collected during the field survey (that is, through active and passive sampling). Under optimal conditions, the estimation would be based on a year-long survey of plastic waste data and hydrological flow data. This is especially important for a river such as the Indus, which has significant variations in flow rate throughout the year, and one that has significant water withdrawals on account of irrigation and other uses. However, given the time constraints of the overall study, it was necessary to extrapolate the results from the field survey using available hydrological data.

To estimate the plastic load in the Indus River and its tributaries, a plastic transportation model used in the study of plastic pollution in the Saigon River in Vietnam by van Emmerik et al. (2019) was applied. This model uses plastic concentration measured through litter booms as an input and extrapolates this information based on the discharge rates of the river, that is, the volume of water per unit time that passes through the sampling sites.[4] The result or output is the total plastic load for a given period, calculated as the product of plastic concentration and the discharge rate for the same period. Hydrological data was obtained from public authorities, primarily from the Pakistan Water and Power Development Authority (WAPDA).

Results

Several important conclusions can be drawn both from the field survey as well as the modeling to quantify plastics in the Indus River system. These are summarized below.

Field Survey Results

Results from the field survey, which included active and passive sampling, are summarized in Table 4.3 and Figure 4.4. Site-wise data are provided in Appendix 2. Limitations of the field survey are summarized in Box 4.1.

Table 4.3: Summary of key findings from active and passive sampling

Indicators	Active sampling	Passive sampling
Total waste collected from all sites (kg)	27,247	2,087
Average amount of waste collected per site (kg)	3,027	232
Total amount of plastics collected at all sites (kg)	10,772	922
Average amount of plastic collected per site (kg)	1,197	102
Plastics as a percentage of total waste	39.5%	44.2%
Site with highest quantity of plastics (kg)	Hyderabad	Dera Ismail Khan
Site with plastics as the highest percentage of total waste	Upper Indus Basin: 53% Dera Ismail Khan: 51%	Upper Indus Basin: 3 60%
Site with lowest quantity of plastics (kg)	Guddu	Uch Sharif
Site with plastics as the lowest percentage of total waste	Guddu: 34%	Uch Sharif: 30%
Most prevalent type of plastic found	LDPE	LDPE
Most prevalent type of plastic as a percentage of total plastic	49%	37%
Least prevalent type of plastic found	HDPE	HDPE, PP
Least prevalent type of plastic as a percentage of total plastic	1%	2% (each)

4 Plastic concentration is a measure of the mass of plastic in a given volume of water (for example, kilogram per cubic meter).

Box 4.1: Limitations of the Field Survey

The field survey presented a number of challenges. These can be broadly categorized as methodology-related or extraneous to the survey itself. These limitations are listed below:

Limitations linked to survey methodology:

- The relatively short duration of the study limited the ability of researchers to collect sufficient data.
- Data collection for varying river flow was limited by the short time span. Data was collected during the winter season in low-flow months. Thus, the findings do not address seasonal variations in flow rate nor variations in plastic flow.
- The design and development of floating litter booms was innovative and unprecedented for Pakistan, and was adapted to suit the local geographical and seasonal context.
- Dimensions of the litter boom result in variations in the amount of waste captured; at low flow the boom might capture more waste, whereas at higher flow a lot of it could escape.
- Only surface waste was collected as part of this survey, which does not look at suspended or sunken waste (height of litter boom was approximately 130 cm).
- Hydrological and SWM data are limited and difficulties were experienced in gathering data from relevant agencies. For instance, municipal authorities do not collect or maintain accurate data related to SWM.
- The survey did not take into account waste leaving the river system and moving into the irrigation system through canals.
- The survey did not consider the amount of waste from outside the country, that is, transboundary pollution entering Pakistan.
- The study did not take into account barrage operations and schedules, which are determinants of how much plastic waste passes through these structures at a given point in time and continues downstream. For example, if barrage gates are being operated to divert water into canals, it will serve as a 'sink' and reduce the quantity of plastic waste that would otherwise have continued being transported by the river.

Limitations extraneous to field survey:

- Various security-related issues created delays in acquiring clearances from authorities and required coordination with relevant agencies, which was a slow and cumbersome process.
- Harsh weather conditions, such as fog, restricted movement of the sampling team causing delays.
- Lockdowns amid the COVID-19 pandemic restricted the survey team's mobility.

Figure 4.4: Composition of waste from active and passive sampling

	Active sampling (kg)	Passive sampling (kg)	Average (%)
Plastic	10,773	924	39.88%
Green waste	7,159	520	26.18%
Textile	4,234	214	15.16%
Tetra Pak	1,946	136	7.10%
Organic waste	1,576	107	5.74%
Leather and rubber	848	91	3.20%
Miscellaneous	541	43	1.99%
Domestic hazardous waste	138	23	0.55%
Glass	26	15	0.14%
Metal	6	7	0.04%
Paper and cardboard	0	7	0.02%

- **Plastics constitute 40 percent of the waste collected from the Indus River system.** Whether in the river or along the banks, plastic waste is overwhelmingly greater in actual value (kilograms) as well as in proportion to other waste types in all locations. From active sampling, Hyderabad and the Upper Indus Basin show the highest quantity (in kilograms) of plastic, while proportionately the Upper Indus Basin and Dera Ismail Khan ranked the highest. This is expected as Hyderabad had the highest recorded total waste in the river. The higher quantity of plastics in the Upper Indus Basin may be due to the fact that in the winter months—when the study was conducted—little or no transport of recyclables takes place due to road closures following snowfall and landslides. Also, the Upper Indus Basin has more plastic waste in the river itself than on the banks of the river. The high rank of Dera Ismail Khan is also unsurprising as the population residing along the river bank here is higher in comparison to other sites in the survey. Local residents use the river bank as a recreational area, to feed and maintain their livestock, wash clothes, dump domestic waste, and so on. Field survey results by site location have been given in Figure 4.5.
- **Macroplastic pollution does not accumulate in a linear way from upstream to downstream.** The Indus River passes through a series of barrages and reservoirs and feeds a wide network of irrigation canals. Hence, it is expected that a significant part of the plastic waste is transported through these canals, ultimately accumulating in canal beds, agricultural land, or other sinks. This is supported by the observation that irrigation authorities are often tasked to remove accumulated waste from canals. As this accumulated waste remains mostly uncollected, it will eventually degrade into smaller particles, increasing the presence and risk of microplastics and nanoplastics. This stresses the need for studies on plastic sinks along rivers to complement research on plastic hotspots along rivers.
- **Green waste is not considered a significant pollutant, despite being the second largest waste fraction found.** Green waste constitutes 25 percent of the total solid waste collected during the survey, and is the second largest waste fraction found in this study. However, green waste, such as branches and leaves, is naturally found in and around rivers and freshwater bodies and does not necessarily have an anthropogenic origin. Moreover, since green waste is biodegradable, it is not considered a significant pollutant in rivers.

Figure 4.5: Field survey results by site location

Sampling site	Total quantity of waste collected (kg)	Share of total waste collected (%)	Total quantity of plastic waste collected (%)	Share of total plastic waste collected (%)
Sampling Site, Upper Indus Basin	3,013	10	1,621	14
Nowshera, Khyber Pakhtunkhwa	3,819	13	1,399	12
Dera Ismail Khan, Khyber Pakhtunkhwa	2,015	7	1,002	9
Trimmu, Punjab	3,269	11	1,214	10
Baloki, Punjab	4,066	14	1,507	13
Uch Sharif, Punjab	2,632	9	931	8
Guddu, Sindh	2,435	8	852	7
Sukkur, Sindh	3,967	14	1,495	13
Hyderabad, Sindh	4,118	14	1,673	14

Indus River

High Value — Low Value

- **Textile waste is the third most significant waste type, which also contributes to plastic pollution in the Indus River system.** Sixty percent of apparel fibers consumed globally are synthetic in nature, containing plastic polymers such as nylon, acrylic, polyester, and polyamide. The usage of synthetic textiles is higher in developing countries given their durability and affordability. Incidentally, the textile industry is the fourth largest consumer of plastic in Pakistan, consuming 280,000 tonnes of plastic annually. The textile industry is also responsible for 13 percent of plastic waste generated in the country (World Bank 2021c). In addition to their contribution to macroplastic pollution, synthetic textiles also release significant quantities of microplastic fibers while washing. Thirty-five percent of microplastics in the ocean have been found to originate from synthetic textiles (Resnick 2019; Stanton 2019).
- **Proportion of high-value recyclables (for example, metal, glass, paper, and cardboard) is low.** Metal and glass contributed less than one percent of total solid waste collected, primarily because most of these materials in the solid waste stream would have been reclaimed by the informal sector. In addition, they are denser and tend not to float in water, thus would not be easily captured during active sampling using a litter boom.
- **No significant variation found in composition of plastics from active and passive sampling, except for low-density polyethylene** (**LDPE).** Although there is no significant variation in quantities of most plastic types found in active and passive sampling, LDPE constitutes almost 50 percent of total plastic waste collected using floating litter booms, while it constitutes only 37 percent of plastic waste collected from the river bank. This is primarily because of the difference in sampling methodology, where active sampling captures light-weight floating materials, characteristic of LDPE, carried downstream by the river, while denser materials tend to get washed up on to river banks. Table 4.4 shows the share of plastics collected during the field survey, the ease and possibility of recycling, and the status of recycling of the particular plastic polymer in Pakistan.

Table 4.4: Plastic polymer by share collected (percent), ease of recycling, and status of recycling in Pakistan

Ease of recycling[5]	Plastic type	Share of plastics collected	Status of recycling in Pakistan
Easy to recycle	PET	4%	Most commercially viable and commonly recycled plastics There are 62 recycling plants in Pakistan, a majority recycling PET bottles (World Bank 2021e).
	HDPE	2%	
Possible to recycle in some places	PP	2%	
	LDPE	43%	LDPE recycling is practiced However, LDPE plastic bags are hard to collect and have low density, thus have a low market value and yield low financial gains for waste pickers. Hence, there is a low preference for collection.
Difficult to recycle	PVC	4%	
	PS	5%	
	Sanitary items	17%	
	Multi-layered packaging	15%	Not being recycled in Pakistan currently
	Other	10%	

- **Low-value plastics make up a significantly higher proportion of waste found (Table 4.4).[6]** Of the various types of plastics categorized in this study, the most common type of plastic waste found during the sampling survey (active + passive) was LDPE, which contributed an average value of 43 percent. This was followed by sanitary items (16.5 percent) and multi-layered packaging (15 percent). This is a common observation in many low- and middle-income countries, where the informal sector collects high-value plastics (for example, HDPE and PET) while the rest remains uncollected.
- **Conversely, high-value plastics make up a small fraction of plastics found in the river and along the river banks.** Polyethylene terephthalate (PET) and High-density polyethylene (HDPE), having recycling symbols 1 and 2, are most easily recyclable and, hence, have a higher monetary value compared to other plastics. Thus, it is unsurprising that the proportion of PET and HDPE (6 percent total) is much lower than the combined proportion of low-value plastics such as Polyvinyl chloride (PVC), Polystyrene (PS), and other (Table 4.4).
- **Tetra Pak is the fourth most commonly collected type of waste during the survey.** Although technically Tetra Pak is multi-layered, comprising 75 percent paper, 20 percent PET, and 5 percent aluminum (Tetra Pak n.d.), it is considered a separate waste type and not part of multi-layered packaging in Pakistan as Tetra Paks are recycled in Pakistan. Tetra Pak Pakistan has partnered with Green Earth Recycling (GER) in Lahore as part of an extended producer responsibility

5 Ease of recycling refers to the economic viability of recycling plastics, which, in turn, depends on the properties of the plastic polymer. Not all plastics are recyclable. For instance, single-material plastics, which are clean and can be melted to create new products (thermoplastics), are preferred for recycling, compared to mixed and multi-layered plastics that are dirty. This is denoted by recycling symbols, ranging from 1 to 7, commonly found on plastic products, with 1 (PET) being the most preferred.

6 Low-value plastics refer to multi-layer packaging, PS, PVC, LDPE, and PP and are not accepted by most facilities globally due to the lack of technology to process them. These plastics have low profitability margins, even if they are sorted and segregated (Gladstone 2019).

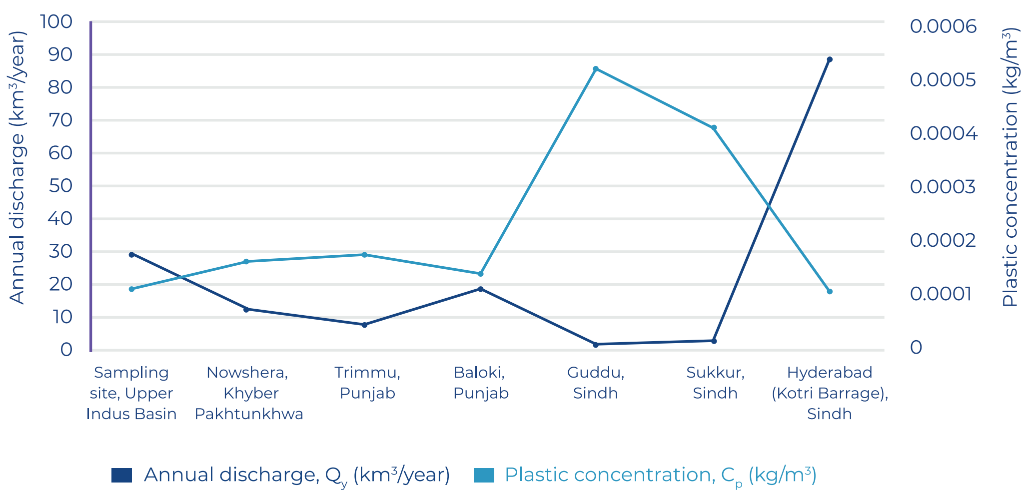
(EPR) initiative, where the former provides the latter with specialized equipment for recycling. Green Earth Recycling is the largest formal sector recycling company in Pakistan, recycling around 100 tonnes of plastic per day (World Bank 2021c). In return, the latter buys used Tetra Pak cartons from scrap dealers in the informal sector. In addition, operations and maintenance of the plant are carried out by GER from the revenue generated from recycling operations. The machinery and equipment used to recycle Tetra Pak cannot be used to recycle other multi-layered plastic products.

- **Sanitary waste is the second most dominant type of plastic waste found in the Indus River.** This is mainly because it offers no value for waste pickers, and, hence, has a low collection rate. This type of plastic waste has numerous environment and human health impacts. Single-use sanitary products can contain up to 90 percent plastic with super absorbent polymers and non-woven plastic components that make it extremely difficult to recycle. Apart from this, it poses health risks to waste collectors and contaminates water and soil (IANS 2017).
- **PVC and PS constitute almost 10 percent of plastics found in the Indus River (Table 4.4)**. These materials are not recycled as much as other plastics like PET and HDPE. However, in Pakistan, production of PVC and PS are only second to PET, and the ban on LDPE packaging has prompted a shift to usage of PS for packaging (World Bank 2021c).

Quantifying and Analyzing Plastic Concentration in the Indus River

Plastic concentration was calculated at each of the sampling sites using the survey findings and compared against the annual water discharge data, collected from WAPDA (Figure 4.6) to draw key findings. For two locations, Dera Ismail Khan and Uch Sharif, hydrological data (annual water discharge rate) was unavailable, and, hence, these locations are not included in the figure.

Figure 4.6: Plastic concentration and annual discharge at sampling sites along the Indus River system



The annual discharge, or flow rate of the river, at Hyderabad is significantly lower than was expected compared to upstream measurement points. There are a few reasons for this: Besides natural outputs, such as evaporation and underground water reservoir renewal, the Indus River feeds a wide network of irrigation canals, and water is extracted for use by industries and municipalities. Sindh Province also faces water shortage, and rainfall is much lower in Sindh compared to Punjab. Hence, by the time the Indus River reaches Sindh, the volume of water discharged reduces drastically (Hafeez 2019).

Plastic concentration in the Indus River increases significantly in the Upper Indus Basin, Balloki, and Hyderabad, as annual discharge drops substantially. Declining water flow naturally increases the concentration of pollutants present in the water. Moreover, the plastic concentration in the Upper Indus Basin was calculated based on the survey carried out in winter, when the flow rate of the river is low, which could have played a role in increasing the value of plastic concentration. High plastic concentration at Balloki can be associated with the pollution load from the city of Lahore, which is the second most populated city of Pakistan, with more than 11 million inhabitants. Hyderabad not only accumulates upstream pollution but also inputs from the city itself, which has more than 2.2 million inhabitants (PBS 2015).

Most macroplastic waste entering the Indus River system does not reach the Arabian Sea. This is assumed due to the distribution and accumulation of plastic debris in various canals and other sinks in the Indus River Basin, as well as the low annual water discharge at Hyderabad. Hence, the effects of macroplastic waste on freshwater ecosystems are much more significant than in the marine environment in the case of the Indus River.

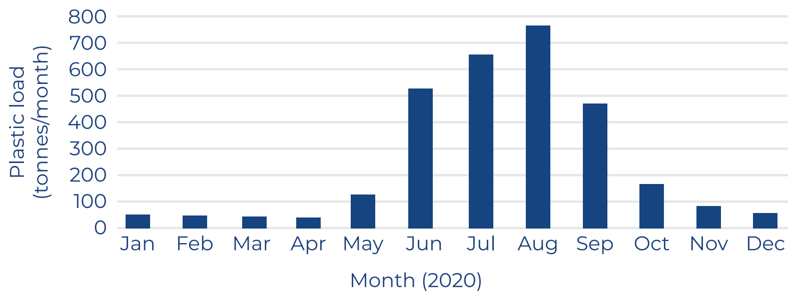
Quantifying Plastic Load Results

The annual plastic load in tonnes per year was calculated for seven of the nine sampled locations since hydrological data (or annual water discharge rate) was unavailable for Dera Ismail Khan and Uch Sharif.[7] With regard to plastic output into the Arabian Sea, Hyderabad was chosen as it is the closest to the mouth of the Indus River and is the last significant physical barrier (Kotri Barrage) before the river meets the Arabian Sea. For detailed calculations of plastic load at each of the seven sampling sites, see Appendix 3.

As an illustrative example, the example of the Upper Indus Basin is provided in order to understand monthly plastic load calculation. Plastic concentration was determined for this site using hydrological data from WAPDA as well as from field survey measurements. A key assumption made during the estimation process was that plastic concentration remained constant throughout the year (for example, in the Upper Indus Basin the plastic concentration remained at 0.1 grams per cubic meter). Based on this information, a monthly and a yearly plastic load can be calculated, as shown in Figure 4.7. The plastic load is given by the product of the plastic concentration and the monthly or yearly discharge, respectively. For example, the water discharge in January was 0.3 cubic kilometres, which corresponds to a monthly plastic load of 52 tonnes.

7 Water discharge rate is the volume of water that passes a cross-section of a river in a specified amount of time, for example, cubic meter per second. Plastic load refers to the mass of plastic that passes a particular point in a river (for example, a sampling site) in a specified amount of time (for example, metric tonnes per year). Mathematically, load is the product of water discharge and the concentration of a substance in the water (Meals et al. 2013).

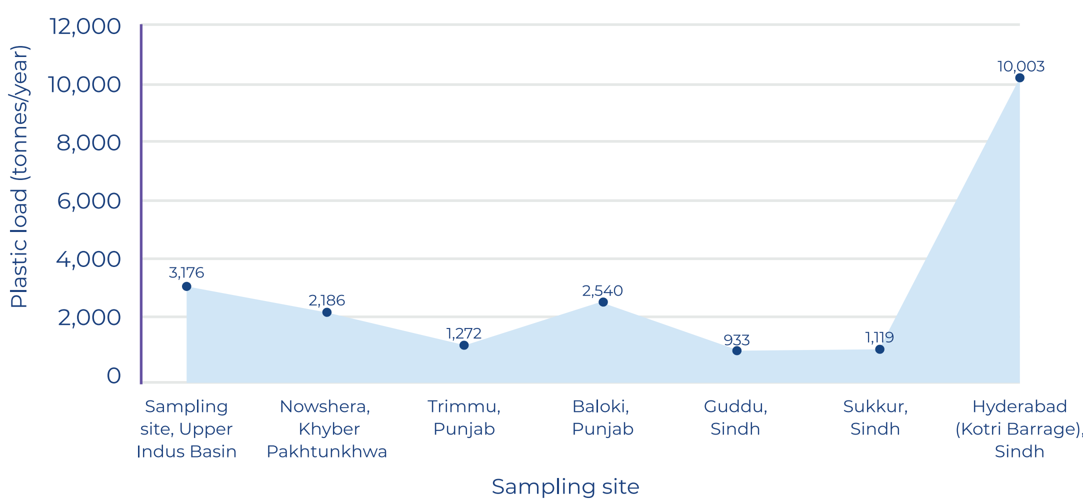
Figure 4.7: Monthly plastic load in the Upper Indus Basin



Source: Calculated based on WAPDA 2021 and field surveys

Plastic load calculated for this study at various sites along the Indus River is provided in Figure 4.8. The figure shows that the Indus River delivers around 10,000 tonnes of macroplastics to the Arabian Sea each year, considering that the total annual plastic load calculated at Hyderabad is 10,003 tonnes per year. To put this number in perspective, it is marginally lower to the value reported by Schmidt et al. (2017) in their seminal study, which reported an annual macroplastic load of 11,977 tonnes per year from the Indus River, making it one of the largest contributors to marine plastic pollution in the world. Even in terms of plastic concentration, the Indus River is known as one of the most polluted, just below the Yangtze River, in the study conducted by Lebreton et al. (2017), which measured plastic load from major rivers around the world. However, it is also important to note that the catchment area of the Indus River is one of the largest in the world, both in terms of population as well in area. Limitations of the modeling for this study are summarized in Box 4.2.

Figure 4.8: Annual plastic load at sampling sites along the Indus River system



Box 4.2: Limitations of Plastic Modeling

All variables were actively measured and, therefore, can be considered robust. However, it is important to stress that in this study, plastic concentration is considered constant throughout the year, despite significant seasonal variations in river discharge. Most of the discharge takes place between the months of July to September. This variation can influence estimates of plastic concentration in two ways. Firstly, during these months, the higher flow—and correspondingly higher water levels—will transport plastic deposited along river banks, but concentrations could also decrease or remain the same due to increased water flow. Similarly, during low flow season some plastic waste might settle and become embedded in sediment deposits on the riverbed and, therefore, not be detected through active sampling sites downstream. These are possibilities that are indicated by the current study but require sampling at different times of the year under different flow regimes to verify. Another limitation is the lack of active sampling downstream of Hyderabad (Kotri Barrage) to estimate plastic contributions from the districts of Thatta, Badin, and Sujawal to the Indus River before it enters the Arabian Sea. Such sampling would make estimates of the Indus River's contribution to marine plastic pollution more robust.

The survey results suggest significantly high plastic waste concentration at all sites. Hyderabad has the highest annual transportation rate of plastic load. This could be explained by the fact that the sample at Hyderabad includes all residual plastic waste from the Indus River system (including parts of the system outside Pakistan) that was not captured, settled, diverted, or broken down. Another important finding that was observed from the data is that plastic waste does not necessarily increase downstream. For example, Nowshera has a higher transport rate than some downstream sites. This once again indicates that there are significant 'sinks' created by the vast irrigation system, barrages, and other infrastructure that remove plastic from the rivers and transfer it to areas supplied by the irrigation system. Another possible driver is that macroplastics get weathered down due to wave action and exposure to sunlight as they make their way down the Indus River and transform into smaller particles that are hard to collect and quantify. Verification of this is critical as a high presence of microplastics in the Indus has implications on food quality and safety, specifically from irrigated crops, horticulture, and fisheries. Further studies are required to determine the actual extent of these sinks and the concentration of microplastics in the irrigation system.

- **More than 90 percent of plastic waste from sample sites in the Upper Indus Basin ends up in the Indus River**. Here, there is little influence from upstream pollution, so the plastic load can be related directly to the population in nearby cities. It is estimated that these sites generate approximately 3,500 tonnes of plastic waste per year, and the estimated annual plastic load is 3,176 tonnes per year, which indicates that more than 90 percent of plastic waste from this site ends up in the Indus River.[8] This does not include seasonal spikes in plastic pollution on account of tourism, which would push the value of plastic load higher.

8 Based on stakeholder consultations, it is estimated that the Upper Indus Basin generates around 35,000 tonnes of waste every year, of which 10 percent is expected to be plastic. Therefore, the estimated annual plastic waste generation is 3,500 tonnes per year

- **Around 27 percent of the total plastic waste generated in Hyderabad ends up in the Indus River.** In the case of Hyderabad, there is a considerable difference in annual plastic load between Sukkur, the sampling point immediately upstream of Hyderabad, and Hyderabad itself, equivalent to 9,800 tonnes per year.[9] The interpretation is that there is a significant input of plastic waste between the two cities and in Hyderabad itself. Comparing the plastic load to the estimated annual plastic waste generation (36,152 tonnes per year)[10] in Hyderabad, it can be calculated that around 27 percent of the total plastic waste generated in Hyderabad ends up in the Indus River.

9 The annual plastic load in the river at Sukkur was found to be 1,119 tonnes per year, while the annual plastic load in Hyderabad was 10,003 tonnes per year, thus showing a difference of around 9,800 tonnes per year.
10 Quantity of plastic waste is calculated as 10 percent of total waste generation, based on stakeholder consultation with the Municipal Officer at the Hyderabad Municipal Corporation.

Chapter 5: Key Findings and Recommendations

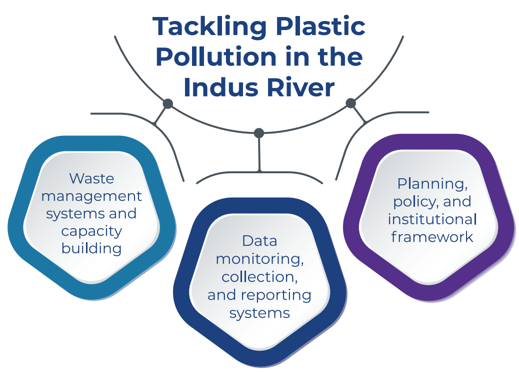
This first-of-its-kind diagnostic study of plastic waste in the Indus River Basin generated some important findings, which serve in the development of recommendations. First, plastic waste does not accumulate in a linear pattern from north to south in the Indus River and its tributaries, as one might expect. This is due to the complex and far-reaching network of barrages and canals along the river system, spanning across 60,800 kilometers (Tabassum 2018). This means that a proportion of plastic waste generated upstream of the barrages likely gets siphoned into canals when irrigation water is withdrawn at barrages. This may also signify that plastic waste reaches areas that are not necessarily responsible for the bulk of the waste generated.

Second, the amount of plastic making its way from the Indus River system into the Arabian Sea is primarily between Hyderabad which is just south of the last barrage—Kotri Barrage—in the network, and areas south of Hyderabad until the point that the Indus enters the Arabian Sea. This finding is, once again, related to the intricate irrigation system of the Indus. The modeling done for this study demonstrates that approximately 10,003 tonnes per year enters the Arabian Sea just south of Kotri Barrage, and is similar to global studies which estimate that roughly 11,977 tonnes per year of plastic waste reaches the mouth of the river (for example, Schmidt et al. 2017). Nevertheless, it should be kept in mind that the Indus River is not the only source of plastic litter pollution into the Arabian Sea. The Malir and Lyari rivers passing through the city of Karachi and draining into the Arabian Sea carry significant macroplastic load, not to mention various *nallas* or open drainage networks leading out into the sea from the coastline.

Given these two significant findings, recommendations have been proposed and grouped into three priority areas to improve: (1) Municipal solid waste (MSW) collection and treatment, (2) Data collection and monitoring along the Indus River Basin, and (3) Policy and institutional frameworks (Figure 5.1).

Although, the problem of plastic pollution and its direct impacts pertain to water, its solutions exists on land. This chapter discusses the various key findings and related recommendations in order to reduce plastic pollution in the Indus River. A phased approach, using short-, medium, and long-term time frames has been suggested; however, implementation may follow different time frames and recommendations may be adopted concurrently.

Figure 5.1: Key focus areas for reducing plastic pollution in the Indus River



Focus Area 1: Solid Waste Management Systems and Capacity Building

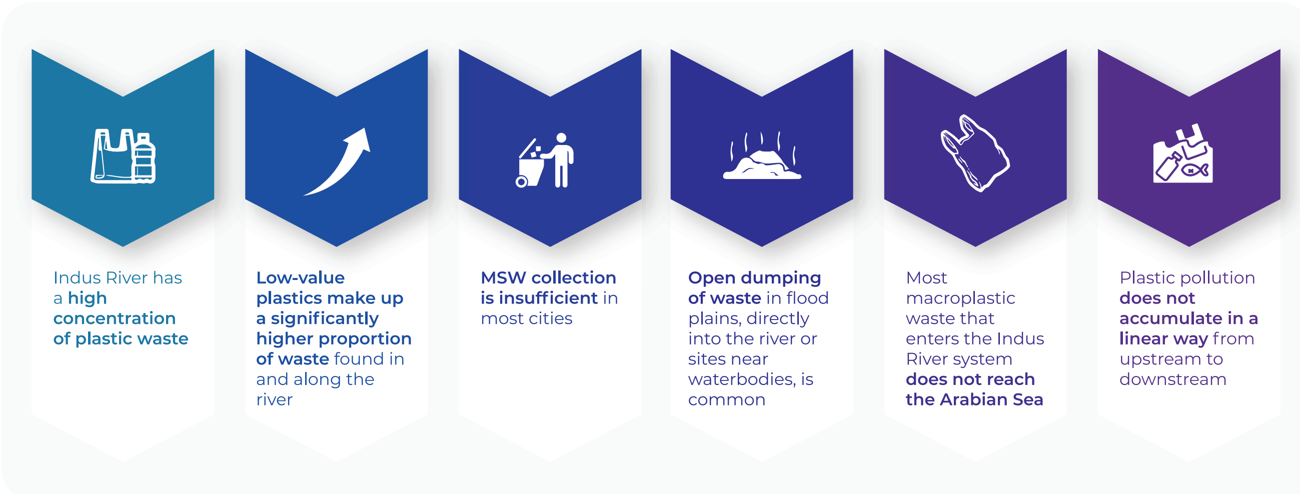
Key Findings

The key findings from this study pertaining to the solid waste management (SWM) sector and capacity building, on which the following recommendations are provided, are summarized in Figure 5.2.

Recommendations

The most obvious and most urgent recommendation is the expansion of waste collection services through a combination of infrastructure investment, capacity building, improved waste monitoring, and enhanced transparency and accountability of waste management agencies/companies. Investments in improved treatment and disposal must be made in parallel to ensure that collected waste is deposited in adequate SWM infrastructure, such as sanitary landfills or incineration facilities, as high collection of solid waste with inadequate treatment and disposal services is likely to lead to similar patterns of waste in rivers as seen in this study. Special attention must be given to mountainous and remote locations, where waste mismanagement rates are even higher. Siting of waste disposal facilities is also important in these locations. Each province will have its own approach,

Figure 5.2: Summary of key findings from this study related to SWM



based on the current policy and institutional architecture for waste management, but the federal government through the Government of Pakistan Ministry of Climate Change (MoCC) should develop an investment guide/strategy, using some of the insights from this report. The investment guide/strategy may also explore multi-sectoral approaches to leverage financial support from a variety of sources, for example, as an investment in climate resilience, environmental health, public health, tourism, water resources management, and so on.

The composition of waste sampled (actively and passively) reveals which types of waste are likely to be intercepted by informal waste pickers. In the short-run, **public waste collection services should prioritize categories that are least likely to be collected informally and that pose significant environmental and public health risks,** for example, sanitary products and low-density polyethylene (LDPE). At the same time, the government should engage with industries producing LDPE, sanitary items, and multi-layered packaging in their products and create a governance system along the globally-accepted concept of extended producer responsibility (EPR).

The success of the informal sector in diverting valuable waste streams, such as polyethylene terephthalate (PET), metal, and glass, suggests that this could be leveraged to play an important role in the collection and recycling of waste. In addition, including the informal sector in formalized waste operations enhances the health, safety, social, and economic conditions of waste pickers, particularly women. According to Medina (2008), "… when organized and supported, waste picking can spur grassroots investment by poor people, create jobs, reduce poverty, save municipalities money, improve industrial competitiveness, conserve natural resources, and protect the environment". NGOs and community-based organizations (CBOs) can also be encouraged to participate in various aspects of SWM.

The value of waste streams for recycling, particularly plastics, is contingent on the cleanliness of the waste stream. Single-material, clean, and light-colored plastics have a higher probability of being recycled, and, hence, **source segregation programs are required along with campaigns to raise awareness and bring about sustained behavioral change.**

Waste collection and disposal are the functions of municipal authorities and agencies. However, from stakeholder consultations it is clear that these agencies usually do not have the resources (for example, equipment, vehicles, and personnel) to meet the needs of the local population. There are different routes to overcome this, including **tasking provincial governments to establish public companies or establishing public-private partnerships (PPPs) that can access capital more easily.** The involvement with the private sector would also help to capacitate solid waste management, since it can more easily engage with experienced professionals. Further development of the private sector could be pursued with the support of other SWM authorities in the Asian region and the multilateral agencies.

It is also critical to address how SWM is financed. Typically, SWM systems are financed by end-user tariffs (for example, households and commercial establishments), sale of recovered materials and energy, and government transfers. A fourth option common in plastic products are transfers from EPR schemes. Pakistani authorities at the federal, provincial, and local levels need to develop legislation and improve capacity to enforce tariffs and EPR transfers. Furthermore—and especially important in the context of plastic waste—local authorities need to avoid the split between high- and low-value waste materials. As the informal sector collects high-value materials and economically benefits from them, official waste collection services are often left with low-value materials and, therefore, do not benefit from them.

It is also necessary to foster public awareness and behavioral change. With the implementation of collection systems, local and regional authorities should implement educational programs to ensure that people understand the importance of using adequate collection systems and that existing dumpsites will have to be terminated. In tandem with awareness-raising, it is important to identify priority actions that could contribute to green, resilient, and inclusive recovery and growth. This could include, for example, adopting an integrated waste management or circular economy approach in government policy and creating a conducive environment to incentivize innovations and encourage proactive participation from both the public as well as private sectors.

Given the provincial irrigation departments' role in operation of barrages and irrigation canal networks, they need to become more active and engaged participants in the management of solid waste. The provincial irrigation departments already play a de facto role in SWM, as solid waste is typically removed from the irrigation network during annual maintenance undertaken by the departments and is trapped in nets sometimes installed across gates of canal head-regulators. **The irrigation department should be incentivized to play a more structured and formal role in waste collection from waterways,** supported by appropriate agencies/departments responsible for treatment and disposal.

Focus Area 2: Data Collection, Monitoring, and Reporting

Key Findings

Data on waste generation, collection, and disposal is essential in order to measure performance, support policy evaluation or governmental decisions, drive investments and industry strategy, and inform the public. However, data monitoring, collection, and reporting systems for SWM face significant gaps in Pakistan. The key findings from this study pertaining to data collection, monitoring, and reporting, on which the following recommendations are provided, are summarized in Figure 5.3.

Figure 5.3: Summary of key findings from this study related to data collection, monitoring, and reporting

Recommendations

To improve data collection, **it is necessary to establish national-level standards and procedures for waste data collection and reporting.** It is also necessary to assign such tasks to specific stakeholders, ensuring that they understand the scope and the importance of the data. This will be significantly easier if there is already adequate waste collection and treatment capacity, with equipment such as truck scales. Ultimately, the whole system could be built on a single digital platform that takes information from all facilities within Pakistan to monitor in real time the waste entering waste treatment facilities. However, in the short term, besides establishing standards and procedures for data collection, the federal and provincial governments could support this goal by providing training to local teams to monitor and register waste collection.

To address the lack of data on river pollution, **it is necessary to implement a monitoring program that encompasses the whole Indus River Basin to help identify major concentrations and movements of plastic pollution across administrative boundaries.** Through linkages with academic institutions and start-ups/small firms, satellite imagery-based dashboards/applications should be developed to monitor build-up and movement of plastic waste in real-time. Specific hotspots, such as transboundary tributaries, larger cities and water infrastructure (major barrages, dams, and canals) should be surveyed at least twice a year to complement and ground truth satellite imagery-based data. Monitoring can also be done using simple methods, such as by visual observation and from clean-up activities along the river bank. The scope of Indus River System Authority (IRSA) needs to be broadened to monitor plastic pollution in water as well, since the issue transcends provincial borders. Data collection must be a continuous exercise, so that targets can be set and progress can be measured, to aid the decision-making process.

All data collected should be readily accessible through public repositories, as is done by the Water and Power Development Authority (WAPDA), for example, with hydrological data. A similar model should be employed for waste data. This will help in evidence-based policy making and programming to deal with SWM, and facilitate policy research on plastic pollution on land and in rivers contributing to marine pollution.

Focus Area 3: Planning, Policy, and Institutional Frameworks

Based on the field survey and stakeholder consultations, the study concludes that there are a significant number of gaps in the planning, policy, and institutional frameworks that contribute to plastic pollution in the Indus River. These gaps exist due to several challenges, such as capacity and resource constraints, and limited engagement with stakeholders and civil society. The key findings from this study pertaining to planning, policy, and institutions, on which the following recommendations are provided, are summarized in Figure 5.4.

Figure 5.4: Summary of key findings from this study related to planning, policy, and institutional frameworks

PLANNING	POLICY	INSTITUTIONS
Absence of national or provincial-level strategies for waste management	Lack of a comprehensive and updated legal framework	Inadequate will and commitment
Lack of incentives for recycling, waste reduction, and segregation	Ineffective law enforcement	Lack of a coordinated approach among federal, provincial, and local agencies to tackle plastic pollution
Lack of quality standards and guidelines for plastic products and services	Lack of transparency and accountability	Lack of a multi-sectoral approach to manage plastics pollution

Recommendations

The federal government should develop a comprehensive national strategy for waste prevention and management, involving both public as well as private sectors, and provide both impetus and guidance for provinces to develop modern legal frameworks for plastic waste management. **Provincial legal frameworks should be supplemented by time-bound strategy documents** that not only include operational and situational details such as waste collection and treatment capacity, but also economic and institutional gaps, investment needs, tariffs, and governance, among others. Although, the responsibility of waste management has devolved to the provinces, the federal government has an important role to play in providing necessary resources and guidelines to help develop local capacity. **The federal government also needs to facilitate private sector involvement and to integrate the informal waste sector and introduce economic and social initiatives for waste reduction and recycling to incentivize diversion from dumpsites, and, eventually, landfills.** The present governance models, where the custodian of the law is also the implementing agency, need to be revised to ensure accountability of involved parties.

The federal government is also ideally placed to **devise protocols and standards for the proper labeling of plastic materials for recycling and identification of additives.** Implementation strategies to meet these standards and protocols can be customized by each province as part of their provincial frameworks.

Improving SWM is an immediate priority with a focus on improving waste collection rates across the country and developing engineered landfills to replace existing dumpsites; however, **a circular economy approach, targeting upstream interventions, is more appropriate for plastic waste,** which does not decompose easily and tends to leak into the environment. Improving plastic recycling rates is only part of the solution, as not all plastic can be recycled easily, and most importantly plastic cannot be recycled several times without loss in quality, unlike metal and glass. In addition, recycling lowers the quality of plastic material and the process requires addition of virgin plastic. The ability to source clean plastic waste is a major barrier, and recycling technologies are not available for the myriad of plastic products available in the market. Hence, limiting the quantity of plastic waste generated, especially composite and low-value plastics, through better product design and take-back programs, will help in tackling plastic pollution in the long term. Banning notorious materials such as single-use LDPE bags and plastic straws help in the short term; however, sustainable and suitable alternatives need to be made available to the public, along with awareness campaigns so that harmful plastics like expanded polystyrene (commonly known as Styrofoam) are not used as substitutes. Suitable solutions must also be devised for plastic manufacturing industries and other stakeholders impacted by product bans to ensure their cooperation.

There is currently a concerted effort to promote both national and international tourism in Pakistan, with a focus on the Hindu Kush Region in the north of Pakistan. The sampling results from the Upper Indus Basin—a popular tourist destination—are particularly concerning given this effort to promote tourism. The consultations for this study also confirmed that tourism contributes significantly to plastic waste, especially in northern areas. As suggested under the first priority, the SWM sector should emphasize the cross-sectoral significance of its outcomes to coordinate and leverage financial resources from actors and financing programs from other sectors, such as tourism, forestry, and natural resources management. From a policy and legal framework perspective, **there needs to be stringent mechanisms such as littering fines** for individual tourists, residents, tourism operators, and hotels. **There should also be public communication and outreach programs to sensitize tourists towards 'zero-waste tourism'.** Lastly, community-led initiatives should be fostered, and incentives such as 'cash-for-scrap' programs for residents should be piloted.

Finally, to address riverine plastic pollution, **it is also necessary to improve coordination of the significant number of federal, regional, provincial, and local agencies involved on this topic.** The federal Ministry of Water Resources and the MoCC should coordinate this effort to bring stakeholders to the table. Insights from the current study can be the starting point and may be used to develop the initial agenda for the dialogue. One output from this dialogue could be the appointment of a taskforce to undertake a comprehensive assessment of how the Indus River and the Indus Basin Irrigation System contribute to—and are affected by—plastic pollution; in addition, the taskforce can recommend institutional changes (or alliances) that can facilitate abatement of plastic loads in the Indus River system. This task force could also help Pakistan to engage and collaborate with the other Indus River system countries of China, India, and Afghanistan for data collection and monitoring. Table 5.1 summarizes the various recommendations and actions that could be undertaken with regard to planning, policy, and institutions, in order to overcome limitations and lack of capacity in these areas. Recommendations are provided for the short-, medium-, and long-term, with the underlying assumption that the proposed actions may follow different time frames and may be adopted concurrently.

Table 5.1: Suggested recommendations for planning, policy, and institutions

Short-term	Medium-term	Long-term
Federal government to develop a plastic waste management policy	Provinces use federal framework to develop their own policies/strategies related to plastic waste management	Implement policy for plastics waste management at the federal and provincial governments
Update existing laws, rules, and regulations, adding plastic waste management in riverine and marine environments	Federal government provides resources and guidelines to provinces to develop local capacity	Adopt administrative and financial penalties, while strengthening enforcement and monitoring mechanisms
Increase accountability of all involved parties and stakeholders	Federal government devises protocols and standards for the proper labeling of plastics and their recyclability	Implement and monitor the SWM Act
Improve coordination of stakeholders across all sectors that are affected by plastic wastes (e.g., tourism, natural resources, and irrigation)	Define mechanisms for enforcement and monitoring	Ban plastics disposal in dumpsites and landfills
Prepare an SWM Act incorporating plastic waste, while including all stakeholders in deliberations	Approve SWM Act and develop rules and regulations	
Impose bans on single-use plastics	Propose alternatives for plastics and incentivize their use	
Generate government and private investments for alternate solutions for waste reduction, collection, and segregation	Incentivize diversion from dumpsites, and, eventually, landfills	
Explore the latest technologies and innovative solutions to eliminate plastic waste	Explore international funding streams for cities' development initiatives and own source revenue generation options to improve waste management systems, such as product levies and earmarked eco-taxes	
Integrate the informal waste sector in formal recycling activities		

Appendix 1: Summary of Relevant Policies, Laws, and Legislation at Federal, Provincial, and Local Levels

The passage of the Pakistan Environmental Protection Act (PEPA) in 1997 by the Government of Pakistan provided the framework for achieving sustainable development objectives through the establishment of provincial sustainable development funds, protection and conservation of species, conservation of renewable resources, establishment of environmental tribunals, and so on. Relevant policies, laws, and rules at the federal level in Pakistan are summarized in Figure A1.1, while Table A1.1 describes the relevant solid waste management (SWM) component.

Figure A1.1: Timeline of federal-level policies, laws, and rules

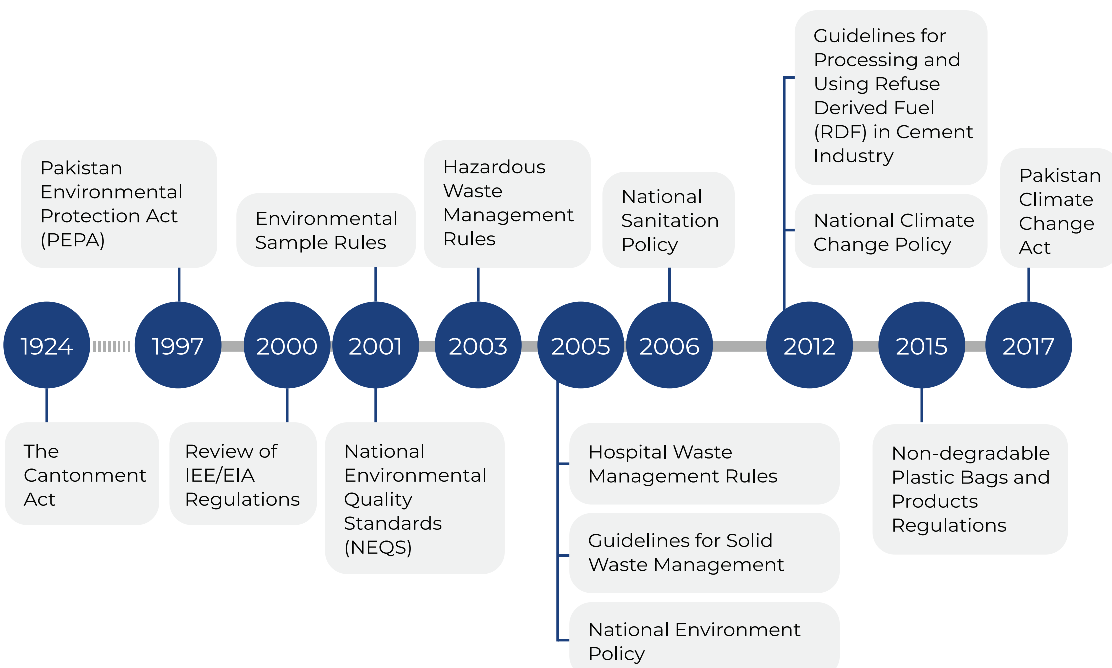


Table A1.1: Federal-level policies, laws, and rules

Year	Name	Relevant SWM component
2017	**Pakistan Climate Change Act**	To establish Climate Change Authority at federal level to manage Pakistan's obligation under international conventions related to climate change, and to address the effects of climate change.
2015	**Non-degradable Plastic Bags and Products Regulations**	These regulations prohibit manufacture, import, usage, and sale of non-biodegradable plastic bags and products.
2012	**National Climate Change Policy**	• NCCP provides a broader framework for adapting to and reducing the effects of climate change. • It provides the operational and institutional mechanisms and adaptation actions for water, agriculture and livestock, forestry, energy, transport, industry, and urban planning sectors. • No specific mention of plastic is made for any of these sectors.
2012	**Guidelines for Processing and Using Refuse Derived Fuel (RDF) in Cement Industry**	The EPA provides guidelines for processing and use of RDF as a supplementary fuel in the cement manufacturing industry and prescribes procedures for monitoring emissions. RDF is created by shredding, cutting, or drying MSW such that it is suitable for use as a fuel source.
2006	**National Sanitation Policy**	Aims to provide adequate sanitation coverage for improving quality of life of residents, and to provide a physical environment necessary for healthy life.
2005	**National Environment Policy**	• Aims to conserve, restore, and efficiently manage environmental resources in order to elevate quality of life through sustainable development. • It also suggests design and implementation strategies for integrated management of all types of waste, at the local, provincial, and national levels.
2005	**Guidelines for Solid Waste Management**	• These guidelines define municipal solid waste management, and explain roles and responsibilities of respective authorities, requirements related to the construction of landfill infrastructure and compost production, and cover solid waste management issues generally. • They also recommend developing new legislation covering both solid waste and wastewater for effective service provision.
2005	**Hospital Waste Management Rules**	• These rules came into force under Section 31 of the PEPA Act, 1997. • They provide guidelines for the management of waste generated by healthcare institutions on how to collect, receive, store, transport, treat, and dispose of hospital waste.
2003	**Hazardous Waste Management Rules**	The Hazardous Substances Rules were added in PEPA Act, 1997 in 2003. They cover all hazardous waste-related matters which include licensing, packing and labeling, condition for premises, general safety procedures, hazardous waste management plans, import and transport related issues.
2001	**National Environmental Quality Standards (NEQS)**	• Issued in 1993 and amended in 2001. • These standards regulate and provide the maximum limits for the discharge of municipal and industrial effluents. • These standards do not provide any level or standard for pollution caused by the mismanaged disposal of municipal waste or plastic waste.
2001	**Environmental Sample Rules**	Developed for the implementation of PEPA 1997.
2000	**Review of IEE/EIA Regulations**	• Regulation on Environmental Impact Assessment for projects requiring an IEE/EIA. • Waste disposal projects are obligated to carry out an IEE/EIA.

Table A1.1: Federal-level policies, laws, and rules (contd.)

Year	Name	Relevant SWM component
1997	**Pakistan Environmental Protection Act (PEPA)**	• PEPA is the primary legislation to provide for the protection, conservation, rehabilitation and improvement of environment, prevention and control of pollution, and promotion of sustainable development. • Prohibits discharge of waste in a quantity or concentration above the National Environmental Quality Standards (NEQS) levels. • Defines municipal waste, hazardous waste, hospital waste, industrial waste, and agriculture waste. • Prohibits the import of hazardous substances and waste. • Deals with handling of hazardous substances, generation, storage, collection, transport, treatment, and disposal. • EPDs are empowered to take stringent actions against the discharge of any waste in violation of the provisions of the Act and direct the responsible party to take necessary measures. • Details penalties for contraventions against the provisions of the Act. • A clause on plastic waste has been added. • Now limited to Islamabad Capital Territory (after the 18th Amendment), the Act has nonetheless been adopted almost fully by the provinces.
1924	**The Cantonment Act**	The Act addresses the disposal of waste and rubbish in cantonment areas, run by cantonment boards (Section 132).

As a result of the 18th Constitutional Amendment in 2010, the regulation of 'environmental pollution and ecology' no longer falls under the executive authority of the federal government. Instead, provinces may pass their own environmental legislation or request Parliament to do so under Article 144 (Alam 2018). A timeline of policies, laws, and legislation related to SWM and plastics since 2010 at the provincial level is shown in Figure A1.2. Table A1.2 provides the relevant SWM component.

Figure A1.2: Timeline of provincial-level policies, laws, and rules

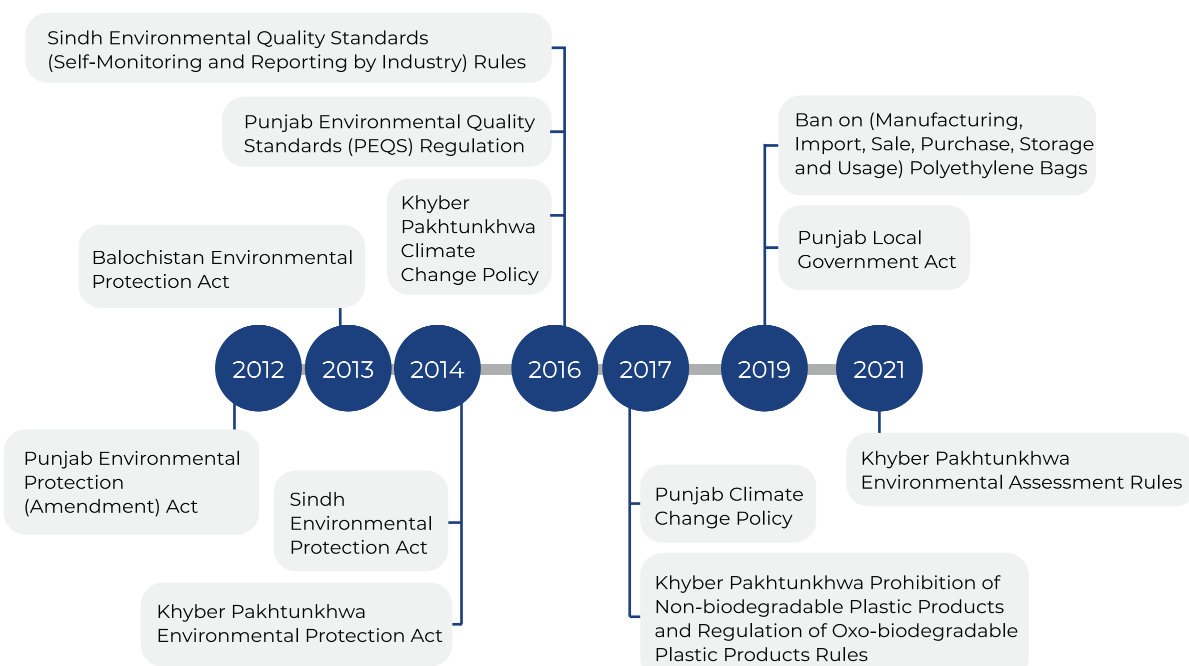


Table A1.2: Provincial-level policies, laws, and rules

Year	Name	Relevant SWM component
2021	**Khyber Pakhtunkhwa Environmental Assessment Rules**	Projects requiring IEE/EIA/GEA rules include waste disposal facilities (for example, incineration plants and landfills) and urban and tourist sites, among others.
2019	**Punjab Local Government Act**	• According to this Act, the metropolitan and municipal corporations, and municipal and town committees are responsible for solid waste collection and management. • Empowers the authorities to impose fines on offenders: first time offender from PRs 500 to 40,000, depending upon the offence committed. For continued offences, fines can be increased from PRs 3,000 to 100,000 or the case can be sent to a competent court, which may impose imprisonment on conviction.
2019	**Ban on (Manufacturing, Import, Sale, Purchase, Storage and Usage) Polyethylene Bags**	Bans the use of plastic bags in the ICT.
2017	**Khyber Pakhtunkhwa Prohibition of Non-biodegradable Plastic Products and Regulation of Oxo-biodegradable Plastic Products Rules**	Prohibits the sale of non-biodegradable plastic products, promotes manufacture of oxo-biodegradable products, and penalizes those who violate these rules.
2017	**Punjab Climate Change Policy**	Recommends the following: • Improve solid management practices by promoting the 3R concept • Confirm suitable labeling and prevent dumping of hazardous waste • Create new jobs in waste management and recovery through research and developing public-private partnerships • Rationalize environmental quality standards • Develop solid waste standards at the provincial level starting from waste collection until disposal • Encourage waste-to-energy projects • Promote waste management-related technologies used worldwide.
2016	**Punjab Environmental Quality Standards (PEQS) Regulation**	Covers: • Testing and analyzing waste samples from factories • Solid waste management, treatment, and disposal • Industrial and hospital waste, hazardous and toxic waste treatment and disposal. • Includes environmental pollution controls for air, water, and soil pollution in accordance with federal and provincial laws and standards.
2016	**Sindh Environmental Quality Standards (Self-Monitoring and Reporting by Industry) Rules**	The provincial government passed environmental quality standards for industrial and municipal effluents, industrial gaseous emissions, motor vehicle exhaust and noise, ambient air, and drinking water quality.

Table A1.2: Provincial-level policies, laws, and rules (contd.)

Year	Name	Relevant SWM component
2016	**Khyber Pakhtunkhwa Climate Change Policy**	Policy recommendations include: • Developing a provincial standard for SWM • Designing a proper waste management system for MSW and wastewater and developing a PPP to implement this management system • Ensuring treatment of solid waste and wastewater • Developing certified waste management systems for solid, hazardous, and electronic wastes • Recognizing industries and sectors responsible for generating e-waste and hazardous waste, and ensuring implementation of the waste management system • Creating awareness about hazardous wastes and their toxic impacts • Encouraging waste-to-energy projects.
2014	**Khyber Pakhtunkhwa Environmental Protection Act**	The Act was passed to protect, conserve, rehabilitate, and improve the environment, prevent and control pollution, and promote sustainable development. The Khyber Pakhtunkhwa Environmental Protection Agency issued a number of checklists and guidelines, including for SWM, construction, and tourist facilities in ecologically-sensitive areas.
2014	**Sindh Environmental Protection Act**	The Act was passed to protect, conserve, rehabilitate, and improve the environment, prevent and control pollution, and promote sustainable development.
2013	**Balochistan Environmental Protection Act**	Uses a very broad meaning of the term 'environment', and was enacted to protect, conserve, rehabilitate, and improve the environment, prevent and control pollution, and promote sustainable development.
2012	**Punjab Environmental Protection (Amendment) Act**	Basic legislative tool that allows the provincial government to frame regulations for protection of the environment and public health.

Table A1.3 provides policies, laws, and rules at the local government level in Pakistan.

Table A1.3: Local-level policies, laws, and rules

Year	Name	Relevant SWM component
2005	SWM By-Laws CDG Lahore	• Covers SWM, collection, and removal of solid waste, night soil/waste, and manure • Prohibits disposal of waste, construction materials, etc. in public places.
2001	LGOs in CDGs and TMAs	Covers waste collection, transportation, and disposal.
1968	Islamabad Capital Territory By-Laws	• Framed by the CDA with the aim of making the capital city clean. • Waste to be disposed of at appropriate places; those failing to comply will be punished appropriately.

Appendix 2: Waste Collected during Field Survey

Table A2.1 provides the various waste categories that the waste collected during the field survey were segregated into. For each category, the table also provides the common types of waste found. Plastics were further segregated by polymer type, and the types of plastic products by polymer type are also listed.

Table A2.1: Categories and types of waste collected during field survey

Categories	Types of waste collected	
Biodegradable waste (Kitchen waste)	Food (e.g., bread, vegtables, fruit)	
Green waste	Tree cuttings, leaves, grass	
Plastic	PET	PET bottles and jars, carpets, clothing, industrial strapping, ropes, automotive parts, fiberfill for winter jackets and sleeping bags, construction materials, protective packaging
	LDPE	Plastic bags, garbage bags, packaging for newspapers, bread, and frozen foods
	HDPE	Containers for milk, motor oil, shampoo, conditioner, liquid soap, detergent, bleach
	PP	Lunch boxes, margarine containers, yogurt pots, syrup bottles, prescription bottles
	PVC	Flooring, plumbing pipes, roofing, siding, trim, protective clothing, shower curtains, tents
	PS	CD and DVD cases, foam packaging peanuts for shipping, food packaging, meat/poultry trays, egg cartons
	Sanitary items	Diapers, sanitary napkins, tampons, other sanitary products
	Multi-layered packaging	Wrappers, packaging sheets, multi-coated materials
	Other	Polycarbonate (sunglasses, police riot gear), ABS (luggage, helmets), CD covers
Paper and cardboard	Office paper, white paper, colored paper, newspaper (bags and strings removed), magazines (all types)	
Tetra Pak	Juice boxes, milk boxes	
Metal	Beverage and food containers, aluminum foil, aluminum take-out containers, cutlery, cookware (pots, pans, and utensils), wires, spare parts	
Bottles and glass	Colored/transparent glass bottles and jars, juice, beer and wine bottles, light bulbs	
Textile	Thread, yarn, fabric, rugs, cotton	
Leather and rubber	Leather, rubber, nylon items, Lycra	
Domestic hazardous waste	Medicine bottles, chlorine bottles, masks, gloves, syringes	
Miscellaneous	Dust, stones	

The following tables in this appendix provide detailed data on waste collected from active (that is, using a litter boom) and passive (that is, foot survey on river banks) sampling during the field survey for each site. Table A2.2 provides the total waste collected at each site from active and passive sampling as well as by waste type. Table A2.3 provides the average waste quantities collected through active and passive sampling in kilograms as well as a percentage of the total for each site. Plastics were further segregated by polymer type, and this break-up is also shown in both tables.

Table A2.2: Waste quantities collected during field survey (kg)

Waste type	Sampling site		Nowshera		Dera Ismail Khan		Trimmu		Balloki		Uch Sharif		Guddu		Sukkur		Hyderabad	
	Upper Indus Basin		Khyber Pakhtunkhwa		Khyber Pakhtunkhwa		Punjab		Punjab		Punjab		Sindh		Sindh		Sindh	
	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling	Active Sampling	Passive Sampling
Biodegradable waste (Kitchen waste)	249	11	244	13	104	15	90	18	262	18	52	4	56	11	251	19	267	27
Green waste	55	4	1,055	65	219	46	995	71	1,094	68	881	91	834	42	1,102	61	921	72
Plastic	1,515	107	1,301	94	875	124	1,123	90	1,404	103	878	54	754	97	1,377	118	1,539	137
PET	57	8	51	7	20	5	29	4	23	2	2	3	5	2	38	6	31	5
LDPE	626	24	592	23	451	37	561	38	620	30	521	29	422	49	710	42	822	66
HDPE	29	4	26	4	11	3	10	1	19	2	6	0	5	2	23	3	28	3
PP	43	4	37	3	14	2	22	2	23	3	11	2	14	2	26	2	31	2
PVC	38	5	40	6	22	8	28	7	19	4	14	1	12	3	32	4	29	5
PS	69	7	58	6	49	5	42	6	70	7	16	3	18	4	42	5	35	6
Sanitary items	294	22	237	18	190	18	201	14	263	19	92	3	78	6	245	24	285	19
Multi-layered packaging	257	16	190	12	73	24	172	14	218	13	163	7	119	14	198	16	204	17
Other	102	16	71	18	47	23	59	3	149	23	53	5	83	14	64	15	73	12
Paper and cardboard	0	4	0	5	0	7	0	6	0	6	0	2	0	6	0	3	0	4
Tetra Pak	307	18	252	11	86	12	220	9	291	13	162	6	140	13	221	9	263	16
Metal	0	3	0	2	0	2	0	2	6	3	0	0	0	1	0	0	0	2
Bottles and glass	2	4	0	2	4	3	0	3	7	2	0	1	7	2	4	3	2	3
Textile	453	22	496	18	352	47	521	22	514	19	404	19	361	24	526	21	602	22
Leather and rubber	103	3	118	9	79	29	76	7	130	6	56	4	49	23	127	3	108	7
Domestic hazardous waste	19	1	15	1	6	1	14	1	20	1	15	0	12	0	19	1	17	1
Miscellaneous	129	1	113	1	0	0	0	0	95	1	0	2	0	0	98	1	106	1
Total	**2,832**	**178**	**3,594**	**221**	**1,725**	**286**	**3,039**	**229**	**3,823**	**240**	**2,448**	**183**	**2,213**	**219**	**3,725**	**239**	**3,825**	**292**

Table A2.3: Average waste quantities collected during field survey

Waste type	Sampling site		Nowshera		Dera Ismail Khan		Trimmu		Balloki		Uch Sharif		Guddu		Sukkur		Hyderabad	
	Upper Indus Basin		Khyber Pakhtunkhwa		Khyber Pakhtunkhwa		Punjab		Punjab		Punjab		Sindh		Sindh		Sindh	
	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)	Average (kg)	Average (%)
Biodegradable waste (Kitchen waste)	130	9	129	7	60	6	54	3	140	7	28	2	33	3	135	7	147	7
Green waste	30	2	560	29	133	13	533	33	581	29	486	37	438	36	582	29	496	24
Plastic	811	54	698	37	500	50	606	37	754	37	466	35	425	35	748	38	838	41
PET	33	2	29	2	13	1	17	1	13	1	3	0	4	0	22	1	18	1
LDPE	325	22	307	16	244	24	299	18	325	16	275	21	235	19	376	19	444	22
HDPE	17	1	15	1	7	1	6	0	11	1	3	0	3	0	13	1	15	1
PP	24	2	20	1	8	1	12	1	13	1	7	1	8	1	14	1	17	1
PVC	21	1	23	1	15	1	17	1	12	1	8	1	7	1	18	1	17	1
PS	38	3	32	2	27	3	24	1	38	2	10	1	11	1	23	1	21	1
Sanitary items	158	10	127	7	104	10	107	7	141	7	47	4	42	3	135	7	152	7
Multi-layered packaging	137	9	101	5	48	5	93	6	116	6	85	6	67	5	107	5	111	5
Other	59	4	44	2	35	3	31	2	86	4	29	2	48	4	39	2	42	2
Paper and cardboard	2	0	2	0	3	0	3	0	3	0	1	0	3	0	1	0	2	0
Tetra Pak	163	11	131	7	49	5	114	7	152	7	84	6	76	6	115	6	140	7
Metal	1	0	1	0	1	0	1	0	4	0	0	0	0	0	0	0	1	0
Bottles and glass	3	0	1	0	3	0	1	0	5	0	0	0	5	0	4	0	2	0
Textile	238	16	257	13	200	20	271	17	267	13	212	16	193	16	273	14	312	15
Leather and rubber	53	3	64	3	54	5	42	3	68	3	30	2	36	3	65	3	57	3
Domestic hazardous waste	10	1	8	0	3	0	7	0	11	1	8	1	6	0	10	1	9	0
Miscellaneous	65	4	57	3	0	0	0	0	48	2	1	0	0	0	50	3	53	3
Total	**1,505**	**100**	**1,907**	**100**	**1,006**	**100**	**1,634**	**100**	**2,032**	**100**	**1,315**	**100**	**1,216**	**100**	**1,983**	**100**	**2,058**	**100**

Appendix 3: Calculation of Plastic Load at Sampling Sites

To estimate plastic pollution in the Indus River, the plastic transport model used in this study relates plastic concentration, taken from active sampling, with hydrological data to obtain a yearly plastic transport rate. Table A3.1 presents both survey measurements as well as hydrological data that were taken from public authorities, primarily from the Pakistan Water and Power Development Authority (WAPDA). Annual discharge *(Q_y)*, that is, the annual water flow at a given site, is calculated taking 2020 as the reference year, while instant flow *(Q)* is taken from the actual survey dates. Instant flow is the estimated flow rate at a given time and site, and is used to calculate plastic concentration *(C_p)*. Two sites (Dera Ismail Khan and Uch Sharif) are missing as no hydrological data was available for these places.

Table A3.1: Calculation of plastic load at sampling sites

Location	Sampling dates	Flow rate, *Q* (m^3/s)	Plastic load, M_p (kg/day)	Plastic concentration, C_p (kg/m^3)	Annual discharge, Q_y (km^3/year)	Plastic load, $M_{p,y}$ (tonnes/ year)
		1	*2*	*3 = 2/(1*86400)*	*4*	*5 = 3*4*10^6*
Sampling site, Upper Indus Basin	March 16-18, 2021	104	1,515	0.00017	18.81	3,176
Nowshera, Khyber Pakhtunkhwa	January 5-7, 2021	190	1,301	0.00008	27.54	2,186
Trimmu, Punjab	January 11-13, 2021	291	1,123	0.00005	28.48	1,272
Balloki, Punjab	January 14-16, 2021	147	1,404	0.00011	23.04	2,540
Guddu, Sindh	January 20-22, 2021	805	754	0.00001	86.03	933
Sukkur, Sindh	January 23-25, 2021	968	1,377	0.00002	67.97	1,119
Hyderabad, Sindh [11]	January 26-28, 2021	33	1,539	0.00053	18.80	10,003

Sources: WAPDA 2021; Field survey data (active sampling)

11 From the survey, a plastic load of 1,539 kilograms per day at Hyderabad was estimated. According to WAPDA data, during the survey dates, the water discharge rate was significantly low and not consistent with other daily measurements; therefore, the monthly average (35.7 cubic meters per second) was considered, resulting in a plastic concentration of 0.49 grams per cubic meter. As per WAPDA data for April 2020 to March 2021, the volume of water discharged below Kotri Barrage for that year was 18.80 cubic kilometres.

Appendix 4: Stakeholder Consultation Summaries

Consultations were carried out with a number of stakeholders to collect relevant information on plastic pollution in the Indus River Basin to enhance and better understand the results of the field survey. The consultations with various stakeholders are summarized in Boxes A4.1-A4.8.

Box A4.1: Khyber Pakhtunkhwa Irrigation Department

- **Water in the rivers and streams is clean** as the areas near irrigation infrastructure and canals are not highly urbanized.
- **Khyber Pakhtunkhwa does not have barrages;** it only has headworks at Upper and Lower Swat. The flow of water is so strong that any waste is flushed towards the Punjab plains and some of it gets trapped along the river banks.
- **Most canals, especially those going through cities like Peshawar, have become equivalent to drains.** The canals are cleaned annually in December and January with excavators, and the waste is taken to dumpsites along with municipal waste.
- **Khyber Pakhtunkhwa does not have proper dumpsites or landfills.** Currently, waste is transported to dumpsites in the city suburbs by WSSCs and TMAs in cities and towns, respectively.
- **Waste has become a nuisance** and increases operation and maintenance costs along with increased wear and tear of machinery.
- A **waste characterization survey is needed** for proper planning and management of solid waste and to promote recycling. Currently, only Mardan has carried out a waste characterization survey.
- **Waste traps or litter booms must be installed** on irrigation canals and streams.

Box A4.2: Peshawar Water and Sanitation Services Company, Khyber Pakhtunkhwa

- **The Peshawar Water and Sanitation Services Company (WSSC) is a separate entity that is not owned by the city** but works in association with the city in terms of deputed human resources and transferred physical resources.
- Incorporated as a company under Article 42 of the Companies Act, 1984, **the company has a board of directors consisting of 14-15 members** who are appointed by the provincial cabinet through the Secretary, Local Government. The CEO is elected based on required technical qualifications.
- **Peshawar WSSC is not sustainable** as the company does not have independence to set tariffs. The Khyber Pakhtunkhwa Water Act will set a mechanism for tariff setting.
- The Peshawar Municipal Corporation has **transferred around 4,000 SWM employees, as well as machinery and equipment, to Peshawar WSSC**. The machinery is outdated and human resources are semi-skilled and need capacity building and training.
- Currently, **only 43 of 91 union councils are being served by the Peshawar WSSC.**
- **Issues that hinder effective SWM service delivery** include lack of monitoring data and equipment, poor area coverage for service delivery, lack of infrastructure, particularly monitoring hardware and collection equipment, and lack of sanitary landfill sites.
- **Alternative sources of funding** and tools to increase own-source revenue **must be explored** for sustainable operations.
- **Training in key skills must be developed** at all levels, from officers to janitorial staff.
- **Tariffs must be set such that they are reasonable** and can cover a significant proportion of costs.

Box A4.3: Mingora Water and Sanitation Services Company, Khyber Pakhtunkhwa

- Mingora Water and Sanitation Services Company (WSSC) **is responsible for managing MSW** in Swat District.
- **Mingora WSSC maintains a daily log** of total solid waste generated in Mingora, which is nearly 180 tonnes per day.
- **Mingora WSSC charges the public for MSW management.** A solid waste fee of PRs 70 is included in the water supply bill of domestic users, while for commercial users this rate varies from PRs 1,000 to 3,000 based on the size of commercial activity.
- **Leakage or uncollected waste is negligible** as solid waste is transported to the Kowtara Mara dumpsite in properly covered vehicles. The area of the dumpsite comprises 64 kanals (roughly equivalent to 3.25 hectares).
- **Mingora WSSC follows guidelines outlined under Schedule 5** of the Local Government Act of 2013 to manage MSW.
- A Mingora WSSC waste composition study shows that the share of **plastic waste is 13 percent of total waste**.
- Presently, **waste is only collected and transported** to the dumpsite. Consultants were recently hired to design a segregation unit and plan the construction of a landfill.
- There is **no data available on water quality** affected by municipal waste.
- Mingora WSSC worked with UNICEF **to create awareness regarding waste segregation and disposal**.
- Mingora WSSC faces several issues including a **shortage of sanitary workers as well as of landfill sites**.

Box A4.4: Punjab Irrigation Department

- There is **no waste collection or monitoring mechanism** at any of the barrages.
- **On Marala headworks, a steel boom was designed** a few years ago to collect wooden logs coming downstream. However, **this project was eventually discontinued**.
- **Solid waste from canals is collected and dumped** in coordination with municipal agencies.
- **Plastic waste,** concentrated along a 50 to 100-foot stretch along the river bank at Balloki, **is removed manually.**
- **Hyacinth is also removed** from canals manually.
- **Removal of solid waste near barrages** is done annually in December/January following a set schedule, for which excavators are used.
- **To reform irrigation laws and develop water quality monitoring systems, the Asian Development Bank funded a technical assistance study**—*Institutional Transformation of the Punjab Irrigation Department to a Water Resources Department*—aiming to transform the provincial Irrigation Department into a Water Resources Department (ADB 2016).

Box A4.5: Punjab Department of Forests, Wildlife, and Fisheries

- The main objective of the department is to **conserve, manage, and develop aquatic resources** by both the public and private sectors.
- The department does not deal with any kind of pollution. **Monitoring and collection of wastes do not fall under the current mandate** of the department. All pollution-related complaints are forwarded to the Environmental Protection Department.
- There is **no penalty system for tourists** who litter in the areas under the Department's jurisdiction.
- There is **no available data on microplastic and macroplastic pollution** in aquatic resources.
- **No study or research has been commissioned** by the department so far to monitor tourism-related waste or pollution management.
- The **fisheries department periodically monitors water quality parameters** such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and turbidity.

Box A4.6: Punjab Environmental Protection Department

- Punjab took the initiative to regulate plastics as per *The Punjab Prohibition on Manufacture, Sale, Use and Import of Polythene Bags (Black or any Other Polythene Bag Below Fifteen Micron Thickness) Ordinance, 2002*. The enactment of the law is currently being challenged in the Lahore High Court. The **Punjab EPD is also formulating a strategy on single-use plastics**.
- Although the Punjab EPD discourages PET imports, importers argue that the EPA does not have any data on the quantity of PET locally available and being recycled. **Importers also claim that a high proportion of PET is being recycled** by the informal sector and that PET is not a major cause of pollution.
- There is **no data available on plastic waste**.
- **Under the Clean Green Pakistan initiative, the focus is on tree plantation drives**, and the Punjab EPD is involved in conducting awareness campaigns under the Government of Pakistan's 'No to Plastic Bags' initiative.
- Currently, the **EPD is implementing the World Bank-funded Punjab Green Development Project** to strengthen environmental governance and promote green investments in the province (World Bank 2022). Project-specific activities include adoption of a plastics management strategy and regulating the production and consumption of single-use plastics. By the time the project concludes, the Punjab EPD will be in a position to implement and enforce a regulatory regime related to climate change.
- While there is no concrete data on plastic waste and pollution, **the Asian Development Bank funded a recently-completed study on the Ravi River** to assess pollution, identify and close institutional gaps, raise awareness, and develop a long-term plan to revitalize and build resilience (ADB 2022).

Box A4.7: Lahore Waste Management Company, Punjab

- The Lahore Waste Management Company **(LWMC) is responsible for waste management in Lahore**.
- **LWMC maintains waste data collection records**, updated daily on a digital database management system. Currently, the amount of waste generated and collected in Lahore is approximately 5,000-5,500 tonnes per day.
- LWMC is **funded by the Government of Punjab** and does not charge the general public for MSW service delivery.
- LWMC waste management vehicle fleet includes a compactor, trailer, and pick-up. These **vehicles are used to transport the waste** to the authorized dumpsite.
- **Leakage or uncollected waste is near zero** as waste is transported to the dumpsite in properly covered vehicles.
- About **2,000 tonnes of waste is dumped daily at the dumpsite**, while the remainder is dumped at an open dumping facility. Both facilities are located in Lakhodair, Lahore.
- In 2019, the **plastic waste generated in Lahore was 22 percent** of total MSW (Ilmas et al. 2021). A previous study undertaken in Lahore showed plastic waste comprised 18.3 percent of total MSW (including PET, nylon, Tetra Pak, diapers, and other plastics) (ISTAC 2011).
- There are huge gaps in laws related to SWM, but **LWMC is working with the provincial government on drafting a Solid Waste Management Act**, which is currently in the documentation phase.
- There is **no data available on tourist-generated waste.**
- Currently, waste is only collected and transported to the dumpsite. However, **projects like waste-to-energy, materials recovery, composting, and biogas are in the planning phase**.
- **LWMC faces problems related to waste segregation and disposal**. LWMC is currently trying to provide waste segregation bags but people use these bags for other domestic purposes.
- LWMC has collaborated with Tearfund Pakistan, an NGO, **to spread awareness regarding SWM**.

Box A4.8: Deputy Commissioner Office, Kashmore, Sindh

- **Guddu Barrage, on the Indus River, falls under the jurisdiction of Kashmore District** in Sindh Province. The district is primarily home to a rural population.
- **Kashmore is an under-developed district** despite the fact that Guddu has one of the largest thermal power plants in the country, generating 1,400-1,750 MW of electricity.
- The Municipal Corporation of Kashmore **lacks the necessary equipment and machinery to collect solid waste.**
- The waste generated is collected with a single tractor trolley, while **rural areas do not have any system of waste collection.**
- As a result, **solid waste mostly ends up in open areas and water channels** that lead to the Indus River.

Box A4.9: Irrigation Department, Guddu Barrage, Sindh

- Guddu Barrage was completed in 1962, with **renovation and upgradation work undertaken from time to time.**
- Guddu Barrage **controls the irrigation supplied to 2.9 million acres of agricultural land** in Kashmore, Jaccobabad, Larkna, Sukkur, and Naseerabad districts.
- Water flow at the barrage is controlled by gates, which are **cleaned by heavy machinery only when the gates get stuck** due to tree logs or animal carcasses.
- There is **no mechanism to collect waste accumulated at the gates** or in the flowing river water.

Box A4.10: Assistant Commissioner Office, Sukkur, Sindh

- Sukkur is the fourteenth largest city in Pakistan with a population of approximately 550,000 and **generates around 1,500 tons per day of MSW.**
- The garbage generated in the city is collected and transported to a **dump site located near the Indus River.**
- The city plans to **outsource waste management services through the Sindh Solid Waste Management Board.**
- Sukkur has **two wastewater treatment plants,** but they are sometimes not operational.
- The **wastewater from the city is discharged directly into the Indus River without any treatment;** however, plans are underway to connect the city's sewerage system to the wastewater treatment plants and make them operational as soon as possible.

Box A4.11: Hyderabad Municipal Corporation, Sindh

- After Karachi, the largest city in Pakistan, **Hyderabad is the industrial hub of Sindh Province.**
- The **solid waste collected in Hyderabad is disposed of at an open dump site** located in the eastern part of the city.
- The Sindh Solid Waste Management Board is in the process of **contracting SWM services to a private company,** which will help in improving overall waste management in the city.
- The city administration also conducts **plastic bag eradication campaigns**, where the Environment Department along with the Municipal Corporation conduct surprise visits to stores and shopping centers and issue fines to shopkeepers who use low quality polythene bags.
- The city sewage system is old and in need of improvement. **Current sewage lines open into the Indus River through various *nullahs*** (drains or gullys).

Box A4.12: Other Stakeholder Consultations during the Field Survey

Stakeholder consultations in the sampling areas were conducted during the field survey. In Nowshera, Dera Ismail Khan, Guddu, Sukkur, and Hyderabad, stakeholder consultations with Deputy Commissioners' offices as well as Irrigation Department officials were held.

During these consultations, the designated officials briefed the consultant team about the waste management systems of their respective cities and showed them the dumpsites and the hotspots where the cities' wastewater is flushed into the Indus River or its tributaries. At Sukkur, the current and proposed wastewater treatment plant locations were also visited. These consultations enabled a better understanding of the current solid waste and plastics pollution scenario, particularly along the Indus River and its tributaries.

Plastic Waste: A Journey Down the Indus River Basin in Pakistan

References

Abbas, Ghulam. 2020. "Import of hazardous plastic scrap surges to 65,000 tonnes." *Pakistan Today*. https://profit.pakistantoday.com.pk/2020/05/21/import-of-hazardous-plastic-scrap-surges-to-65000-tonnes/.

ADB (Asian Development Bank). 2016. *Islamic Republic of Pakistan: Institutional Transformation of the Punjab Irrigation Department to a Water Resources Department*. Project Number: 49048-001. https://www.adb.org/sites/default/files/project-document/216581/49048-001-tar.pdf.

ADB (Asian Development Bank). 2022. *Pakistan: Revitalizing the Ecosystem of Ravi River Basin*. Sovereign Project: 51324-001. https://www.adb.org/projects/51324-001/main.

Ahmad, N. and D.O. Lodrick. 2021. "Indus River." March 19. *Encyclopedia Britannica*. https://www.britannica.com/place/Indus-River.

Alam, Ahmad Rafay. 2018. *Situational Analysis of National Environmental Laws and Policies, Non-Compliance of these Laws, Resource Efficiency Issues and Gaps in Implementation and Enforcement*. WWF-Pakistan.

Ashraf, U., I. Hameed, and M. N. Chaudhary. 2016. "Solid waste management practices under public and private sector in Lahore, Pakistan." *Bulletin of Environmental Studies* 1(3), 98-105. https://tuhat.helsinki.fi/ws/files/126992317/Ashraf2016.pdf.

Boucher, J. and G. Billard. 2019. "The challenges of measuring plastic pollution." Field Actions Science Reports. *The Journal of Field Actions - Special Issue,* 19: 68-75. https://journals.openedition.org/factsreports/5319.

Conchubhair, D.Ó., D. Fitzhenry, A. Lusher, A.L. King, T. van Emmerik, L. Lebreton, C. Ricaurte-Villota, L. Espinosa, and E. O'Rourke. 2019. "Joint effort among research infrastructures to quantify the impact of plastic debris in the ocean." *Environmental Research Letters,* 14(6), 065001.

Constable. Pamela. 2019. "Pakistan moves to ban single-use plastic bags: 'The health of 200 million people is at stake'". August 13. *The Washington Post*. https://www.washingtonpost.com/world/asia_pacific/pakistan-moves-to-ban-single-use-plastic-bags-the-health-of-200-million-people-is-at-stake/2019/08/12/6c7641ca-bc23-11e9-b873-63ace636af08_story.html.

Dawn. 2003. "Informal Waste Management." https://www.dawn.com/news/133388/informal-waste-management.

Dawn. 2008. "Indus river pollution a risk to livelihoods". https://www.dawn.com/news/295877/indus-river-pollution-a-risk-to-livelihoods.

Dawn. 2020. "Plastic Ban" (Editorial). *Dawn*. https://www.dawn.com/news/1580816.

Derraik, J.G.B. 2002. "The pollution of the marine environment by plastic debris: A review." *Marine Pollution Bulletin*, 44(9), 842–852.

EJ (Environmental Justice) Atlas. 2020. "Marginalized informal recycling and the start of waste-to-energy in Lahore, Punjab, Pakistan." https://ejatlas.org/conflict/waste-worries-marginalized-informal-recycling-and-the-start-of-waste-to-energy-in-lahore-punjab-pakistan.

FAO AQUASTAT. 2011. "Transboundary River Basins – Indus River Basin". Rome: Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/3/ca2136en/CA2136EN.pdf.

Ghai, Rajat. 2019. "Indus river system among world's most vulnerable water towers: Study." *Down To Earth*. https://www.downtoearth.org.in/news/water/indus-river-system-among-world-s-most-vulnerable-water-towers-study-68339.

Gladstone, Rachel. 2019. "Co-processing: Today's Best Solution to Recovering Low-Value Plastics." rePurpose. https://blog.repurpose.global/co-processing-recovering-low-value-plastics/.

Hadid, Diaa and A. Sattar. 2019. "How Bad Is Pakistan's Plastic Bag Problem? See For Yourself". *Goats and Soda*. https://www.npr.org/sections/goatsandsoda/2019/08/13/749362829/how-bad-is-pakistans-plastic-bag-problem-see-for-yourself.

Hafeez, A. 2019. "Fishing villages dry up on the Indus". *The Third Pole*. https://www.thethirdpole.net/en/nature/fishing-villages-dry-up-on-the-indus/.

Hamblyn, Charlie. 2019. "Plastic in everyday life – Let's reduce the use!". April 26. *Natura Pacific*. https://www.natura-pacific.com/plastic-everyday-life-lets-reduce-use.

Hoornweg, Daniel and Perinaz Bhada-Tata. 2012. *What a Waste: A Global Review of Solid Waste Management.* Urban Development Series Knowledge Papers, No. 15. Washington, DC: The World Bank.

IANS (Indo-Asian News Service). 2017. "Non-Compostable Sanitary Waste Is A Huge Threat To Health and Environment: Experts". *NDTV*. https://swachhindia.ndtv.com/non-compostable-sanitary-waste-huge-threat-health-environment-experts-8349/.

Ilmas, Bibi, Y. Dongbei, S. Khalid, and K.A. Mir. 2021. "Characterization and energy potential evaluation of urban municipal solid waste of Pakistan." *Carbon Management,* 12(6), 581-591. https://doi.org/10.1080/17583004.2021.1976675.

ISTAC. 2011. *Summer Waste Characterization Study.* Consulting Services Project for Integrated Solid Waste Management of Lahore City of the State of Punjab in Pakistan. https://lwmc.com.pk/uploads/Waste%20Characterization%20Study/Nov%202011%20Waste%20Charecterization%20Study.pdf.

Jambeck, J.R., R. Geyer, C. Wilcox, T.R. Siegler, M. Perryman, A. Andrady, R. Narayan, and K.L. Law. 2015. "Plastic waste inputs from land into the ocean". *Science*, 347(6223), 768-771. https://www.unep.org/interactive/beat-plastic-pollution.

Kamran A., M. N. Chaudhry, and S.A. Batool. 2015. "Role of the Informal Sector in Recycling Waste in Eastern Lahore." *Polish Journal of Environmental Studies* 24(2), 537–543. http://www.pjoes.com/Role-of-the-Informal-Sector-in-Recycling-r-nWaste-in-Eastern-Lahore,89442,0,2.html.

Kaza, Silpa, L. Yao, P. Bhada-Tata, and F. Van Woerden. 2018. *What a Waste 2.0–A Global Snapshot of Solid Waste Management to 2050.* Washington, DC: The World Bank.

Lebreton, Laurent C. M., J. van der Zwet, J.-W. Damsteeg, B. Slat, A. Andrady, and J. Reisser. 2017. "River Plastic Emissions to the World's Oceans." *Nature Communications*, 15611. https://doi.org/10.1038/ncomms15611.

Majeed, A., S.A. Batool, and M. N. Chaudhry. 2016. "Informal Waste Management in the Developing World: Economic Contribution through Integration with the Formal Sector." *Waste and Biomass Valorization* 8, 679–694. https://link.springer.com/article/10.1007/s12649-016-9648-4.

Masood M. and C. Y. Barlow. 2013. "Framework for integration of informal waste management sector with the formal sector in Pakistan." *Waste Management & Research* 31(10), Supplement 93 –105. https://www.researchgate.net/publication/256377327_Framework_for_integration_of_informal_waste_management_sector_with_the_formal_sector_in_Pakistan.

McKinsey Center for Business and Environment. 2015. "Stemming the Tide: Land-based strategies for a plastic-free ocean". *Ocean Conservancy.* https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf.

Meals, D.W., R.P. Richards, and S.A. Dressing. 2013. "Pollutant load estimation for water quality monitoring projects." Tech Notes 8, April 2013. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc. https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-monitoring- technical-notes.

Medina, Martin. 2008. "The informal recycling sector in developing countries – Organizing waste pickers to enhance their impact." *Gridlines.* Note No. 44, October. PPIAF (Public-Private Infrastructure Advisory Partnership). Washington, DC: The World Bank.

Meijer, L. J. J., T. van Emmerik, R. van der Ent, C. Schmidt, and L. Lebreton. 2021. "More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean". *Science Advances*. https://advances.sciencemag.org/content/advances/7/18/eaaz5803.full.pdf.

Michel, D. and Russel Sticklor. 2013. "Toxic Brew: Water Quality, Public Health, and Human Welfare in the Indus Basin". *Stimson*. https://www.stimson.org/2013/toxic-brew-water-quality-public-health-and-human-welfare-indus-basin-0/.

Mukheed, M. and A. Khan. 2020. "Plastic Pollution in Pakistan: Environmental and Health Implications." *Journal of Pollution Effects & Control* 8(4), 251.

Our News. 2019. "Indus is second most polluted river with plastic, speaker tells KU event." October 24. *Our News.* https://www.thenews.com.pk/print/545282-indus-is-second-most-polluted-river-with-plastic-speaker-tells-ku-event

Pakistan MoCC (Ministry of Climate Change). 2021. “Clean Green Pakistan.” Clean Green Pakistan Movement. Islamabad: Government of Pakistan, Ministry of Climate Change. https://cleangreen.gov.pk/eng.

PBS (Pakistan Bureau of Statistics). 2015. “Compendium on Environment Statistics of Pakistan”. Islamabad: Government of Pakistan, Pakistan Bureau of Statistics. https://www.pbs.gov.pk/sites/default/files//crops_and_climates/compendium_environment/compendium_environment_2015.pdf.

Pappas, Gregory. 2011. “Pakistan and Water: New Pressures on Global Security and Human Health.” *American Journal of Public Health,* 101 (5). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3076420/#:~:text=Water%20pollution%20in%20the%20Indus,is%20discharged%20into%20the%20river.

Qureshi, Asad Sarwar. 2011. “Water Management in the Indus Basin in Pakistan: Challenges and Opportunities”. August 1. *Mountain Research and Development*, 31(3), 252-260. https://bioone.org/journals/mountain-research-and-development/volume-31/issue-3/MRD-JOURNAL-D-11-00019.1/Water-Management-in-the-Indus-Basin-in-Pakistan--Challenges/10.1659/MRD-JOURNAL-D-11-00019.1.full.

Qureshi, Zubair. 2019. “Pakistan uses 55b plastic bags each year, Indus second most polluted river of the world.” April 27. *Gulf News.* https://gulfnews.com/world/asia/pakistan/pakistan-uses-55b-plastic-bags-each-year-indus-second-most-polluted-river-of-the-world-1.63591505.

Resnick, B. 2019. “More than ever, our clothes are made of plastic. Just washing them can pollute the oceans”. Vox. https://www.vox.com/the-goods/2018/9/19/17800654/clothes-plastic-pollution-polyester-washing-machine.

Ritchie, Hannah. 2021. “Where does the plastic in our oceans come from?” Our World in Data. https://ourworldindata.org/ocean-plastics.

Rochman, C.M., A. Tahir, S.L. Williams, D.V. Baxa, R. Lam, J.T. Miller, F. Teh, S. Werorilangi, and S.J. The. 2015. “Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption.” *Scientific Reports,* 5, 14340.

Safar, Korai M., R.B. Mahar, and M.A. Uqaili. 2017. “The Feasibility of Municipal Solid Waste for Energy Generation and its Existing Management Practices in Pakistan.” *Renewable and Sustainable Energy Reviews,* 72, 338-353. DOI: 10.1016/j.rser.2017.01.051.

Sanchez, Michael. 2019. “Trash Talk: Putting the Garbage Crisis in Perspective”. *LinkedIn*. https://www.linkedin.com/pulse/trash-talk-putting-garbage-crisis-perspective-michael-a-sanchez/.

Schmidt, Christian, T. Krauth, and S. Wagner. 2017. “Export of Plastic Debris by Rivers into the Sea.” *Environ. Sci. Technol*. 51, 21. https://doi.org/10.1021/acs.est.7b02368.

Sobkowiak, Leszek, Adam Perz, Dariusz Wrzesinski, and Muhammad Abrar Faiz. 2020. “Estimation of the River Flow Synchronicity in the Upper Indus River Basin Using Copula Functions.” *Sustainability*, 12, 5122.

Stanton, A. 2019. “Why Are Synthetic Fabrics So Popular—And What Can We Do To Move Away From Them?” *The Good Trade*. https://www.thegoodtrade.com/features/synthetic-fabric-plastic-pollution.

Tabassum, Shaista. 2018. "The Indus Basin is indispensable: An agro-hydropower dependency of India and Pakistan." *Journal of Political Studies,* 25(1), 257:269. https://www.researchgate.net/publication/334737603_The_Indus_Basin_is_indispensable_An_agro-hydropower_dependency_of_India_and_Pakistan.

Tetra Pak. n.d. “Recyclable Tetra Pak Cartons”. https://www.tetrapak.com/en-in/sustainability/planet/good-for-you-good-for-the-earth/tetra-pak-cartons-recyclable.

Thompson, R.C., Y. Olsen, R.P. Mitchell, A. Davis, S.J. Rowland, A.W.G. John, D. McGonigle, and A.E. Russell. 2004. “Lost at sea: Where is all the plastic?” *Science,* 304(5672), 838–838.

Tiseo, I. 2021. “Global Plastic Production 1950–2019.” *Chemicals & Resources*. https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950.

Tramoy, R., J. Gasperi, R. Dris, L. Colasse, C. Fisson, S. Sananes, V. Rocher, and B. Tassin. 2019. “Assessment of the plastic inputs from the Seine Basin to the sea using statistical and field approaches”. *Frontiers in Marine Science,* 6, 151. https://www.frontiersin.org/articles/10.3389/fmars.2019.00151/full.

UNEP (United Nations Environment Programme). 2020. “Monitoring Plastics in Rivers and Lakes: Guidelines for the Harmonization of Methodologies”. Nairobi. https://wedocs.unep.org/bitstream/handle/20.500.11822/35834/MPRLS.pdf?sequence=1&isAllowed=y.

Van Emmerik, T., Emilie Strady, Thuy-Chung Kieu-Le, Luan Nguyen, and Nicolas Gratiot. 2019. “Seasonality of riverine macroplastic transport.” *Scientific Reports,* Vol. 9, 13549. https://www.nature.com/articles/s41598-019-50096-1.

van Emmerik, T. and A. Schwarz. 2020. “Plastic debris in rivers”. *Wiley Interdisciplinary Reviews: Water,* 7(1), e1398. https://onlinelibrary.wiley.com/doi/full/10.1002/wat2.1398.

WAPDA (Water and Power Development Authority). 2021. Personal communication with WAPDA officials, February/March 2021.

Wolf, Mattis., K. Berg, S.P. Garaba, N. Gnann, K. Sattler, F. Stahl, O. Zielinski. 2020. “Machine learning for aquatic plastic litter detection, classification and quantification (APLASTIC-Q).” *Environmental Research Letters,* 15 114042. https://iopscience.iop.org/article/10.1088/1748-9326/abbd01/pdf.

World Bank. 2021a. *Pakistan: Sustainable Solid Waste Management in Mountain Areas.* Washington, DC: The World Bank. http://hdl.handle.net/10986/35501.

World Bank. 2021b. “South Asia Water Initiative (SAWI)”. Washington, DC: The World Bank. https://www.worldbank.org/en/programs/sawi#1.

World Bank. 2021c. *SAWI Baseline Assessment for Plastic Debris flowing into Rivers and Seas of South Asia.* (Unpublished). Washington, DC: The World Bank.

World Bank. 2022. “Punjab Green Development Program.” Projects & Operations. Washington, DC: The World Bank. https://projects.worldbank.org/en/projects-operations/project-detail/P165388.

WWF (World Wildlife Fund). 2020. “Indus River Dolphin.” https://www.worldwildlife.org/species/indus-river-dolphin.

WWF-Pakistan. 2021. “Tackling Plastic Pollution in Pakistan.” World Wide Fund for Nature. Lahore: WWF-Pakistan. https://www.wwfpak.org/issues/plastic_pollution/.

Young, William J., A. Anwar, T. Bhatti, E. Borgomeo, S. Davies, W.R. Garthwaite III, E.M. Gilmont, C. Leb, L. Lytton, I. Makin, and B. Saeed. 2019. “Pakistan: Getting More from Water.” *Water Security Diagnostic*. Washington, DC: The World Bank.

Plastic Waste: A Journey Down the Indus River Basin in Pakistan

Plastic Waste: A Journey Down the Indus River Basin in Pakistan represents the first-of-its-kind study to identify, quantify, and analyze plastic waste in the Indus River Basin in Pakistan. Although a lifeline for Pakistan's economy and population, the Indus River and its tributaries are known to be the most polluted rivers in the world due to the perennial presence of plastic waste. This raises a number of questions that this report seeks to answer: Where does plastic waste in the Indus and its tributaries come from and what does it consist of? Where does plastic waste in the Indus end up? What drives the high plastic load carried by the Indus? And to what extent can questions about plastic pollution in the Indus River Basin, including the ones above, be answered?

This report, funded by the South Asia Water Initiative (SAWI), presents the findings of this new research, quantifying plastic litter in the Indus River and its tributaries, using techniques applied in other parts of the world to quantify riverine plastic waste. Based on the insights generated by this study, a number of recommendations are proposed for stakeholders. The report seeks to elevate the management of solid waste, particularly plastics, as a crucial development issue, and one that requires targeted action with intense coordination among various stakeholders determined to make the Indus garbage-free.

THE WORLD BANK

SAWI SOUTH ASIA WATER INITIATIVE

1818 H Street NW, Washington DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org