ENVIRONMENTAL SCOPING STUDY

The LYARI RIVER

#SeeingTheUnseen

DRAFT

ENVIRONMENTAL SCOPING STUDY

The LYARI RIVER

#SeeingTheUnseen

Environmental Scoping Study | The Lyari River #SeeingTheUnseen

First published in Pakistan in 2022 by Markings Publishing

Research, Development and Compilation by
SEED Ventures

Layout Design at Markings
Samia Fatima
Tuba Arshad

Cover Design
Cover Image
rawpixel.com on FreePik

We would like to thank the following institutions and communities for the their contributions in the making of this report;
Karachi Port Trust,
National Institute of Oceanography,
Sindh Solid Waste Management Board,
Pakistan Navy Hydrographic Department,
Garbage Can,
Trashit,
and the local fishermen communities of Shamspir and Bababhit Island

For more information and to download the digital version of the study, please visit: https://www.coca-cola.pk/

Hiba Dar
Senior Communications Manager
The Coca-Cola Export Corporation
hdar@coca-cola.com
sustainabilitypakistan@coca-cola.com

THE Coca-Cola COMPANY | Pakistan & Afghanistan Region

world without waste
THE COCA-COLA COMPANY

SEED
Social, Entrepreneurship & Equity Development

TOGETHER WE CAN HELP TURN THE TIDE ON RIVER PLASTIC POLLUTION

THE Coca-Cola COMPANY | Pakistan & Afghanistan Region

world without waste
THE COCA-COLA COMPANY

SEED
Social, Entrepreneurship & Equity Development

CONTENTS

Executive Summary

Oceans are not only the biggest store-houses of biodiversity, but also possess great potential for carbon sequestration. Along with the large river networks of the world, oceans continue to provide valuable fisheries, an important economic resource that has enabled growth and development of communities, countries and coastal regions. This 'blue economy' has been under threat for several decades now; exponential growth of coastal populations, lack of adequate policy/motivation for protection and management of oceans, and a narrow view of the economic life of goods and services, have all contributed to the demise of our rivers and oceans. Karachi, the economic capital of Pakistan suffers from a plethora of environmental hazards, not the least of which is the large volume of waste, including plastics, that is dumped in Karachi's drains, rivers and coastal waters.

Karachi falls amongst the top 10 cities in terms of area and population and visibly suffers from urban sprawl. Open dumping of all types of solid waste in to Karachi's drains, rivers, and coastal waters is a common phenomenon. A recent study on the types and volume of waste generated by each district in Karachi shows that after organic kitchen waste, non-biodegradable plastic is the second largest waste-type. Based on the 9-day sample survey conducted during the study, nearly one-fifth of the entire waste produced in Karachi is plastic.[1] Moreover, a study on marine litter by the Ministry of Climate Change in 2018, found that inland flows of untreated sewage and industrial waste are the main culprits behind marine debris.

The Ocean Cleanup, a Dutch NGO has embarked on an ambitious initiative to clean the world's oceans and water bodies of plastic pollution through innovative technological solutions driven by sound science and targeted delivery. The Ocean Cleanup's River Project and Coca-Cola are looking to build a coalition that explores solutions to clean the accumulated debris and create community-based backward and forward linkages. The Ocean Cleanup will be visiting Pakistan to explore the landscape, understand the scope of the problem, speak to stakeholders, and make an assessment of the kind of solutions that are applicable.

The present study is a baseline assessment of the existing plastic pollution problem in Karachi, with a focus on how solid waste (especially plastics) end-up in water bodies. In particular, to better understand the suitability and practicality of particular locations for deployment of any technological solutions, the study team focused on the following areas: downstream sites of Lyari River (particularly the intersections of Mewa Shah Road and Mauripur Road and Lyari River), Lyari Outfall, Lunkinawala Dor, Baba and Bhit Islands.

Based on an assessment of waste disposal practices and patterns of accumulation and aggregation, we can recommend and propose possible solutions that can help address this problem. Moreover, to ensure a comprehensive evaluation of the problem and possible solutions, a robust stakeholder mapping and engagement exercise has been carried out. This helps help identify various partners and contributors from government departments, academia, research institutes and the like, all of whom will be integral to the successful implementation and operations of any plausible solutions to address Karachi's plastic pollution problem.

1. Waste Amount Characterization Survey, Sindh Solid Waste Management Board (2021)

The main findings of the report were as follows:

• In Pakistan, 30 million tons of solid waste are produced annually, out of which 9% are plastics. An estimated 6.4 million tonnes of plastic are being produced annually in Pakistan, home to some 6,000 plastic products' manufacturers. Environmental Protection Agency suggests that around 55 billion disposable plastic bags are used by Pakistanis in a year. This does not account for single-use cutlery, crockery and packaging material. Most of this municipal waste is either burned, dumped or buried on vacant lots, or it is disposed of in rivers without any proper planning. Like other developing countries, Pakistan lacks waste management infrastructure, creating serious environmental problems.

• Plastic is the second largest constituent of all waste produced in Karachi. Based on the data provided by SSWMB, after organic waste the second largest contribution to waste if of plastics.

• Karachi is the largest and most populous metropolitan city in Pakistan and the capital of Sindh province. The city was historically a fishing village that originated along a fresh water river though seasonal –The Lyari River.

• There are two main rivers in Karachi Lyari and Malir. Three fourth of these industries are discharging their effluents into the Lyari river and the rest into different channels including the Malir river and both the rivers enter into the sea. Lyari River is badly contaminated and has now transformed into a major sewage drain from a fresh water river that once was supporting local agriculture as well as replenished underground water table. The Lyari River along with its tributaries has been completely converted to main sewage drain.

• The Lyari River, runs through the most densely populated northern section and accommodates approximately 0.8 million people in near about 50 Katchi abadies along both sides of its banks. Accumulation of plastics and solid waste in Lyari downstream is due to lack of protective fencing and encroachments . The most plastic accumulation is found at the outfalls of Orangi and Gujjar Nallah, and then around the islands of the western backwaters.

• The harbor area requires initiatives and solutions which can skim the floating debris. Efforts by Marine Pollution Control Department are focused on removing the debris that enter via the Lyari outfall. These efforts are but a drop in the ocean, and they need to be supported with solutions and interventions that can amplify their efforts.

1. OVERALL SITUATIONAL ANALYSIS

1.1 Is Pakistan a focus country?

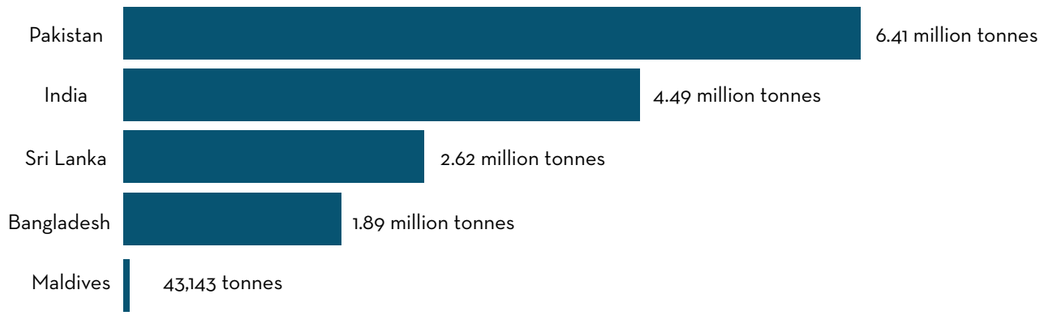
Unlike China, Indonesia, the Philippines and Vietnam, Pakistan does not fall among the top plastic-waste-producing countries. But with a growing population, growth in consumerism, and rapid urbanisation, a large amount of waste is being generated that is being dumped on land and is eventually making its way to the Arabian Sea. The Environmental Protection Agency has suggested that even from a conservative perspective, approximately 55 million disposable plastic bags are being used in the country per year, and this number does not include plastic packaging, single-use crockery or cutlery.

The solid waste management situation in Pakistan is a matter of grave concern. Due to environmental vulnerability, Pakistan has received a lot of attention for its serious waste management (SWM) problems. Recent assessments in major cities of Pakistan showed that the average waste generation rate from all types of municipal controlled areas vary from 0.283 kg to 0.613 kg per person each day, and waste production is growing annually at a rate of 3.67% to 7.42%

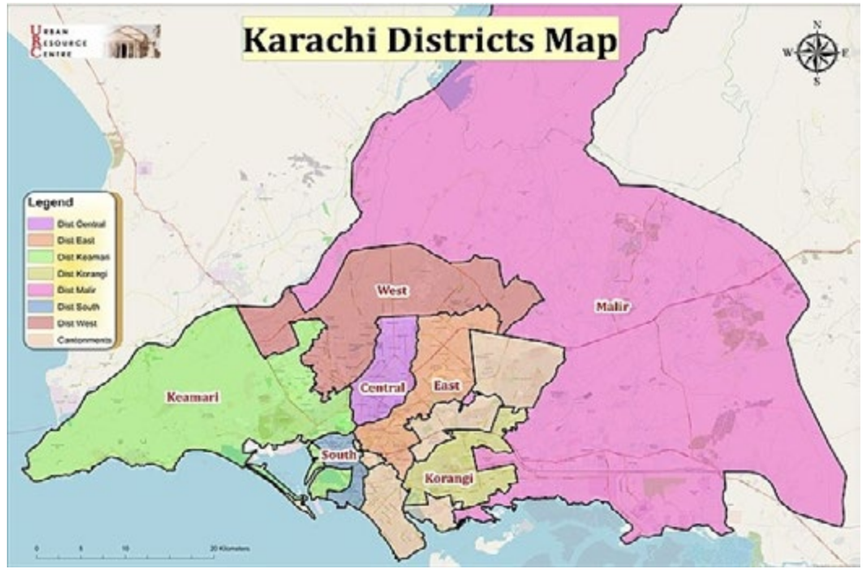
Pakistan ranks highest for poorly handled plastic in South Asia. In Pakistan, 30 million tons of solid waste are produced annually, out of which 9% are plastics, contributing approximately 0.2 million tons of plastic waste along the Indus River to the Arabian Sea. Several countries—including Bangladesh, France, and Rwanda—have banned the use of plastic bags. In Pakistan, the Environment Protection Agency (EPA) has also released a Statutory Regulatory Order to ban plastic bags in the Federal Capital, Islamabad, and in other cities, like Lahore and Hunza. Currently, there is no constitutional mandate at the federal and provincial levels that address the implications of single-use plastics and plastic waste management in a wider area.

An estimated 6.4 million tonnes of plastic are being produced annually in Pakistan, home to some 6,000 plastic products' manufacturers. Irrigation canals especially those passing through big urban centers such as Lahore, Peshawar, Faisalabad are major carriers of plastic into the river. The illustration below clearly shows that Pakistan is the largest generator of plastic pollution in South Asia.

Figure 1.1: Comparison of Annual Plastic Generation in South Asian Nations



On an annual basis, Pakistan generates about 48.5 million tons of solid waste, which is increasing by more than 2 percent each year. Most of this municipal waste is either burned, dumped or buried on vacant lots, or it is disposed of in rivers without any proper planning Like other developing countries, Pakistan lacks waste management infrastructure, creating serious environmental problems. Most municipal waste is either burned, dumped or buried on vacant lots, threatening the health and welfare of the general population. According to the Pakistan Bureau of Statistics (2015), waste collection service in Pakistan is not widely available. Even in the urban area, 43% of the area has no waste collection service. Moreover, more than 90% of rural areas in Pakistan has no waste collection system.



1.2 What are the local conditions in Karachi?

Karachi is the largest and most populous metropolitan city in Pakistan and the capital of Sindh province. According to the 2017 census, the population of the city is 16.062 million which is approximately 34% of the total population of Sindh. Karachi is also the largest industrial city of Pakistan and has about 5000 registered and hundreds of unregistered industrial units.

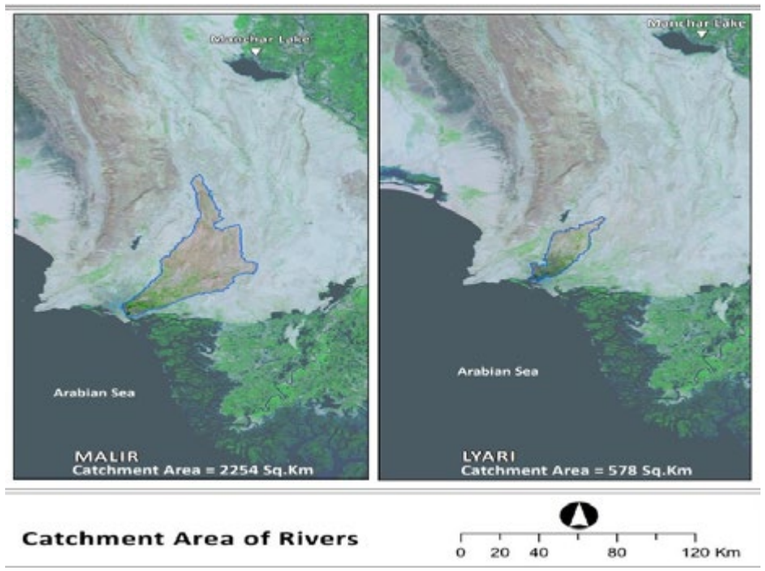
Karachi's port does not open directly to the Arabian Sea. Between the port and the ocean, a barrier island runs northwest-southeast. East of this island and west of the port sits a large expanse of water and mangroves. Water in the Lyari River Delta must empty into the sea through the Baba Channel. Located immediately east of the Port of Karachi are two more mangroves, the larger of which is named Chinna Creek.

There are two main rivers in Karachi, Lyari and Malir. Nearly three fourths of the industrial units are discharging effluents into the Lyari river and the rest into different channels including the Malir river, both these rivers eventually discharge into the sea. The Lyari River passes through the heart of the city and some of the most densely populated areas, and thus carries a much larger proportion of various types of solid waste, before dumping the same in the Karachi harbor areas. Emptying through a narrower delta, the Malir River is nevertheless more conspicuous than its neighboring waterway; the river is wider, and the corridor of vegetation along its banks extends farther out into the city.

Administrative Context and Governance

Since Pakistan's independence, Karachi has gone through several changes in its governance framework, with different political powers bringing out different governance structures. These frequent changes in the city's management approach are partly blamed for the overall poor quality of municipal services in the city. A major landmark change occurred after the introduction of a Local Governance System in Karachi in 2001 that led to the establishment of the City District Government of Karachi (CDGK) that directly supervised Karachi's 18 Towns through locally elected leaders. There was no second-tier of Local Government in this system.

After the enactment of the Sindh Local Government Act, 2013, the, Sindh Government restored the second tier of local governance (i.e., districts) and abolished City District Government Karachi. Presently, the Karachi Division comprises of seven districts (identified in the map below) that are governed by a public governing body, the Karachi Metropolitan Corporation (KMC) led by a designated Administrator and a Municipal Commissioner. Each district within Karachi is governed by a District Municipal Corporation (DMC) headed by a Chairman and a Deputy Chairman. These seven DMCs are administratively managed and supervised by the KMC. Each district of Karachi is further divided into Union Councils and Wards, the lowest tiers of governance in Pakistan. Apart from these seven districts, Karachi's designated rural areas, are governed separately as one 'District Council' to ensure that the interests of the large population on the peripheries of the city are represented. Moreover, six cantonment areas are also established within the city limits and are directly governed by the military. A total of 19 Federal, Provincial and Local Institutions govern different parts of the city, leading to a complex and intricate division of roles and responsibilities.



Climate

Karachi has pleasant weather for the greater part of the year. May and June are the hottest months when the mean maximum temperature is about 93 °F (34 °C). May and October can bring spells of heat, during which the temperature shoots up to 105 °F (41 °C). The coolest months are January and February, during which the mean minimum temperature remains about 56 °F (13 °C). A biting north wind occasionally blows in these months, during which the temperature may drop to 40 °F (4 °C). The relative humidity varies from 58 percent in October, the driest month, to 82 percent in August, the wettest month. The average rainfall is 8 inches (203 mm); most of the rain falls during a total of 9 or 10 days in the months of June, July, and August.

The city faces pollution problems. High humidity in the region does not permit evaporation of stagnant water in some places, while fumes from factories and automobiles contribute to air pollution, despite land and sea breezes. A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Karachi varies throughout the year. The wetter season lasts 1.9 months, from July 6 to September 2, with a greater than 7% chance of a given day being a wet day. The month with the wettest days in Karachi is July, with an average of 3.2 days with at least 0.04 inches of precipitation. The drier season lasts 10 months, from September 2 to July 6. The month with the fewest wet days in Karachi is May, with an average of 0.1 days with at least 0.04 inches of precipitation. Among wet days, we distinguish between those that experience rain alone, snow alone, or a mixture of the two. The month with the most days of rain alone in Karachi is July, with an average of 3.2 days. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 14% on July 30.

Malir and Lyari Basins

Karachi's excess surface water drains into four basins: Budnai Basin, Coastal Basin, Malir River Basin, and Lyari River Basin. River Malir, followed by the Lyari channel drain the Malir basin. Both channels are temporary, therefore, sewage and industrial waste generally flow in them.

Rivers Malir and Lyari basins are the two main basins that drain about 80 per cent of the surface overflow of the city. The picture below represents the geographical locations of Rivers Malir and Lyari. Minor basins include Budnai and the coastal basins. Surface overflow drains into hundreds of small and large channels in the basins and finally flows out into the Arabian sea.

Drainage system and Urban Flooding

The total rainfalls of August 2020 in Karachi city were particularly notable. It recorded 588.0 mm at Karachi-Faisal, 436.0 mm at Karachi-Masroor and 367.0 mm at Karachi-Airport, being wettest August in 48-, 63- & 89-years respectively of record. On 28th August, the Karachi-Faisal site recorded 231.0 mm 24-hours rainfall, the heaviest one-day rainfall on record. This was also the highest 24- hours rainfall for any month among three Karachi sites. The previous August record in the city was 209.8 mm at Karachi-Masroor on 18th August 1978, and the previous record for any month was 211.3 mm also at Karachi-Masroor on 26th July 1967. As a result of this unprecedented August rainfall, one of history's worst urban flooding occurred in the city affecting millions of people and inflicting widespread infrastructure damages.

Why this happened is explained by the city's drainage system's history. Stormwater from Karachi is discharged into the Lyari and Malir, two seasonal rivers. Both begin in the Kirthar mountain's foothills and go parallel for 14-20 kilometers. According to the Karachi Water and Sewerage Board, the rivers use a network of hundreds of smaller drains to carry water from their enormous catchment regions to 64 natural drains (KWSB). (For a depiction of Karachi's drainage system, please see the photo at the end of section one)

Trash was eventually dumped into the sewers as a result of an expanding population load and inadequate waste collection and management, which frequently choked and clogged the whole system. Additionally, many of even smaller nullahs have been covered by real estate development. Due to the lack of a viable social housing strategy, unofficial communities along the nullahs have grown, and they also dump their waste into them. In the absence of an alternative after the mid-1960s, formal sector developments likewise utilised the nullahs for disposal. It is reasonable to state that after the middle of the 1960s, Karachi's sewage system was formally intended to discharge into the nullahs, and as a result, sewage sludge started to block the nullahs and their tributaries. The homes along the nullahs also throw their waste into them.

The table below outlines stormwater drainages and nallahs under each township administration. Drainages are artificial water channels for stormwater drainage; on the contrary, nallahs are natural water channels. Many drainages are connected to nallahs, and some drainages connected to river directly; Nallahs discharge into rivers such as Lyari River and Malir River receiving stormwater. As sewage collection system in Karachi City is not enough and its maintenance is not satisfactory, stormwater drainage and nallahs receive sewage all year long in addition to stormwater in rainy season.

Table 1.1: Town-wise Dimensions of Stormwater Drains & Nallahs in Karachi

Towns	Depth (m)	Width (m)	Length (km)
Keamari Town	1.21	0.91~3.04	7.62
SITE Town	2.13	3.65	16.08
Baldia Town	1.22	2.43	11.77
Orangi Town	1.52	2.43~3.65	34.1
Lyari Town	1.37	0.6~13.7	19.4
Saddar Town	1.37	3.05	11.14
Jamshed Town	1.5	2.43	33.8
Gulshan -e- Iqbal Town	3.64	2.4~15.2	28.0
Faisal Town	1.22~4.57	1.52~24.0	20.1
Landhi Town	1.22	2.43	35.36
Korangi Town	1.52	2.74	36.4
North Nazimabad Town	1.22	2.4	30.7
North Karachi Town	1.22	2.4	45.1
Gulberg Town	1.37	2.4	22.1
Liaquatabad Town	1.52	3.65	19.5
Malir Town	1.22	3.04	6.15
Bin Qasim Town	1.22	3.64	14.63
Gadap Town	1.22	3.65	24.43
Total			**416.38 km**

Source: Karachi Water & Sewerage Board (KWSB)

Every year, KMC cleans the roadside drains a month to two before the monsoon season. The removed and collected silt/garbage is transported to specified solid waste disposal facilities. The local government does clean the roadways afterwards, and the silt and trash are then redirected to the drains. Along with the administrative problems already described, several drains and nallhas have already been invaded by squatter homes and structures. It is anticipated that the construction code and other pertinent legislation will be strictly enforced.

Karachi's Water Supply

Presently, the drinking water supply to the Metropolitan Karachi is maintained through three main sources (i) Indus River (ii) Hub Dam. (iii) Good quality groundwater through tube wells and dug wells. However, over-exploitation of groundwater and limited recharge of aquifer system has caused severe decline in water table during the last two decades. It is likely that abstraction of groundwater at such rate may accelerate seawater intrusion resulting into the contamination of coastal aquifer system since a mixing of two to three percent seawater with groundwater may render it unfit for human consumption.[3] Indus River, Hub dam, Sea, Lyari and Malir rivers coupled with occasional rain are main surface water sources which are accounted for coastal groundwater recharge. Hub dam and Indus River are factually major source of drinking water supply to Karachi Metropolitan. However, Lyari and Malir rivers are drains carrying municipal wastewater and industrial effluents, with occasional influx of rainwater during monsoon.

1.3 Identify best-suited locations and types of technology to deploy

Please see section 6.2
Best-suited Locations and Types of Technology to Deploy

1.4 Identify potential waste disposal methods and locations

Please see 6.3 Potential Waste Disposal Methods and Locations

1.5 Characterize the existing plastic pollution problem

The Government of Pakistan only allows the manufacture and use of oxo-biodegradable shopping bags, which are usually above 30 microns. The shopping bags of 30 micros are thicker, do not fly with air pressure and are also reusable. However, there is no implementation of these sanctions from the authorities as bags without D2W, a substance that sets a pre-programmed life of plastic and starts naturally decomposing, are openly used everywhere in Pakistan, including Karachi. The non-biodegradable shoppers are nearly impossible to recycle, and they do not decompose. As a result, they become a threat to the environment. A significant chunk of this plastic ends up in rivers and oceans through different channels, which adversely affects marine life.

While PET bottles and other plastics of higher economic value get scavenged, most of the single-use non-biodegradable plastic finds its way to open garbage sinks, landfill sites or municipal sewers, choking sewage disposal systems. Current urban waste management practices are partners to this crisis, since they only focus on picking waste from communal bins and disposing of it in urban fringes without segregation, material recovery or recycling, and by not making communities act responsibly.

One important thing to understand here is that though we may want to avoid plastics altogether, there is no motivation to do so in the ecosystem. Plastics are cheaper, durable and accessible in the country. With no replacement for packaging, and with so many small and big players in the market, considering Pakistan has a struggling economy, a ban on this industry will put many people out of jobs. In the absence of a low cost, convenient alternative consumers are also not too pushed to shift. This further exacerbates the plastic pollution problem.

In Karachi, uncollected municipal waste has decreased the operating capacity of much of the urban infrastructure and contributes to persistent flooding. The environmental and human health implications are severe, feeding into the prevalence of water-borne diseases. More specifically, existing waste transfer locations are below capacity and poorly designed and mainly reliant on ground waste lifting resulting in massive waste dumping across the city, and adverse impacts on the urban environment and social acceptability of waste management activities. Likewise, existing landfills have reached their maximum capacity and have transformed into uncontrolled dumpsites leading to a critical need to develop adequate disposal capacity while identifying options for transition and closure of both sites. Karachi, first tried to ban bags in 2006. It largely failed. Then in 2009, the federal government tried to ban plastic bags that did not contain biodegradable materials. It failed. The Sindh government tried again in 2014 to ban the bags — effectively copying the federal government's law, it also failed.

Then there is the issue of discarded ghost nets. This ghost gear threatens the seas of Sindh and Baluchistan, making crabs, fish, tortoises and dolphins utterly vulnerable. Fishing boats regularly visit areas such as Keamari, Baba and Bhit islands, Rehri Goth, Ibrahim Hyderi and Shams Pir, for their catch. There is a growing use of monofilament nets that are made of plastic/fiber, which when disposed of in the sea usually become irretrievable. Last year alone, up to seven tonnes of ghost nets were retrieved from Sandspit Beach.

1.6 Define the Government support structure

Please see 5.3
Stakeholder Roles and Responsibilities

1.7 Study Objectives and Scope

The objective of the study is to find the quantity of solid waste, majorly plastic waste entering the Arabian Sea through Karachi's water bodies, specifically the Lyari River. For this purpose, solid waste management status of Karachi city is reviewed, and solid waste generation rate and the composition of solid waste is identified to understand how much waste is generated in this city and how much of it is entering the rivers and what are the causes of mixing of waste into the river. This study aims to establish the baseline conditions of the solid waste situation at the waterways' outfall. This report facilitates the solid waste situational analysis and identifies the potential solid waste mixing areas in downstream portion of Lyari River and the western backwaters of Karachi.

THE ENVIRONMENTAL AND HUMAN HEALTH IMPLICATIONS ARE SEVERE, FEEDING INTO THE PREVALENCE OF WATER-BORNE DISEASES.

3. Appelo and Postma, 1994; Clark and Fritz, 1997

1.8 Study Area

Whereas the study is focused on an analysis of the solid waste and plastic pollution problem for the entire city of Karachi, particular locations have been selected for a deeper understanding of the plastic pollution pathways in the city and solutions to address these. Moreover, it is important to mention here that even though both Lyari and Malir Rivers transport pollution to the coastal areas, the focus of this study has been particularly on the Lyari River, as a significantly larger amount of solid waste and plastics (more than 70%) flows through this river before entering the Karachi coast. The sites that have been studied in detail and covered in Sections 3 & 4 are: Lyari Downstream (particularly intersections of Mewa Shah and Mauripur Roads and Lyari), Lyari Outfall, Lunikanawala Dor, and Baba and Bhit Islands. A map of the study area with designated locations are shown in the figure below.

Figure 1.3: Detailed Map of the Study Area and Environs

SUPER IMPOSED KARACHI MAP SHOWING THE DOCUMENTED NALAS & DRAIN (WHICH ARE THE MAIN DISPOSAL FOR SEWERAGE AND THE INTEGRATION OF THESE WITH THE MAIN & STPS) (CONCEPTUAL PLAN FOR REALISTIC DISPOSAL SYSTEM)

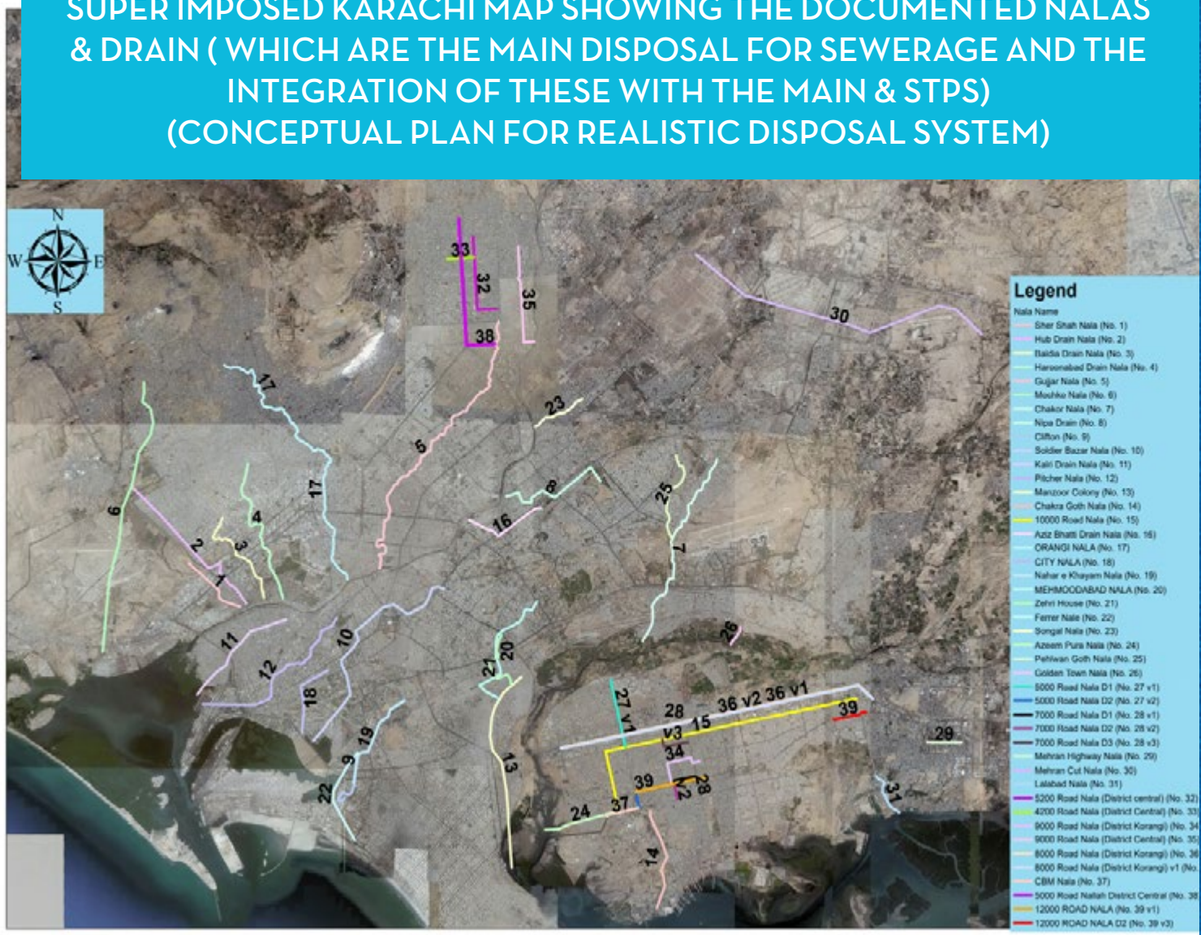


Figure 1.4 Major Nallahs and Drains in Karachi

PLASTICS ARE CHEAPER, DURABLE AND ACCESSIBLE IN THE COUNTRY. WITH NO REPLACEMENT FOR PACKAGING, AND WITH SO MANY SMALL AND BIG PLAYERS IN THE MARKET, CONSIDERING PAKISTAN HAS A STRUGGLING ECONOMY, A BAN ON THIS INDUSTRY WILL PUT MANY PEOPLE OUT OF JOBS.

1.9 Approach and Methodology

After a preliminary review of the information and data required to conduct this study, the study team concluded that majority of the updated environmental data (waste and plastic types and volumes, bathymetry, tides and nautical maps) had to be collated through different government departments. District-wise solid waste and plastic waste generation statistics were gathered from the Sindh Solid Waste Management Board (SSWMB) and is based on a series of studies focused on waste characterization in 2020-2021. Whereas the generalized and historical physical oceanography data for Karachi was obtained from the National Institute of Oceanography (NIO), specific bathymetry, tide levels, and nautical maps were obtained from the Pakistan Navy's Infographic data (2021) published annually. For sites located in the downstream portion of Lyari River, certain physical parameters are irrelevant (such as tide levels etc. as the flow is seasonal). All the data was validated through several engagements with each relevant government department and comparison with other relevant studies. Moreover, the information on environmental characteristics of Lyari and the drains flowing into Lyari, and the Karachi Harbor were obtained from published literature and validated through meetings with officials of KMC and KPT.

In order to gather primary information on the communities in the vicinities of the particular sites and understand the impacts of solid waste and plastic pollution on them, Focus Group Discussions were held with those residing near the downstream locations of Lyari River (Mewa shah, Mauripur) and the fishing communities at Baba and Bhit Island.

Moreover, to enable a first-hand account of the localized waste collection issues, several discussions were held with on –site waste collectors, sweepers, and drivers of waste collection trucks. These engagements helped in uncovering the ground realities of the waste pollution problem in Karachi and the severity of this issue.

Detailed site visits on-foot and boat were carried out to capture UAV images of all the study areas and photographic evidence of the plastic pollution problem. The photos and images clearly reflect the enormity of the plastic pollution problem in Karachi's coastal areas. The drone images were captured on 27th January and 5th February 2022. Stakeholder mapping was carried out to identify stakeholders from all walks of life for this project. Meaningful consultations were carried out with stakeholders to solicit feedback on the plastic pollution issues in Karachi and possible solutions/mitigation measures. A summary list of the stakeholders that were approached and engaged is shown in Table 1. All the site visits, field work and stakeholder engagements were carried out in the months of January and February 2022.

Table 1.2: Stakeholders Engaged During Scoping Study

S.No.	Stakeholders	Stakeholder Type
1	National Institute of Oceanography (NIO)	Federal Research Institute
2	Marine Pollution Control Board, Karachi Port Trust	Part of Federal Port Operations- Periodic Clean-up in Karachi harbor
3	Hydrography Department, Karachi Port Trust	Part of Federal Port Operations-Research on Hydrological Aspects of Karachi Harbor
4	Sindh Solid Waste Management Board (SSWMB)	Main Provincial Institution responsible for all aspects of Waste Management in Karachi, including islands in the Karachi Harbor
5	Karachi Metropolitan Corporation (KMC)	Apex Local Body overseeing all municipal services in Karachi, including cleaning and maintenance of rivers and stormwater drains.
6	CLICK, Local Government Department, Government of Sindh	A World Bank-supported project responsible for upgrading various municipal services in Karachi, including solid waste management
7	WWF-Pakistan	International NGO
8	IUCN Pakistan	International NGO
9	Karachi Water Sewerage Services Improvement Project (KWSSIP)	A World Bank-supported project responsible for improving water supply services to Karachi
10	Community Representatives, Baba, Bhit and Shamspir Islands	Fishing Communities
11	Community Representatives, Mewa Shah and Mauripur	Community Elders, Youth residing in the nearby neighbourhoods

2. WASTE MANAGEMENT

2.1 How is waste managed in the city of Karachi?

Karachi is the greatest urban center of Pakistan and the second largest Muslim city in the world. It is a metropolitan city having a population of around 16 million (Census 2017). As the population of this megacity is increasing exponentially, the amount of waste generation also increased in these past years. According to research conducted in 2007, Karachi was producing 6000 tons/day of solid waste (Aman et al., 2007). The city generates more than 11,000 tons of domestic solid waste daily with a 60% collection published by Khan et al., 2018. The various types of waste generated include household, office, commercial and industrial, litter, parks and gardens waste. Solid waste management creates a huge challenge for local governments because of a steady rise in leftovers.

The Sindh Solid Waste Management Board (SSWMB) has been functional since 2014. It began working in three districts initially with East, South and Malir and later also worked with West and Kemari but Central and Korangi districts were never given Any No Objection Certificate by their DMCs, so the board was not able to work and pick the garbage up from these districts until August 2020, when the local government completed its term and now the responsibility of picking up garbage from all the districts lands with the SSWMB.

- In 2014 Karachi's solid waste management was extricated from the hands of the local government's Karachi Metropolitan Corporation (the mayor and the municipality) and taken over by the provincial government after the Sindh Solid Waste Management Board Act was adopted by the Sindh Assembly.

- The third authority is the cantonment boards that are providing municipal services, including stormwater cleaning, a water supply and garbage collection to their respective cantonments.

Waste management in Karachi comprises of three major steps:

1. Front End Collection - this is done either through the door-to-door collection, or households make their arrangements of dumping their garbage at katchra kundis (designated or informal spaces, empty plots of lands or the pavement in some cases). SSWMB and DMC have tendered the door collection to private vendors, who take monthly Rs 200 from each family across Karachi and collect garbage from their door to the muhalla kachra kundi/designated garbage point. The waste collection fleet typically consists of handcarts and donkey pull-carts for primary collection; then open trucks, tractor/trolley systems, and arm roll containers/trucks for secondary collection and transport. Some municipalities hire street sweepers and sanitary workers to augment other collection methods. They use wheelbarrows and brooms to collect solid waste from small heaps and dustbins, then store it in formal and informal depots.

The waste is primarily collected by street sweepers and sanitary workers using wheelbarrows and brooms. They collect solid waste from small heaps and dustbins outside streets or homes and store it in informal or formal depots. Then the collection fleet consists of handcarts or donkey carts, open trucks, tractor/trolley systems, and arm roll containers/trucks for secondary collection and transport varying from place to place. Developed areas in Karachi have trucks and trolley systems whereas the underdeveloped areas, at the most, have a handcart, donkey cart or tractor system. Many areas are not served by any system and the waste is left unattended in open areas, stormwater drains, water valve chambers and other spaces as they are available. In katchi abadis (squatter settlements), solid waste is not collected in trolleys or containers but is disposed of onto natural drains (nullahs), streets or open plots by households and or sweepers

2. Garbage transfer stations - The second step is the waste collection: Waste is collected through front end collection points and stored at a garbage transport facility before being dumped into two main landfill areas. The respective municipal authorities then collect waste from these sites, taking them to collection points and then ultimately the garbage ends up at either of the two landfill sites. There are 9 garbage transfer stations in Karachi. Their details will be provided in part e of this section.

3. Landfill sites - The last step of the process is dumping. Once the waste is hauled in open dumpers from the garbage transfer stations, it is taken to the landfill sites. Karachi has two main landfills; one is Jam Chakro, and the other is Gondpas. There are no recycling mechanics for the city's waste. Without recycling, tackling such a huge city waste becomes almost impossible. The landfill sites are the only option available at present for managing Karachi city's solid waste, which is a dilemma itself.

Figure 2.1: Front-End and Back-End Waste Management Process in Karachi

Front End Waste Collection Process

Door to door collection

Local seggregation by waste collector

Local Transportation to Kachra Kundi (Temporary Storage area)

Kachra Kundi (Temporary Storage area)

Garbage Transferring Station

Back End Waste Management

Collection at GST

Trasportation to Landfill Sites

Landfill

Scavengers enter the recycling system at the start of the cycle, usually at commercial markets, neighbourhoods and the informal and formal Katchra Kundis (garbage dumping points); they pay monthly or weekly charges to the middleman to let them pick garbage without any hurdle. Further segregation and sorting continue when the garbage reaches the landfill sites and scavengers continue to look for recyclable junk that can be sold. These men, women and children, can make up to Rs.250 per day.

2.2 Who is/are the responsible authority (ies)?

2.2.1 Government Departments

Sindh Solid Waste Management Board (SSWMB)
The establishment of the Sindh Solid Waste Management Board by the Government of Sindh (GoS) is solely focused on providing efficient and regular solid waste collection and disposal in Sindh. SSWMB has been established as per Sindh Solid Waste Management Board Act, 2014. SSWMB is responsible to develop and operate the infrastructure for collection, transfer and final disposal & treatment of waste generated in Sindh. This institution is mainly responsible for collecting and disposing of solid waste for all Karachi districts, and they are the primary stakeholders for any decision-making.

Karachi Municipal Corporation (KMC)

The KMC is responsible for providing waste collection, transport, and disposal services. Waste collection and transportation has been the responsibility of district municipal committees while management of landfill sites, large procurements and future planning lies with the Solid Waste Management Department of KMC. As an organization, KMC is a key stakeholder. However, the staff of the KMC working at different levels cannot be neglected in decision making. The director of solid waste management in KMC has the responsibility for supervising the existing designated dumpsites of KMC and developing new treatment plants for waste.

District Municipal Corporations (DMC)s

Every day an estimated average of 400 tons of solid waste is generated per district and District Municipal Corporation (DMC) has the responsibility to collect waste from all commercial, residential, and industrial areas, whereas KMC provides dumping sites to DMCs, where all the collected solid waste can be discarded. KMC is also responsible for providing transportation support to the DMCs for solid waste collection all over the city. For this purpose, they are provided with trucks, tractors, and dumpers from the KMC who also look after the maintenance and repairs of all garbage transport vehicles.

Cantonment Boards

Apart from the DMCs, Karachi has 6 cantonment areas that are run by Cantonment Boards. Vice-Presidents of all the Cantonment Boards are elected through Local Government Elections. The President of a cantonment Board is always a designated senior Military Officer. All the elected leaders of each Cantonment Area are responsible for various municipal services in their area. The cantonment areas of Karachi are Karachi Cantonment, Clifton Cantonment, Korangi Creek Cantonment, Malir Cantonment Faisal Cantonment, and Manora Cantonment. Clifton Cantonment has by far the largest customer base and is home to some of the poshest locations in Karachi.

2.2.2 Is this type of work contracted to private companies?

SSWMB decided to outsource the MSW contracts to Chinese firms after the formation of the board in 2014. Privatization of MSW is the solution to the MSW crisis in Karachi according to SSWMB since multiple Chinese firms are working in several districts of Karachi. In 2017, SSWMB signed a seven-year contract with a Chinese company called "Changyi Kangjie Sanitation Engineering Company" to lift municipal solid waste from District South of Karachi. The provincial government will pay this Chinese company $26 per ton whereas previously, the local institutions were doing it for approximately $3-4 (Rs. 320) per ton.

Furthermore, the SSWMB outsourced the responsibility of collecting garbage from two more districts in 2017. The DMCs of Malir and West signed an agreement with the Hang Zhou Jin Jiang Group Sanitation Service Company Limited at the office of local government minister Jam Khan Shoro. The performance of these foreign firms is questionable at best since, in 2018, the judicial commission on water and sanitation expressed their disappointment and dissatisfaction with the performance of the Chinese firms in Karachi.

2.2.3 Or is it fully carried out by the municipalities/ government?

As indicated in the earlier section, the waste collection is not fully carried out by the government but a portion of it has been contracted to private companies.

2.3 What are the types of available disposable facilities

Waste Disposal Sites[4]

SSWMB is currently managing two waste disposal sites at the outskirts of the city of Karachi. The waste disposal site near Deh Jam Chakro, in Surjani Town, District West covers approximately 500 acres of land, and has been used for disposal of solid waste from different parts of the city for decades. The land at the Jam Chakro site is under the ownership of the Sindh Government and the site is being operated by the SSWMB. The second site is at Deh Gond Pass of District West, adjacent to Northern Bypass, is also being used for disposal of solid waste, but not as old as the waste disposal site in Surjani Town. Most recently, the Government of Sindh is strongly considering increasing the waste disposal sites to meet the increasing demand of waste disposal and decreasing space for continuous dumping of solid waste at the Jam Chakro and Gond Pass sites. The site for establishing another dedicated waste disposal area has already been identified at Dhabeji along the National Highway.

4. The term waste disposal sites and landfill sites are used interchangeably in this document

Solid Waste Transfer Stations

SSWMB operates 9 solid waste transfer stations, or Garbage Transfer Stations (GTSs) across Karachi. The table below shows the distribution of GTS across different districts in Karachi. The land at all these sites is owned by the Government of Sindh and SSWMB is using these sites for solid waste management operations. Location and approximate road distance of all the GTS from the two existing landfill sites are illustrated in the map below from SSWMB. Not only are the locations of these facilities important considerations for operational service and delivery of solid waste management services, but also have significant repercussions for the environmental and socio-economic conditions of the micro-environment.

Table 2.1: List of Garbage Transfer Stations Serving Different Districts of Karachi

District	Malir		East		South		West			Kemari	Korangi	
Zones	Malir	Landhi	Jamshed	Gulshan	Lyari	Saddar	SITE	Orangi	Baldia	Kemari	Korangi	
GTS	Sharafi		Imtiaz		Dhobi Ghat		Gatar Baghicha	German Playground	Qabristan	Truck Stand	100 Qts	Sharafi

Image 2.1: Dhobi Ghat GTS located near Lyari River

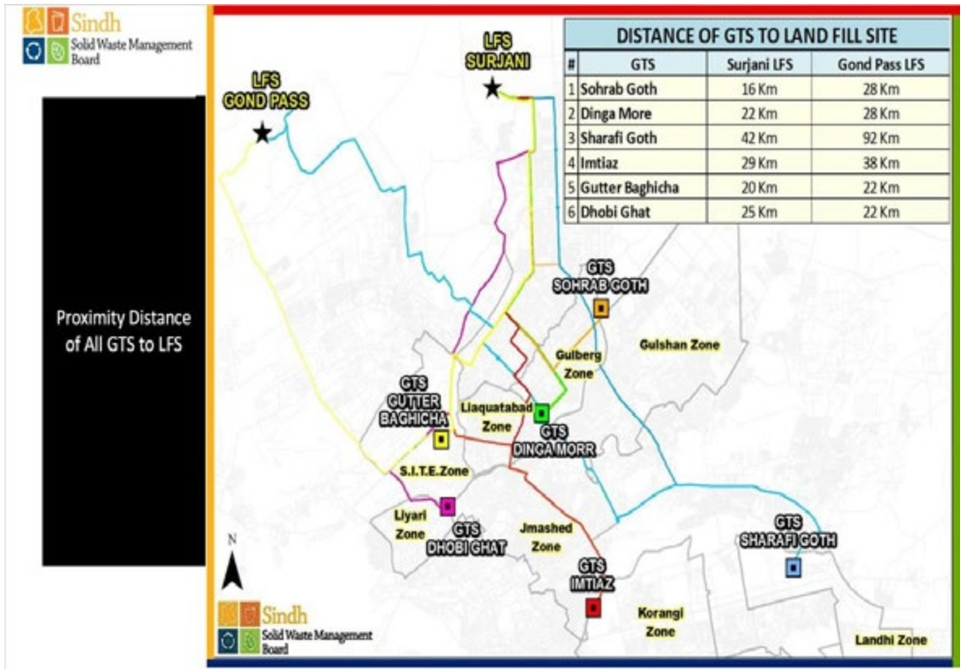
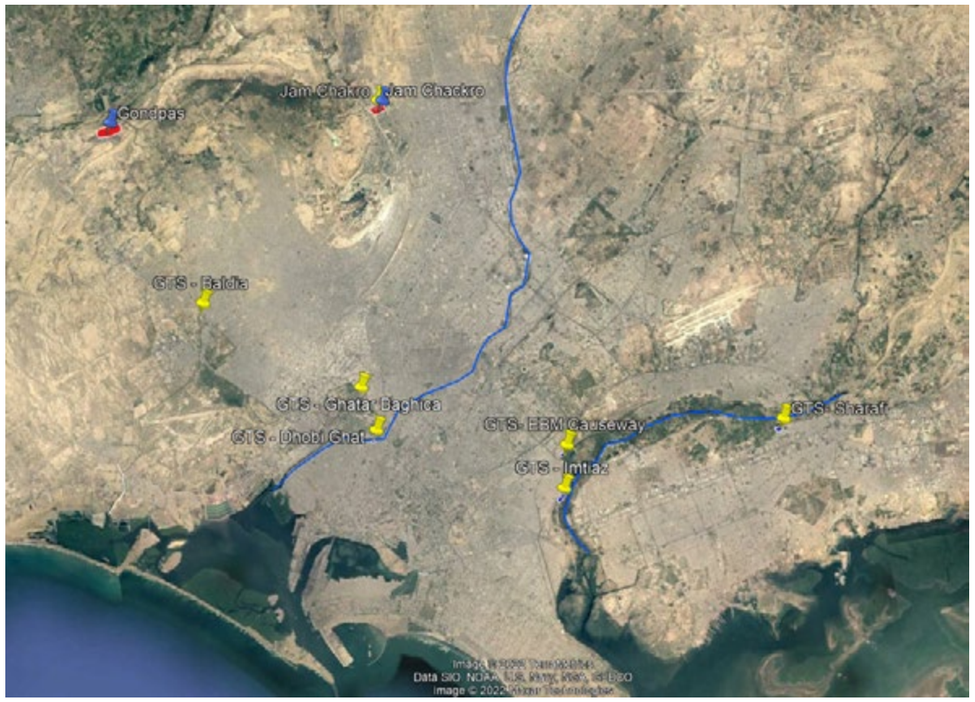


Figure 2.2: Current Locations of Landfill Sites and GTS in Karachi[5]



Out of the 9 GTS sites, 4 of them are situated on rivers or near rivers including Sharafi goth and GTS Imtiyaz near Malir river and GTS Dhobi Ghat near Lyari River. Sharafi Goth garbage station is located near Malir River, and it is easy for the waste to escape into the river from the garbage station. Malir River is heavily polluted with plastic waste, and it is a possibility that large quantities of waste enter the Malir River from Sharafi Goth dumping site or garbage station.

5. Adapted from website of Sindh Solid Waste Management Board (SSWMB)

Image 2.2: Jam Chakro, Oldest and Largest Landfill Site for Karachi

Image 2.3: Gond Pas Landfill Site, Second Largest Landfill Sites for Karachi

2.4 Planned Waste Management Infrastructure and Operations

Competitive and Livable City of Karachi (CLICK)

The World Bank is providing funds for improving the solid waste management situation in Karachi since 2019. The first programme introduced through this initiative is the Competitive and Livable City of Karachi (CLICK) Project being implemented by the Local Government Department. CLICK is supporting upstream policy and regulatory work, institutional capacity strengthening of the Sindh Solid Waste Management Board (SSWMB), development of sector strategies and public awareness.

Solid Waste Emergency and Efficiency Project (SWEEP)

The second programme under this funding materialized in March 2021 is the Solid Waste Emergency and Efficiency Project (SWEEP) that aims to improve solid waste management services in Karachi, through the incremental upgrading of infrastructure for collection, transfer, final disposal, and treatment of solid waste in Karachi. The Sindh Solid Waste Management Board (SSWMB) is the implementing agency for SWEEP and has established a Project Implementation Unit (PIU) led by a Project Director, with technical experts for engineering, environmental and social management, procurement, financial management and other key functions. The major initiatives currently already underway are briefly described below:

(a) Construction of a new sanitary disposal cell at Jam Chakro disposal site. It is planned as a bioreactor landfill site that allow for optimal environmental performance and longer lifespan.

(b) Establishment of a new Landfill Site at Dhabeji, near the National Highway, covering an area of 3,000 acres

(c) Improvement/Rehabilitation of Six Garbage Transfer Stations: Dinga Morr, Dhobi Ghat, Gattar Baghicha, Imtiaz, Sharafi Goth and Sorhab Goth. It is expected that a capacity of 1,000 to 1,500 tons per day per site is required at the proposed locations. Parameters such as types of waste, suitable technology for transporting and processing waste as well as secondary functions (access to citizens, material recovery, vehicle maintenance) are being assessed by consultants hired by SSWMB.

2.5 Waste Sorting and Recycling Facilities

A few recycling industries operate in Karachi, both in the formal and informal sectors. They purchase material from main dealers and other industries and re-process them to other saleable products. There are several conversions and re-use of waste materials. Some of the common uses of the materials are given in the table below.

Table 2.3: Common Uses of Waste Materials In-Practice

Waste Materials	Common Options for Re-use and Recycling
Broken Glass	Separated by color and converted to glass bottles
Bottles (glass)	Washed and sold again
Bread	Used for livestock feed, sold to cattle yards directly by middlemen
Newspapers	Various types of packing for shops and vendors
Ferrous metal	Recycled in re-rolling mills (particularly in Punjab)
Paper	Turned into pulp and converted to cardboard or brown paper
Aluminum	Remelted and sold to various industries
Plastics	Uses/recycling depends upon the type of product it will be used for
Car Batteries	Broken to extract lead metals
Magazines, digests, old books	Sold again at reduced prices
Old furniture	Sold again at reduced prices.

Shershah in the South-West of Karachi is where the small recycling industry exists mainly. There is a small-scale paper industry that is located in Azizabad, North Karachi and Korangi areas. This unstructured sector contributes significantly, and according to statistics provided by the Urban Resource Centre, in 2001 there were a total of 145 registered recycling industries dealing in glass, plastic, paper, animal waste, bones and ferrous metals recycling.

The recycling sector in Karachi can be divided into two broad categories:

· Dirty Stream: Mostly conducted by Afghan pickers and sweepers from disposal sites and communal bins. This waste is then passed through dealers to the unregulated recycling industry. Typical materials in this stream are wastepaper, plastic bags, broken glass and bottles and bones.

· Clean Stream: Post waste segregation, the material is sold to small waste buyers. Ultimately this waste reaches the bigger players in the industry. Typical materials in this stream are ferrous cans, metals, newspaper separated at source, bottles and plastics.

Had it not been for this informal and unregulated recycling sector, the waste issues in Karachi would perhaps have been larger than what they are at the moment. Scavengers (mostly Afghan collectors) work in small groups and bring the collected waste to common yards. This waste is then packed like bales and is sold to dealers and recyclers for processing.

Table 2.4 Stakeholders Involved in the 'Clean Stream'

Stakeholders	Role
Households	Although not frequently, some households separate the waste and sell the sellable components to waste buyers (kabariya) at a known or agreed price
Domestic Servants	In high income areas, they separate and store the saleable waste components. Then sell the separated components to waste buyers
Kabariyas (waste buyers)	They purchase the separated waste from the households and sell it to the middle dealers
Middle dealers	They purchase off the material from waste buyers and sell it to the main dealers. They clean and sort the waste so as to reduce transportation cost and add value
Main dealers	They deal in a single kind of waste and focus on larger volumes of one kind of waste. They may also add value at their end or further process it for ease of transportation.
Recycling industry	Convert waste material into other saleable parts i.e., ferrous metal is rerolled, broken glass is reused to make more glass.

Table 2.5 Stakeholders Involved in the 'Dirty Stream'

Stakeholders	Role
Sweepers	While collecting waste from households, they separate and sell saleable components. The remaining waste is disposed of at communal bins or open plots
Street Pickers	Many Afghan immigrants are involved in the separation of paper and carboard from waste on streets and communal bins. They also look for other items that can be sold. All the waste is brought to a common yard and then sold off to middle dealers
Middle dealers	They procure waste from the waste pickers yards and sell it to the recycling industry.
Recycling industry	Mostly small-scale industry involved in the recycling of poor-quality paper and cardboard to paperboard. There are a few industries which deal in plastics

2.6 Waste Volumes Generated in Karachi

Solid Waste Management is the generation, separation, collection, transfer, transportation, and disposal of waste in a way that takes into account public health, economics, conservation, aesthetics, and the environment and is responsive to public demands. Solid waste management is strongly influenced by political, legal, social, cultural, environmental, economic, and available resources. Based on the most updated data on solid waste generation in Karachi by the SSWMB, approximately 10,840 tonnes of solid waste are generated daily, of which, approximately 10% (1,840 tonnes) has been identified as plastics. Moreover, the pie-charts below clearly illustrate the volume of waste and plastics generated from each district of Karachi

Table 2.6: District-wise Solid Waste and Plastic Waste Generation (2020-2021)

Waste Generation	Solid Waste Generation Per day (tons)	Solid Waste Generation Per year (tons)	Plastic Waste Generation Per day (tons)	Plastic Waste Generation Per year (tons)
District West (Baldia)	1,550	565,750	277	101,437
District Kemari	450	164250	95	34,769
District South	1000	365,000	136	49,924
District East	1465	534,725	277	101,437
District Malir	700	255,500	113	41,544
District Korangi	1575	574,875	199	72,718
District Central	1600	584000	240	87,600
Cantonment Areas	~ 2500	912,500	500	182,500
Total	**10,840**	**3,956,600**	**1,840**	**671,932**

Table 2.6: District-wise Solid Waste and Plastic Waste Generation (2020-2021)

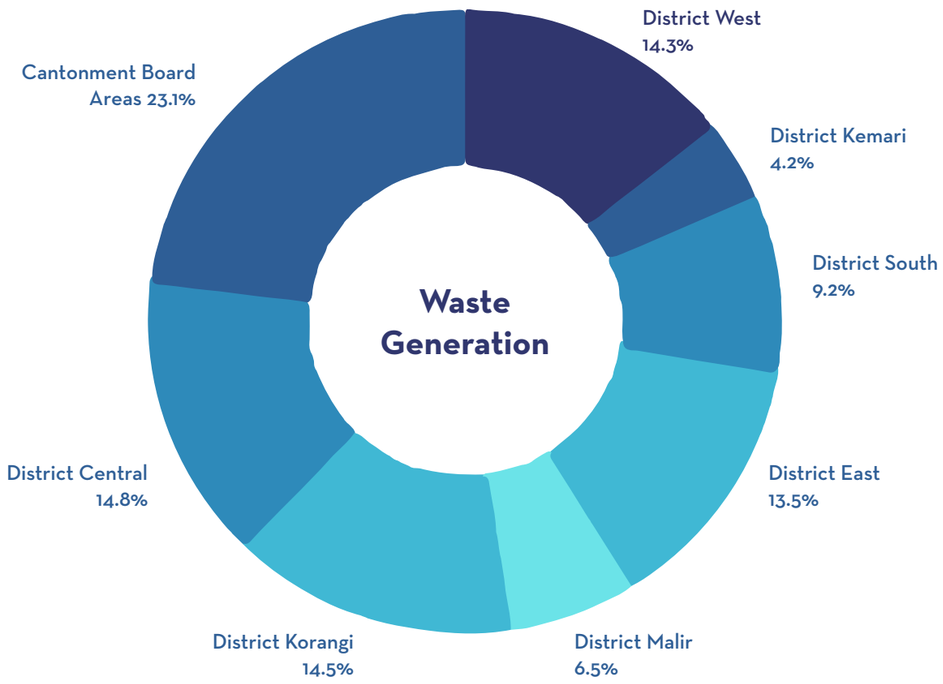
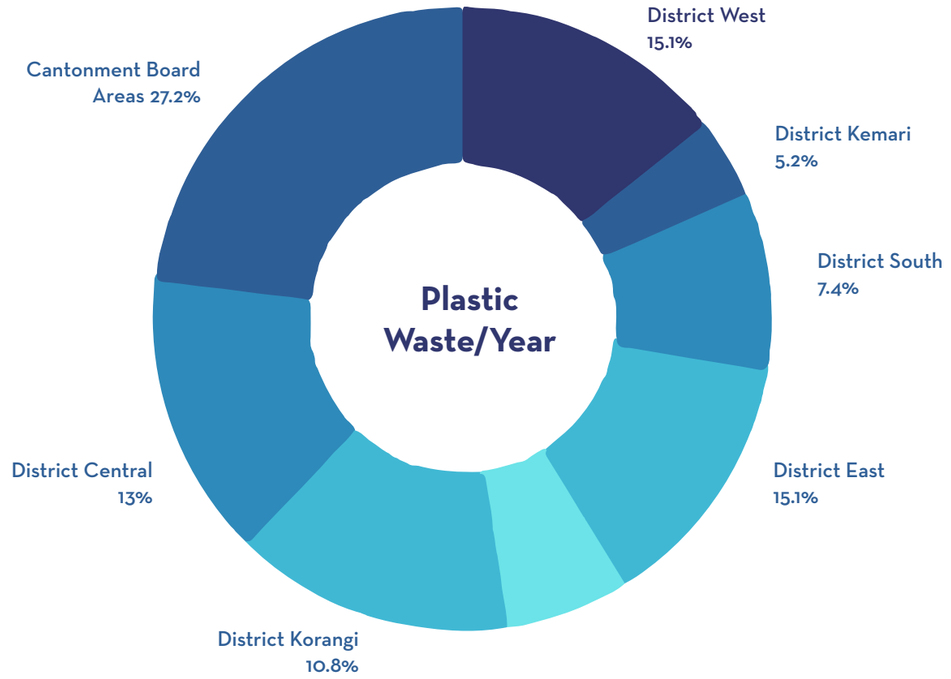


Figure 2.5: District-Wise Plastic Waste Generation in Karachi



2.7 Solid Waste Composition

Solid waste in Pakistan is generally composed of three categories i.e., biodegradable such as food waste, animal waste, leaves, grass, straws, and wood. Non-biodegradable is plastic, rubber, textile waste, metals, fines, stones and recyclable material includes paper, cardboard, rags and bones. The waste is disposed of within or outside municipal limits and flows through drains, streams and Rivers to enter the marine ecosystem. The source of marine debris in Pakistan is mainly man-made waste that gets through coastal environment intentionally or unintentionally by disposal of solid waste, untreated effluent, careless handling of shipbreaking activates, fishing activities, beach tourism, as well as due to natural disasters such as annual floods in Indus River and rain feed streams.

Most of the items found at the beach or in the ocean itself are made of plastic or other synthetic materials. The different kinds of marine debris found in Pakistan include plastic bags, balloons, buoys rope, medical waste, glass bottles, beverage cans, Styrofoam, lost fishing lines and nets, and various wastes from ships such as oil-laden rags are among the items commonly found to have washed ashore. **Plastic pollution has become very prominent on the beaches of Pakistan because of the indiscriminate use and uncontrolled disposal of polythene shopping bags which litter the common beaches of Karachi.** The other important form of plastic pollution is the presence of plastic pellets (polyethylene and polystyrene balls) of plastic products.

Based on detailed surveys conducted by the SSWMB from 2019-to 2021, the composition of waste generated in each district is reflected in the tables below. **Most importantly, it is evident from this study that after kitchen waste, plastics is the second biggest contributor to Karachi's solid waste problem.** Cantonment Boards generate the most amount of plastic. These areas are primarily inhabited by the affluent class and upper-middle classes. The consumption of consumer goods is much higher as compared to other districts.

Table 2.7 (a) Characterization of municipal solid waste in District East

Sr. No.	Items	Percentage		
		Gulshan Zone	Jamshed Zone	Overall
1	Kitchen Waste	44.39	50.68	48.09
2	Paper	5.50	2.45	3.71
3	Textile	8.50	8.15	8.29
4	Grass And Wood	4.24	2.95	3.48
5	**Plastic**	**19.67**	**18.47**	**18.97**
6	Leather & Rubber	0.51	0.68	0.61
7	Metal	0.05	0.03	0.04
8	Bottle And Glass	0.46	0.26	0.34
9	Ceramic, Stone	0.22	0.24	0.23
10	Domestic Hazardous Material	0.14	0.26	0.21
11	Residue Remaining Material	2.22	3.36	2.89

Table 2.7 (b) Characterization of municipal solid waste in District Malir

Sr. No.	Items	Percentage		
		Malir Zone	Landhi Zone	Overall
1	Kitchen Waste	46.86	30.75	38.23
2	Paper	0.75	0.74	0.75
3	Textile	11.65	9.23	10.35
4	Grass And Wood	0.56	4.71	2.78
5	**Plastic**	**16.03**	**16.45**	**16.26**
6	Leather & Rubber	1.11	1.58	1.36
7	Metal	0.05	0.04	0.04
8	Bottle And Glass	0.11	0.15	0.13
9	Ceramic, Stone	1.13	0.17	0.61
10	Domestic Hazardous Material	0.14	0.13	0.13
11	Residue Remaining Material	5.45	5.00	5.21

Table 2.7 (c) Characterization of municipal solid waste in District South

Sr. No.	Items	Percentage		
		Lyari Zone	Saddar Zone	Overall
1	Kitchen Waste	52.07	53.44	52.74
2	Paper	1.53	2.00	1.81
3	Textile	7.25	9.03	8.12
4	Grass And Wood	0.93	2.23	1.57
5	**Plastic**	**21.17**	**17.85**	**19.54**
6	Leather & Rubber	0.62	1.33	0.97
7	Metal	0.05	0.14	0.10
8	Bottle And Glass	0.30	0.92	0.61
9	Ceramic, Stone	1.04	1.13	1.17
10	Domestic Hazardous Material	0.12	0.17	0.15
11	Residue Remaining Material	3.07	2.60	2.84

Table 2.7 (d) Characterization of municipal solid waste in District Kemari

Sr. No.	Items	Percentage
		Malir Zone
1	Kitchen Waste	46.86
2	Paper	0.75
3	Textile	11.65
4	Grass And Wood	0.56
5	**Plastic**	**16.03**
6	Leather & Rubber	1.11
7	Metal	0.05
8	Bottle And Glass	0.11
9	Ceramic, Stone	1.13
10	Domestic Hazardous Material	0.14
11	Residue Remaining Material	5.45

Table 2.7 (e) Characterization of municipal solid waste in District West

Sr. No.	Items	Percentage			
		Orangi	SITE	Baldia	Overall
1	Kitchen Waste	50.98	46.33	47.33	49.48
2	Paper	2.88	0.99	0.99	1.83
3	Textile	6.02	5.54	5.54	6.51
4	Grass And Wood	0.59	2.23	2.23	1.52
5	**Plastic**	**21.77**	**19.34**	**19.21**	**20.34**
6	Leather & Rubber	1.46	0.96	0.86	0.98
7	Metal	0.11	0.07	0.27	0.15
8	Bottle And Glass	0.46	0.15	0.72	0.48
9	Ceramic, Stone	1.31	8.33	2.89	3.27
10	Domestic Hazardous Material	0.16	0.24	0.55	0.35
11	Residue Remaining Material	4.30	5.65	5.80	4.61

Table 2.7 (f) Characterization of municipal solid waste in District Central

Sr. No.	Items	Percentage			
		High	Middle	Low	Average
1	Kitchen Waste	53.03	54.57	49.31	52.56
2	Paper (recyclable)	3.12	2.88	3.32	3.10
3	Paper (non-recyclable)	0.46	0.88	0.66	0.62
4	Textile	2.52	4.67	6.40	4.01
5	Grass And Wood	1.24	0.38	1.00	0.95
6	**Plastic (recyclable)**	**1.26**	**0.60**	**1.82**	**1.21**
7	**Plastic (non-recyclable)**	**10.61**	**15.55**	**13.49**	**12.65**
8	Leather & Rubber	0.45	0.49	3.76	1.25
9	Metal (recyclable)	0.48	0.11	0.10	0.29
10	Metal (non-recyclable)	0.11	0.16	0.04	0.10
11	Bottle And Glass (recyclable)	0.49	0.41	0.34	0.43
12	Bottle And Glass (non-recyclable)	0.50	0.48	0.54	0.50
13	Ceramic, Stone	0.44	1.93	0.88	0.95
14	Domestic Hazardous Material	0.68	2.56	1.24	1.32
15	Residue Remaining Material	2.59	0.95	1.32	1.84
16	Miscellaneous				

Table 2.7 (g) Characterization of municipal solid waste in District Korangi

Sr. No.	Items	Percentage			
		High	Middle	Low	Average
1	Kitchen Waste	56.87	48.24	54.86	53.11
2	Paper (recyclable)	4.59	7.98	4.73	5.89
3	Paper (non-recyclable)	0.67	0.84	0.41	0.66
4	Textile	3.31	3.50	4.25	3.64
5	Grass And Wood	0.02	0.79	0.49	0.44
6	**Plastic (recyclable)**	**10.89**	**1.26**	**0.69**	**0.97**
7	**Plastic (non-recyclable)**	**14.27**	**13.56**	**17.89**	**14.99**
8	Leather & Rubber	0.78	0.81	1.16	0.90
9	Metal (recyclable)	0.27	0.59	0.28	0.39
10	Metal (non-recyclable)	0.07	0.63	0.05	0.27
11	Bottle And Glass (recyclable)	0.07	0.58	0.04	0.25
12	Bottle And Glass (non-recyclable)	0.05	0.80	0.54	0.46
13	Ceramic, Stone	0.37	2.20	0.02	0.96
14	Domestic Hazardous Material	0.58	0.82	0.96	0.77
15	Residue Remaining Material	1.45	1.52	2.21	1.68
16	Miscellaneous				

3. KARACHI'S WATERWAYS: PATHWAYS FOR PLASTICS

3.1 For the Karachi waterways and surrounding regions have you gained fundamental knowledge regarding the quantity and spatiotemporal variation of plastic waste that reaches the ocean?

Almost eight million tonnes of plastic enter oceans globally, which meant plastic accounts for 60 to 80 percent of marine garbage and an estimated 8 million pieces of plastic enter the world's oceans every day. Pakistan alone produced an estimated 3.9 million tonnes of plastic waste in 2020. Around 70% of this plastic waste (2.6 million tonnes) is mismanaged, left to landfills, unmanaged dumps, or strewn about land and water bodies across the country. Studies suggest that marine plastic pollution is majorly caused by land-based plastic. This plastic enters the ocean either directly from the coastal areas or is transported through the rivers. In Pakistan, each year, 30 million tons of solid waste is produced, out of which nine percent is plastic waste. Moreover, Pakistan's plastic manufacturing industry is thriving at an average annual growth rate of 15 percent.

Coastal areas suffer from the issue of plastic pollution due to the dumping of waste in these areas. More than 50% of the solid waste found in the coastal belt of Karachi is plastic waste. Some of the marine litter is also introduced by people that use the beaches for recreational activities such as swimming, sailing, and scuba diving. Even the remote coastal regions (Ormara beach, Kund Malir) are littered with plastic waste which is affecting the life of marine species. Paradise Point has been identified as the most polluted beach in a study conducted in 2015, containing almost 5kg of marine debris along the coast in the month of August.

According to Mr. Fayyaz Rasool (Manager of the Marine Pollution Control Department at Karachi Port Trust), 350 million gallons/day of raw sewage and untreated industrial waste flows into the Arabian Sea from Karachi, where in addition 8,000 tons of solid waste is dumped into the harbor each day.

More than 50% of the solid waste found in the coastal belt of Karachi is plastic waste.

Open dumping and waste incineration present a major hazard for the poor as it contributes to diarrhea, infectious diseases, premature deaths from air pollution, and other health complications (in Pakistan, 14,000 people die each year from air pollution caused by open burning of waste, with Karachi being the 14th most polluted city in the world), environmental degradation, climate change and an increased risk of disasters such as floods.

Plastic waste discarded into the Indus River ends up in the ocean where it poses a serious threat to marine life and humans alike as it enters the human food chain. Existing waste management approaches are expensive, environmentally unsustainable (as the waste collected mainly goes to landfill sites) and the economic value of the waste is mostly lost. The informal waste collection provides a limited amount of income for vulnerable waste pickers but with low incomes, a strong social stigma surrounding the work, and significant health and safety risks to those involved, the amount of waste picked is almost negligible.

3.1 Sources of Plastic Pollution in the Lyari River

The Lyari River runs through Pakistan's megacity of Karachi from north to south and then into the Arabian Sea via the Manora canal. The Lyari River is approximately 50 kilometres (30 miles) long. As a seasonal river, it transports the rainwater accumulated in the catchment region. The Lyari river is basically a seasonal river but due to carrying excessive solid waste and untreated wastewater, Lyari currently functions more as a sewerage disposal and transport water body. A cross-sectional view of Lyari and Karachi's harbour area, is illustrated in Figure 6 below. Moreover, there is also recent imagery of the downstream portions of the river captured through drones by the study team (see Images 8 and 9).

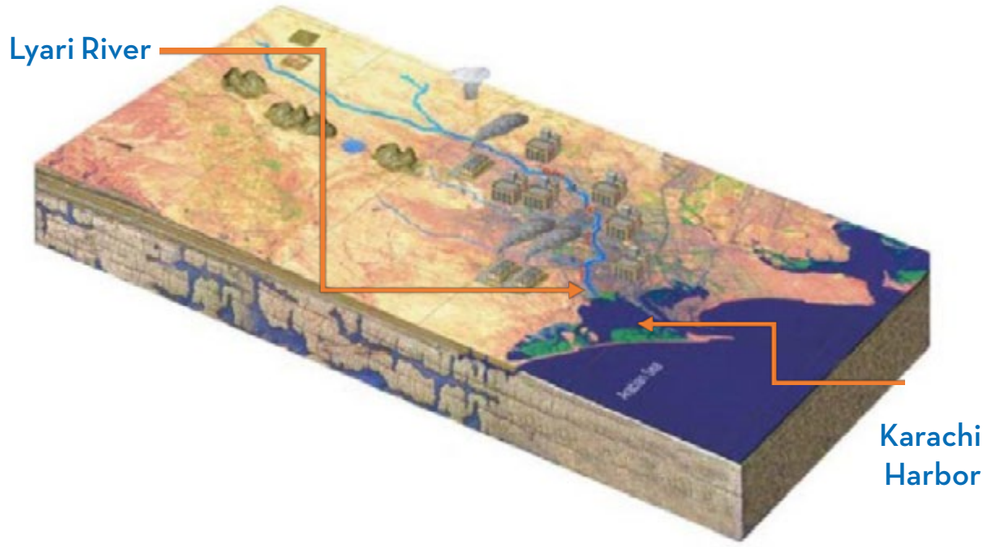


Image 3. Lateral and Cross-sectional view of Lyari River

A large number of industries including leather tanning units, pharmaceuticals, petrochemicals, refineries, chemical, textile, paper and pulp, engineering works and thermal power stations, located along the river, regularly discharge their untreated industrial waste, including the waste flows from the SITE industrial estate in Orangi that flows via the Orangi Nullah to the Lyari and thence to the ocean. Malir River is shorter with a smaller drainage area. It is ephemeral and is constituted from two major tributaries, the Mol and Khadeji, as well as some minor tributaries. Khadeji is a perennial stream that originates at Khadeji falls and gains flow as it travels across the Malir Basin.

Drainage channels collect surface runoff through hundreds of small/large side channels and lined nullahs (drains) that serve as important components of the drainage network. These are generally dry built channels and streambeds that flow into the main rivers described above. Whenever a heavy rain takes place, the huge amount of runoff that course through these channels may cause the rivers to overflow their banks and spread over adjacent floodplains. In any event, the drainage network of the city is severely stressed due to increased runoff from paved surfaces, and encroachment on drainage channels.

The principal tributaries that discharge surface runoff to the Lyari River are Mokhi nullah, which originates in the Taiser hills, Orangi nullah, which originates in the Orangi hills, and Gujar nullah, which originates in the Manghopir hills.

Images 3.1 & 3.2: The choked arteries of Orangi (above) and Gujjar (below) Nallahs

Images 3.2: The choked arteries of Gujjar Nallahs

Image 3.3: Plastic Waste Strews Near the River-bank: A Common Practice for Dwellers Near Lyari

Images 3.4: Deposition of Plastic waste from Settlements along Lyari, near Mauripur

There are many ways that plastic reaches the Lyari river which includes the drains falling into the river, surrounding people directly dumping waste into the river, wind also plays a major role in the transportation of plastic into the river.

Major sources of the pollution and waste in the Lyari river are the drains that are discharging their waste in the river in addition to the communities and settlements that are settled along the banks or close to the river. More than 10 million population of Karachi including major and small industries lying therein discharges about 244 MGD of untreated effluents through Lyari River into the sea. These effluents are the main cause for the pollution of south-eastern creeks. During northeast monsoon when current moves in anticlockwise direction, this contaminated polluted water also pollutes the main picnic spots at Manora, Sandpit, Hawks-bay and Paradise Point. The walls of the Lyari river are fully covered with plastic wrappers and shoppers. The unattended plastic waste also ultimately travels randomly and goes into the river and drains.

3.3 Sources of Pollution in the Karachi Harbor

Karachi harbor (also called Lyari estuarine area) has become one of the most highly polluted harbors in the region. It receives heavy pollution load from Lyari that is largely responsible for pollution in the harbour area.

The Karachi harbour and its surrounding estuarine ecosystem spreads over an area of appx. 35.0 km and include the Keamari Fish Harbor, Karachi Shipyard, Naval Dockyard, Keamari Boat Basin, Shamspir Island, Baba Island, Bhit island and the backwater Zone, which hosts mangrove forests. The major drains falling the harbour area, Lyari river outfall, and the three main inhabited islands in this area have been identified in the Figure below.

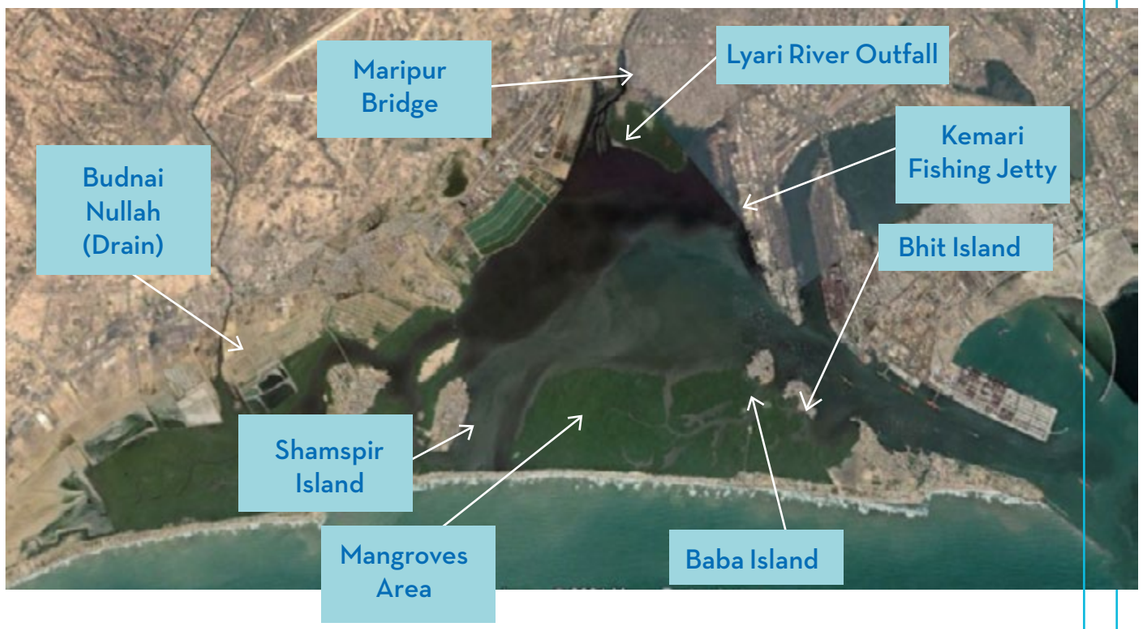


Image 3.5: Map of Karachi Harbor

According to the KPT, no effort has been made to quantify this marine debris in a scientific manner. According to Mr. Fayyaz Rasool (Manager of the Marine Pollution Control Department at Karachi Port Trust), approximately 350 million gallons/day of raw sewage and untreated industrial waste flows into the Arabian Sea from Karachi, whereas an additional 8,000 tons of solid waste is dumped into the harbour each day.

Industrial pollution is mostly found on the coast of Karachi and brings various chemicals through the Lyari River including Magnesium, Arsenic, Sulphates, heavy metals, Carbonates Calcium, Alum, and Nitrates in the significant amount into the channel waters and ultimately into the Karachi Harbor.

According to the KPT, regular cleaning of the harbor is carried out, but the proportion of solid waste taken out of the harbor on a periodic basis is very small compared to the large amount of solid waste, especially plastics that have accumulated in the environs of the Karachi Harbor over the past few decades. Based on an interview with MPCD official at KPT - Salis Yunis, Anti-Pollution Officer, **Marine Pollution Control Department - MPCD is removing 2.5 Metric tonnes of solid waste from the harbor daily. This waste flows into the harbor from Lyari outfall, from the Pichar and Kalri Nallas, and the squatter communities.**

According to MPCD official estimates, plastic accounts for approximately 40% of the debris that is removed, of this plastic waste a large amount is attributed to polyethene bags. MPCD has developed its inhouse waste reuse mechanism. Large plastic bottles are taken from the waste and reused as containers for mangrove seeding purposes; the wooden debris is used for framing of the plant pots. There are few things that can prove to be beneficial in understanding - the kind of solid waste that flows through the city and to the harbor reflects the trends of the city i.e., religious festivals particularly. The waste from the vessels that are berthed at the harbor is managed under the Shore Reception Facility - this is a kind of provision that any international shipping port must provide to collect residues, oily mixtures, and garbage generated from a sea going vessel. All garbage collected from the vessels is collected by KPT preapproved contractors and is disposed at the landfills.

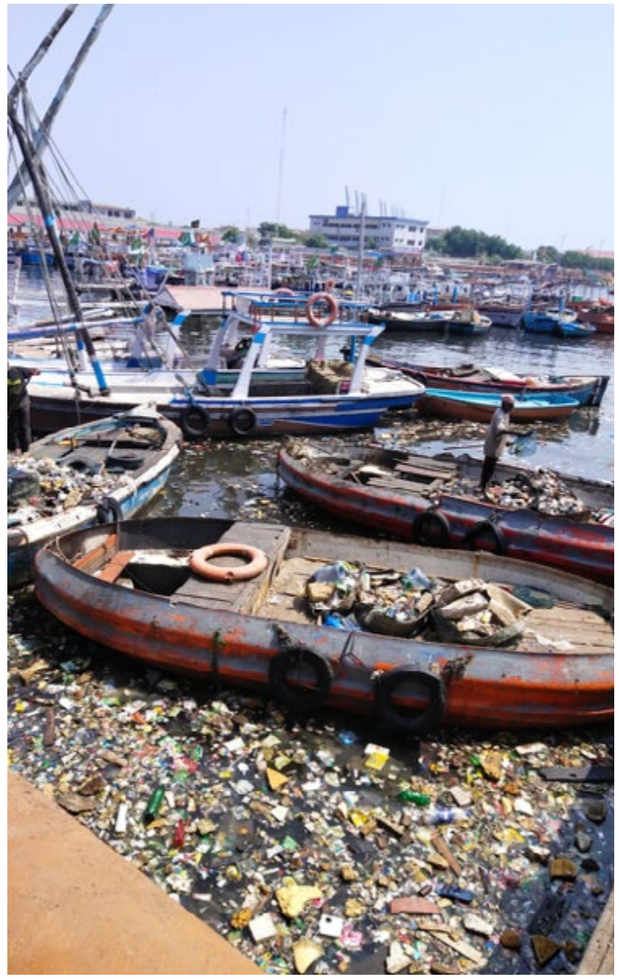


Image 3.6 & 3.7 - waste in the harbor area that flows in from the city, being collected by MPCD

Image 3.5: Map of Karachi Harbor

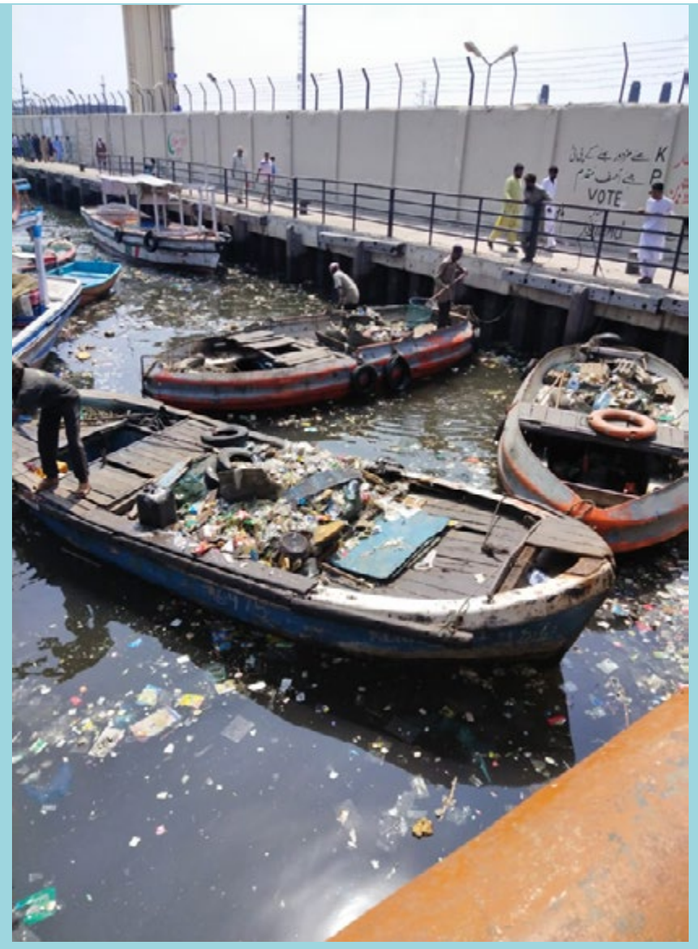


Image 3.8 & 3.9 – waste collection and preparation for disposal by MPCD in the harbor area

Image 3.10 Picher Nallah also drains directly in the Karachi harbor

Image 3.11: Neher-e-Khyaam (depositing its waste in Chinna Creek)

Image 3.12: Mangrove Forests in Karachi Harbor
(Opposite end of the Lyari River outfall area)

Image 3.13: Shamspir Island in Karachi Harbor Area

Image 3.14: Dockyard Area & Fishing Jetty in Harbor Area

Image 3.15: Lyari River towards Karachi Harbor

Image 3.16: Lyari River view from Karachi City

Image 3.17: Plastic Deposition from Settlements along the Lyari River

3.4 Sources of Pollution in Lyari River Outfall

Several site surveys of the outfall area of Lyari River led to the following conclusions:

• Many years of solid waste deposition in the area have led to the development of thick and deep sludge beds. Significant pockets of plastic pollution (mostly plastic bags) are also visibly evident. According to the local fishing communities inhabiting islands in the harbor area, the situation has become progressively worse after the construction of Karachi Port.

• The waters in the outfall area are also characterized by high levels of oil and grease, mostly from harbor operations.

Significant volumes of plastic pollution are evident in the mangroves area, not only inhibiting mangrove growth, but also the marine biodiversity that usually thrives in these ecosystems.

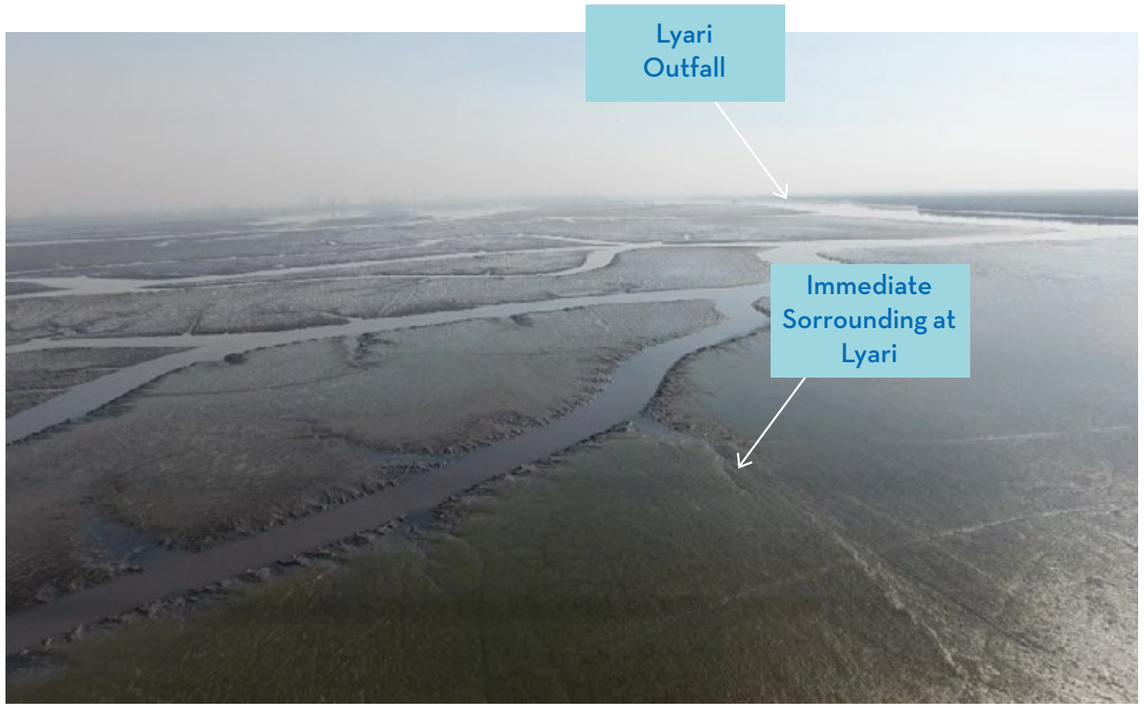


Image 3.18: Immediate surrounding at Lyari Outfall: More Sludge Than Water

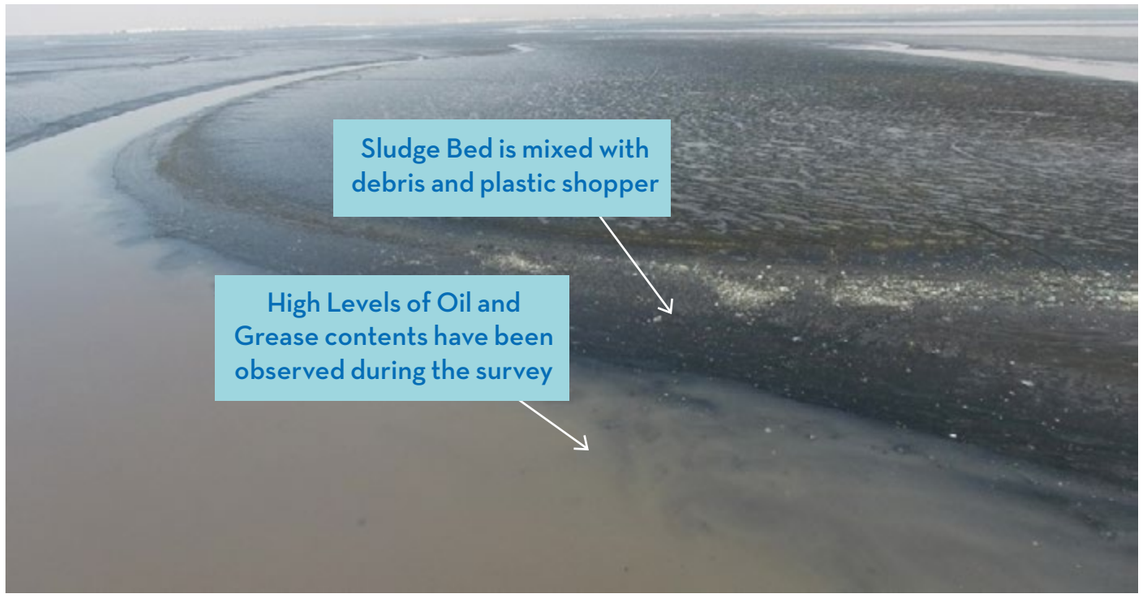


Image 3.19: Sludge Bed Situation

Image 3.20: Plastic garbage at mangroves mud after ebbing tide

Image 3.21: Plastic garbage all along the mangrove sludge bed

Image 3.22: Plastic garbage all along the mangrove sludge bed

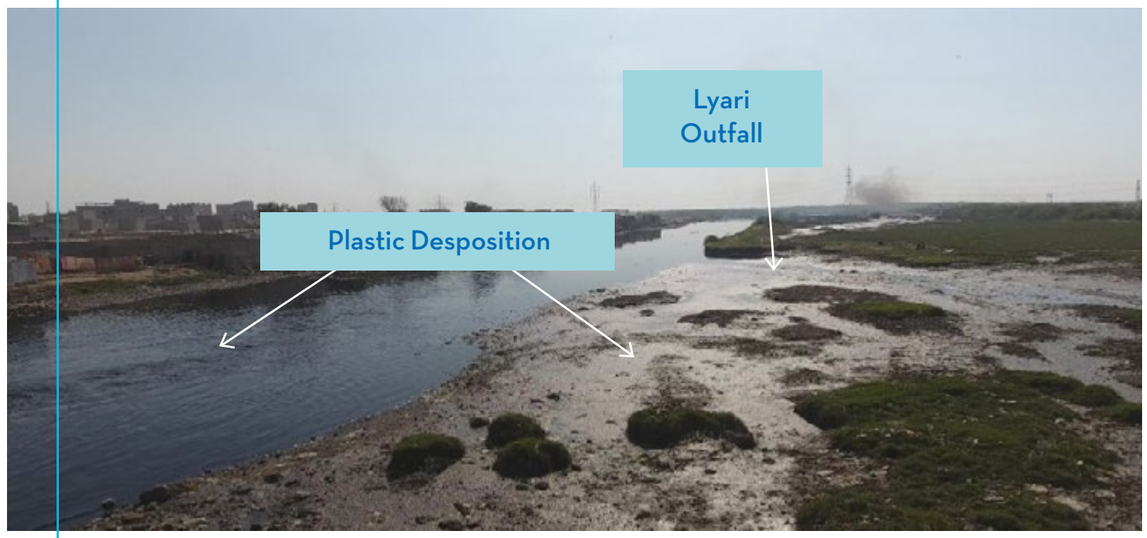


Image 3.23: Plastic Waste Near Outfall of Lyari River

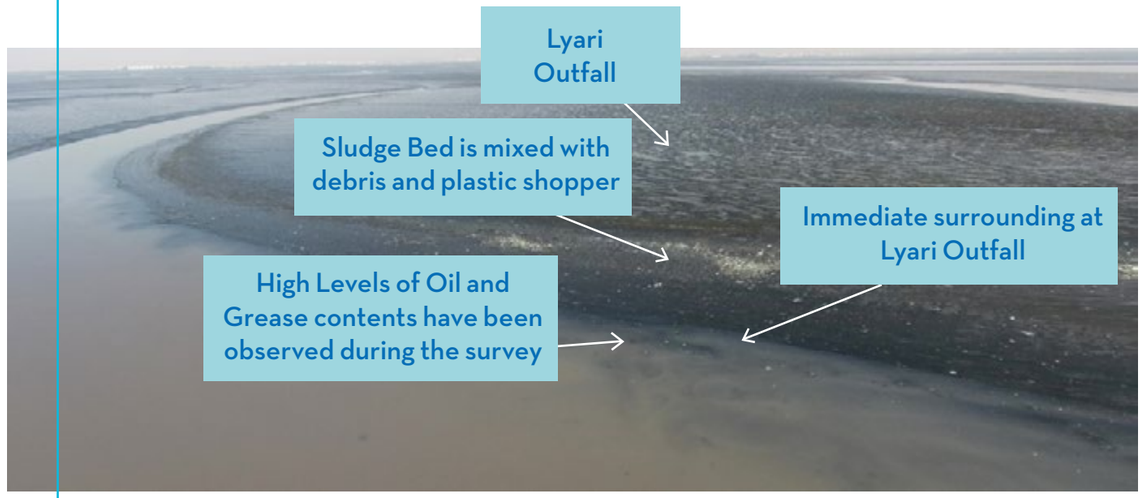


Image 3.24: Thick Sludge Beds Formed Near Lyari River Outfall

3.5 Concentration of Plastic Pollution in the Island Areas

There are three islands in the Harbour area-Shamspir, Baba, and Bhit. During the site surveys, significant volumes of plastic waste, mostly plastic bags, were found around all of the islands. According to the local fishermen, who claim to have inhabited these islands for centuries, the pollution problem has become progressively worse and plastic pollution is now a common sight for the villagers. Many years of solid waste deposition in the area have led to the development of thick and deep sludge beds. Significant pockets of plastic pollution (mostly plastic bags) are also visibly evident. The solid waste situation surrounding these islands is drastic and large solid waste heaps surround the islands.

The volume and severity of the problem can be gauged from the fact that the locals walk on these heaps of plastics to reach their homes and park their fishing boats. According to communities on this island, no effort has been made by the municipal authorities to clean this waste. There is a common agreement amongst all stakeholders that the situation has become progressively worse after the construction of Karachi Port. The waters in the outfall area are also characterized by high levels of oil and grease, mostly from harbor operations. Significant volumes of plastic pollution are evident in the mangroves area, not only inhibiting mangrove growth, but also the marine biodiversity that usually thrives in these ecosystems.

Images 3.25 & 3.26: Shamspir Island is Surrounded by Plastic Waste

Image 3.26

Images 3.27 & 3.28: Large Volumes of Plastic Waste Surrounding Baba and Bhit Islands

Image 3.28

Image 3.29 & Image 3.30 - Garbage waste situation at Bhit Island

Image 3.31: Garbage waste situation at Bhit Island

3.6 Daily Commuting in the Harbor area

The dwellers of the island daily commute to the Karachi port by using small and medium-sized boats. The fishermen also anchor their launces (boats) in the harbor area and frequently sail to the open sea for fishing activities. Plastic bags are the biggest visible

Image 3.32: Fishermen boats in the harbor area

Image 3.33: Harbor water is mixed with plastic shopper

3.7 Impact of Plastic Pollution on the Surrounding Communities

There are three islands in the Harbour area-Shamspir, Baba, and Bhit. During the site surveys, significant volumes of plastic waste, mostly plastic bags, were found around all of the islands. According to the local fishermen, who claim to have inhabited these islands for centuries, the pollution problem has become progressively worse and plastic pollution is now a common sight for the villagers. Many years of solid waste deposition in the area have led to the development of thick and deep sludge beds. Significant pockets of plastic pollution (mostly plastic bags) are also visibly evident. The solid waste situation surrounding these islands is drastic and large solid waste heaps surround the islands. The volume and severity of the problem can be gauged from the fact that the locals walk on these heaps of plastics to reach their homes and park their fishing boats. According to communities on this island, no effort has been made by the municipal authorities to clean this waste. There is a common agreement amongst all stakeholders that the situation has become progressively worse after the construction of Karachi Port. The waters in the outfall area are also characterized by high levels of oil and grease, mostly from harbor operations. Significant volumes of plastic pollution are evident in the mangroves area, not only inhibiting mangrove growth, but also the marine biodiversity that usually thrives in these ecosystems.

The dwellers of the island daily commute to the Karachi port by using small and medium size boats. The fishermen also anchor their launces (boats) in the harbor area and frequently sail to the open sea for the fishing activities. Plastic bags are the biggest visible solid waste all around these islands and the larger harbor area.

3.8 Types of Plastic Waste

Based on discussion with the Karachi Port Trust, the main types of marine pollution found in the harbor area is presented in Table 3.2. To remove this floating debris, MPCD has designated 8 boats and 24 labourers (3/boat) at Chenna Creek, East Wharf, West Wharf, and all piers. These boats have a maximum capacity of 250 Kgs, and all removal is done by hand i.e., sieves, and nets. The debris is collected in KPT vehicles (dumpers and trucks) and is taken to the landfill sites for proper disposal. Among the most common debris collected - there are clothes, shoes, food items, wood and plastic. Coastal areas suffer from the issue of plastic pollution due to the dumping of waste in these areas.

Some of the marine litter is also introduced by people that use the beaches for recreational activities such as swimming, sailing, and scuba diving. Paradise Point has been identified as the most polluted beach in a study conducted in 2015, containing almost 5kg of marine debris along the coast in the month of August. WWF-Pakistan studies also reveal that 65 percent of the garbage that litter beaches along Pakistan's coast consist of plastics, which includes mineral water bottles, caps, polythene bags, balloons, wrappers, shoes, broken utensils, and discarded fishing nets. According to MPCD officials, the plastic waste is a major hazard, not only does it negatively impact the marine species, but it also proves detrimental to the sailing vessels often getting caught in their motor propellers and causing damage. The port is a place where there is international traffic and all this waste creates a very bad impression for the international traffic that sails into Pakistan's waters.

Polyethylene and Wrappers	Plastic	Plastic material and wood	Cloth and Jute
Polyethylene sheets & shopping bags. Wrappers of sweets, suparis, etc	Bottles, Buckets & Utensils, bags Packing materials. Toothbrush, Hairbrush & combs, syringes & other surgical equipment. Ropes, Strapping bands, plastic sheeting. Hard hats, Resin pellets. Nets, Buoys, Traps, Fishing lines.	Sticks/twigs Leaves, wooden pieces of all kinds. Mangrove parts and Alga Grass and sugarcane Flowers Coconuts and other fruits	Old cloth pieces Holy sheet (cloth) Jute cargo bags Jute ropes and pieces Woolen cloth pieces Fiber ropes etc.
Shoes and Sleepers	**Material made of metals**	**Glass**	**Papers**
Every kind of shoes and sleepers	Vehicle spare parts Juice tin boxes Paint boxes Oil boxes	Medicine bottles Juice bottles Jam bottles Tube lights/bulbs, Glass pieces	Religious material, books, invitation cards Hard paper boxes Books and copies
Food waste	**Animals & their parts**	**Rubber and Leather**	**Thermo pol**
Roti, Nan Fruits Flour bags Rice and pulses bags	Fish and fish offal Meat Parts of the animal bodies Dead animal	Tire &tubes Packing material Balloons/condoms Leather bags and other products	All material made of thermos pore

Source: Interview with Mr. Fayyaz Rasool, Manager, Karachi Port Trust

4. SITE-SPECIFIC ANALYSIS

4.1 Hydrological Context of Karachi's Coastal Areas[6]

Hydrodynamic processes such as coastal circulation, low and high tide, Turbidity flow and currents profiles are the part of the overall process of environmental management. For problems dealing with the water environments created by manmade changes in the natural environment one concerns with the processes that take place between the point where a pollutant is discharged in to the water environment and some other sites where the ambient water quality is observed. The ocean has always been the sink for all materials washed off the land. In order to develop a sustainable use, a full understanding of the present region is required. Therefore, choosing a location for the port, jetty, desalination plant or any other technology and its related facilities depends upon many factors, including land, depth and space requirement, suitable hydrodynamical conditions required for intake and discharge and suitable protection against wave, current action and sedimentation. Before discussing site-specific findings for the study area, an explanation of the physical oceanography parameters that influence Karachi's coastal areas is provided here to enable a broader understanding of the study area.

4.1.1 Bathymetry

Previous seafloor topographic and morphologic studies undertaken by NIO in the area adjacent to Clifton and test runs off Clifton beach indicates that the seafloor off Clifton beach appears to be relatively flat and featureless as compare to the Hawk's Bay or the adjacent creek and deltaic area (Figure below). Nevertheless, NIO has prepared a satellite-derived bathymetry map of the Karachi coast. This bathymetric map has, therefore, been only employed in the discussion of the morphology, but not in defining the absolute depth of the seafloor.

THE OCEAN HAS ALWAYS BEEN THE SINK FOR ALL MATERIALS WASHED OFF THE LAND. IN ORDER TO DEVELOP A SUSTAINABLE USE, A FULL UNDERSTANDING OF THE PRESENT REGION IS REQUIRED.

6- All the findings for this sub-section has been gathered from discussion with specialists from the National Institute of Oceanography (NIO)

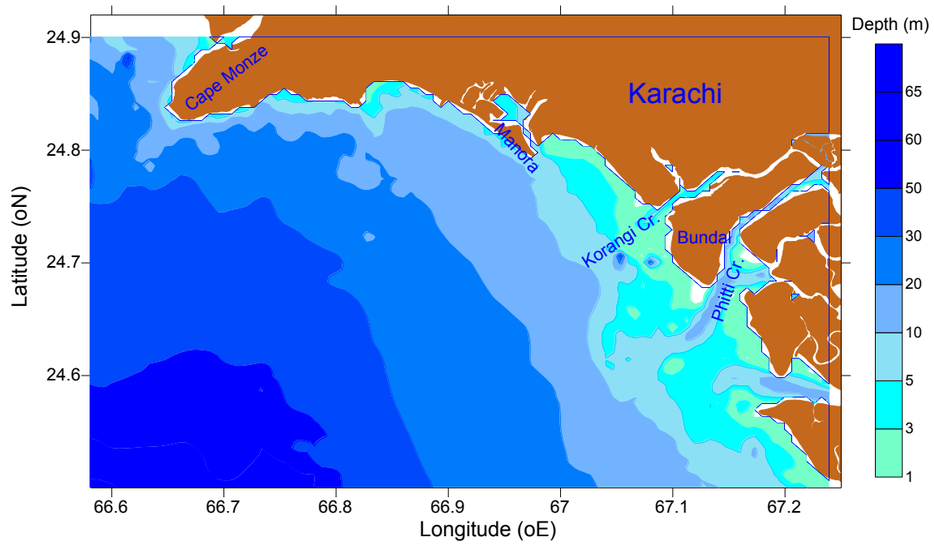


Figure 4.1: Bathymetric Map of Karachi's Coastal Areas

4.1.2 Wave Action

Available data in the vicinity of Karachi show that mean significant wave height exceeds one meter during the SW monsoon period and reaches a peak of 2.5m during June and July. The average wave period during the SW monsoon is 8 seconds. During the rest of the year, including the Winter (NE) monsoon, the wave height remains below 0.7m with a wave period of 10 13 seconds. The maximum tidal height at Karachi port is 3.4 m at the equinoxial tide (range is 0.60 m to 3.4 m). The tides at Karachi are mixed semi diurnal with a strong diurnal component. The movement of water in the vicinity of Karachi harbor is somewhat complex. As the tide recede water tend to move to Manora beach while at flooding stage it is bi-directional, i.e., inside the harbor and towards the Clifton beach. The result of the previous study for the site offshore Hawks Bay revealed that during winter season the movement of the dye was northwest-southeast that is along the coast.

4.1.3 Wind Action

The general seawater circulation pattern in the off-shore and near-shore coastal waters of Karachi during the summer monsoon season is not only influenced by the tidal forces but also by the wind system. The strong westerly wind prevails during this season and the dominant direction of the surface sea water flow, follows the wind and remains clockwise. It means major flux of seawater from offshore area enters into the Karachi coastal region at the western side of the coastline.

The influence of the tide is very significant in the Karachi and surrounding region. In particular, the channel areas have remarkably strong currents. The tide-induced currents range from over 10 cm/s to about 100 cm/s with averaged values of about 40 cm/s. As the tidal range in the study area is very large (> 3m), the occurrence of strong tidal currents is expected. The magnitude of the maximum current is dependent on the tidal range. The higher the tidal range in the area, the stronger is the tidal current as is the case during spring tides. The strong tidal currents are of course reduced in magnitude during neap tides. Relatively stronger currents occur during ebbing than during flooding due to the extra potential energy stored after flood tide at higher elevations upstream.

4.1.4 Coastal Storms and Cyclones

The Cyclones and storm surges in the Arabian Sea develop in the pre and post monsoon period in the southern part of Arabian Sea. Move usually Northward and then northwest or northeast direction hitting Arabian Peninsula or India Pakistan coast. Tropical cyclones normally do not affect the Pakistan frequently because of its location. However, the long fetches have resulted flooding in association with swells generated by the storms and monsoon depressions in the south of Pakistan coastline. A map of cyclonic activity along Karachi's coastal areas based on data is illustrated in the figure below.

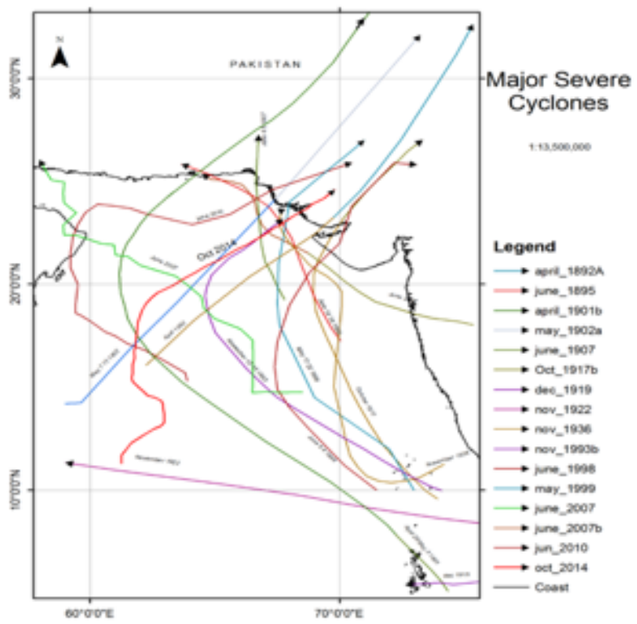


Figure 4.2: Historical Cyclonic Patterns off Karachi's Coast

4.2 Downstream Lyari River: Mewa Shah

4.2.1 Conditions of the Communities and Impacts of Plastic Pollution on Area

The respondents have been living in this area (Mewa shah) for more than 20 years and are facing various issues regarding solid waste in the Lyari river. There are no frequently cleaning activities which causes major garbage heaps along the riverbanks. The open dumping of garbage also causes many diseases here, especially malaria, which is very common in the surrounding communities of the Lyari river. The two main drains (Orangi and Gujjar) carry enormous amounts of solid waste, primarily consists of plastic directly dumped into the Lyari river. Moreover, surrounding communities through garbage into the river area, and sadly construction wastage/rubble is also dumped here and causes a major problem in the river areas. During monsoon period, because of the garbage is chocking various locations along the water pathways, the rain water has no place to go and inadvertently the river over flows, and floods the neighboring areas.

Image 4.1: Mewashah Road Bridge

Images 4.2 (a, b): Consultations with Communities Near Mewa Shah

Images 4.2 (a, b, c): Garbage deposited by the Lyari stream at Mewa Shah Road

4.2.2 River Parameters at Mewa Shah

The design parameters of Lyari river at Mewa Shah bridge are given in the table below. As this is a perennial stream, other physical oceanographic parameters (waves, tides, flow speed measurements etc) are not relevant here. The discharge data below is thus an average estimate during the monsoon season. Navigational maps are irrelevant here as well.

Location	Designed Bed width (m)	Designed Dept (m)	Bed Slop	Side Slope	Capacity Cusecs	Discharge from Catchment area (Cusec)
Mewa Shah	170	3.5	0.0018	2:1	61,523	56,650

4.2.3 Local Precipitation Data

There is no site-specific data with respect to precipitation available with any organisation. We have received data on the last 10 years of precipitation for Karachi from the Pakistan Met department. Please note that the data provided in the tables is from the Karachi Airport station, and provides figures for all catchment areas of Karachi.

4.2.4 Potential Deployment Location for a Plastic Cleaning Solution

There are many factors that will make any major technological solution in this location a challenge. Even though this location is downstream, the average water levels are very low, except during 2-3 months in the monsoon season. Moreover, as there is no law enforcement agency in the immediate area, protection, security, and storage of the technology can be a grave concern and additional arrangements may be required to cardon off the area.

PLASTIC BAGS CLOGGING DRAINS IS ONE OF THE BIGGEST ISSUES, AND DESPITE THE PROBLEM THAT IT POSES, COMMUNITIES ARE NOT PARTICULARLY PUSHED TO NOT USE PLASTIC.

4.3 Downstream Lyari: Mauripur Bridge

4.3.1Conditions of the Communities and Impacts of Plastic Pollution

Most of the communities living in the area are from Sindhi, Balochi, Hindu, Kachi Memon, and Christian community. There are small communities of Pashtun, Punjabi and Urdu speaking also living here. The main issues that plague the communities living here are water shortage, electricity, and a lack of opportunities for livelihood development. The area is very congested, livelihood and health are major issues. The youth have been seen using drugs. People tend to keep to themselves. The whole of Mauripur has severe water shortage issues, and there is no drinking water available. Community members order water tankers to fulfil their needs. Infrastructure is dilapidated, and drains are blocked. The aftermath is often witnessed when there are heavy rains.

With respect to waste management, KMC has placed metal dumpsters in different location around the area. There is however, according to community members a dearth in understanding and not everybody throws their trash in these dumpsters, there a majority of people who end up throwing their trash into the drains, primarily because of the inconvenience of having to walk to the dumpster. They would prefer trash collection from homes but such a service is not available in the area, and then most people cannot afford to avail such a service. Some local NGOs called Voice of Student organisation, Shah Abdul Latif Bhittai organisation that have been working to educate people in the area about cleanliness, and have been training them on disposing their waste in KMC dumpsters.

Awareness about plastic pollution is low, when asked about whether people would be willing to convert to other packaging options, most of the responses that we received were neutral. Plastic bags clogging drains is one of the biggest issues, and despite the problem that it poses, communities are not particularly pushed to not use plastic. It is important to understand here that these communities are already bogged down with the burden of lack of basic utilities. In spite of the fact that there are plastic bags lying on the sides of the road, or that there is plastic debris, it is of little or no concern to them.

Image 4.3: Lyari Waste Stream at Mauripur Bridge

Image 4.4: Aerial Imagery of Lyari Downstream Mauripur Bridge

Images 4.5(a, b): Consultations with Nearby Communities

4.3.2 River Parameters at Mauripur Bridge

The design parameters of Lyari river at Mewa Shah bridge are given in the table below. **As this is a perennial stream, other physical oceanographic parameters (waves, tides, flow speed measurements etc) are not relevant here.** The discharge data below is thus an average estimate during the monsoon season. Navigational maps are irrelevant here as well.

Location	Designed Bed width (m)	Designed Dept (m)	Bed Slop	Side Slope	Capacity Cusecs	Discharge from Catchment area (Cusec)
Mauripur	190	3.6	0.0011	2:1	63,301	58,950

4.3.3 Local Precipitation Data

There is no site-specific data with respect to precipitation available with any organisation. We have received data on the last 10 years of precipitation for Karachi from the Pakistan Met department. Please note that the data provided in the tables is from the Karachi Airport station, and provides figures for all catchment areas of Karachi.

4.3.4 Potential Deployment Location for a Plastic Cleaning Solution

The study findings for Mauripur Bridge Area are not much different than Mewa Shah. The flow and depth are better than Mewa Shah, however flow is only available for 4-5 months, making a permanent technological solution infeasible. Moreover, as there is no law enforcement agency in the immediate area, protection, security, and storage of the technology can be a grave concern and additional arrangements may be required to cardon off the area.

4.3 Lunikanwala Dor and Lyari Mouth

River Lyari stems from the foot-hills of Kirthar Range at the point of Manghopir. It has a catchment area of about 578 km2. Its length is shorter i.e., 180 km, as compared to River Malir and a smaller number of tributaries constitute it. Mokhi nullah originating from Taiser hills, Orangi nulllah originating from Orangi hills and Gujro nullah originating from Manghopir hills are the main tributaries which discharge surface runoff to the Lyari River.

River Lyari, like other rivers of Karachi, is a non-perennial water channel flowing only when rain falls in its catchment. The river also passes through the urban areas of Karachi, carrying industrial effluents and domestic wastewater with it and finally falling into the Arabian Sea. Along the banks of River Lyari, almost 50 slum areas of approximately 0.8 million people reside. This makes them the most vulnerable to floods during seasons of heavy rainfall.

Drainage level patterns of River Lyari Basin

Length of Stream	180 km
Basin Area	578 km2
Drainage Pattern	Dendritic
Branching Ratio	5.6
Drainage Density	10.1 km/sq.km

This river has very mild slopes in the outfall touching almost zero level downstream of Mauripur Road Bridge. The slope of the bed gradually increases upstream of the estuary up to the end of city limit. In the hilly areas, the bed slope is very steep and the river is about 50 km (30 miles) long.

Lunikanwala Dor is a tidal creek(s) and is in Sindh, Pakistan. The estimate terrain elevation above sea level is -9999 meters. This is essentially an estuary where the Lyari River mixes with the salt water of the ocean. It is situated west of Mangarwala, and northeast of Chachi Dor. This estuary is receiving water from the Lyari river that flows through Karachi. In order to understand the scope of the plastic pollution problem in this area, it is important to first understand the Lyari river structure and its drains. To the north of this estuary is the outfall of the Lyari river, with the port to the east, and southeast. The Shamspir, Baba and Bhitt Islands are located to the South and Southwest of the channel. This area is also referred to as the Western Back waters because it is to the west of the port and essentially is the channel that leads to the doorway of the port and into the ocean

Image 4.6 Lunikanwala Dor is the heart of the Karachi's Western Backwaters

WITH THE DEVELOPMENT OF THE KARACHI PORT AND REGULAR INFLUX OF SEWAGE AND SOLID WASTE OVER THE PAST DECADES, THE AREA IS NOW FULL OF MOUNDS AND MOUNDS OF SLUDGE.

4.3.1 Bathymetry and Other Hydrological Parameters

This is the intertidal zone area with average depth of the channels varying between 1 – 3 m. With the development of the Karachi Port and regular influx of sewage and solid waste over the past decades, the area is now full of mounds and mounds of sludge. Thus, the channels have changed in size and depth over time and are not connected to any particular island or site. With a largest tidal range of 3.68 meters, the high tide fills the backwaters and creeks of the harbor area, covers the intertidal zones of the small islands and mudflats in the estuary and, going back the mangroves. Both the hydrological data and the engagement with communities indicate that the network of channels used to be much deeper and cleaner, but with continual accumulation of sludge, only navigation with small boats is now possible.

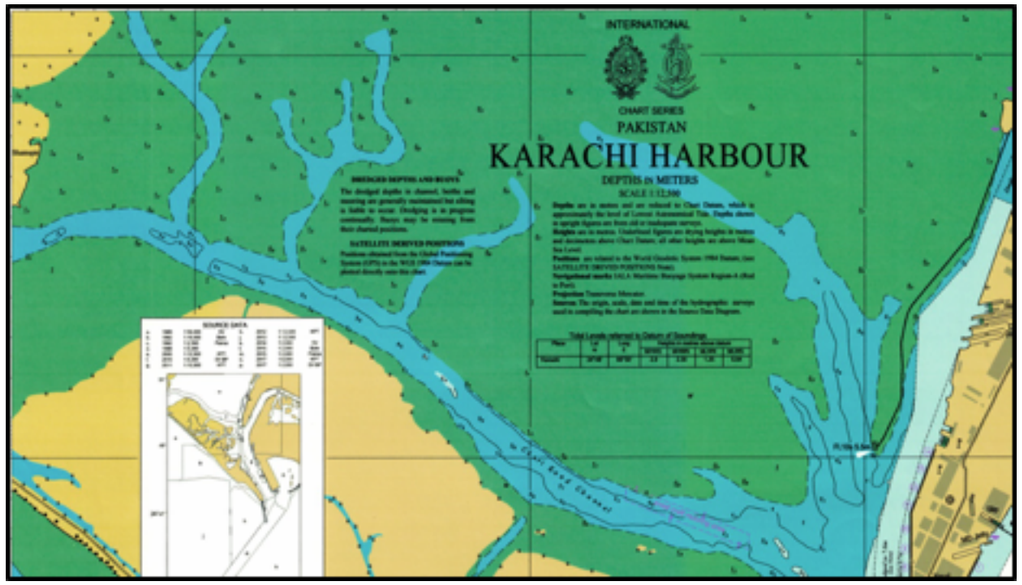


Fig: 4.3: Lunikanwana Dor Area Bathymetry

4.3.2 Tidal Range

The Pakistan coast has semi-diurnal tides with diurnal inequality. The mean tidal range is 2.3 meters for the Karachi port.

Highest Astronomical Tide (HAT)	3.50 meters
Lowest Astronomical Tide (LAT)	-0.42 meters
Maximum Tidal Range Possible	3.71 meters
Mean High Water Spring (MHWS)	2.91 meters
Mean High Water Neap (MHWN)	2.30 meters
Mean Low Water Neap (MLWN)	0.64 meters
Tide type	0.54 (mixed)
Shallow Water Influence	0.02
Highest tide (1st Jan-31st Dec 2022)	3.43 meters
Lowest tide in this period (1st Jan-31st Dec 2022)	-0.35 meters
Largest tidal range (1st Jan-31st Dec 2022)	3.68 meters
Average Flood time	06 hours 12 minutes
Average Ebb time	06 hours 12 minutes

4.3.3 Nautical Maps

Positions are related to the World Geodetic System 1984 Datum; Navigational marks Maritime Buoyage system region-A (Red to Port)

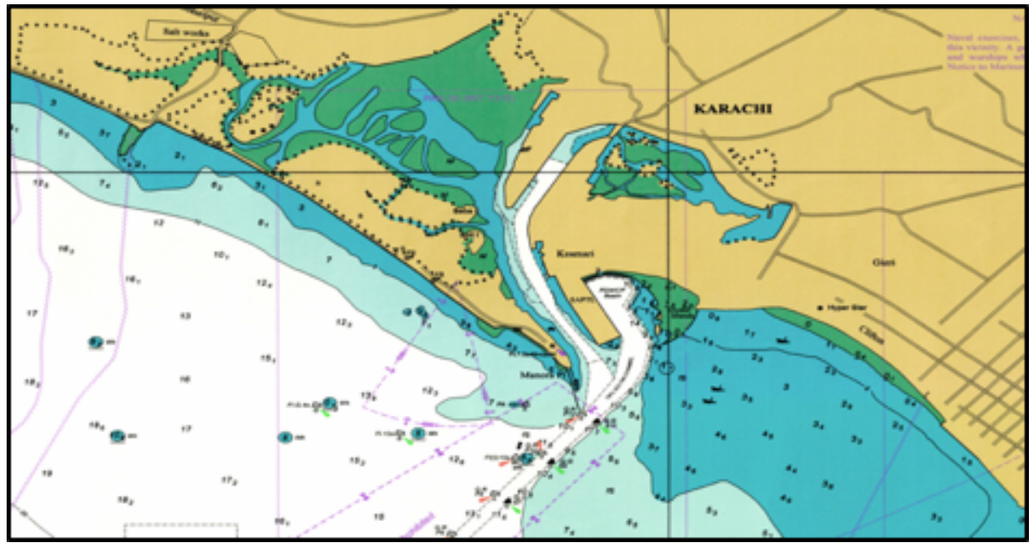


Fig: 4.4: Nautical Maps of Lyari Mouth and Lunilkanwala Dor Area[7]

7 - **Depths** in meters and are reduced to Chart Datum, which is approximately the level of lowest astronomical tide. **Heights** are in meters underlined figures are drying heights in meters and decimeters above Chart Datum; all other heights are above Mean Sea Level. **Positions** are related to the World Geodetic System 1984 Datum; **Navigational** marks Maritime Buoyage system region-A (Red to Port)

4.3.4 Precipitation Records

There is no site-specific data with respect to precipitation available with any organisation. We have received data on the last 10 years of precipitation for Karachi from the Pakistan Met department. Please note that the data provided in the tables is from the Karachi Airport station, and provides figures for all catchment areas of Karachi.

YEARS AND YEARS OF DISCHARGE OF SOLID WASTE AND ACCUMULATION OF THE SAME AS SLUDGE HAD MADE NAVIGATION IN THIS AREA VERY DIFFICULT NOW. AS THE BATHYMETRY DATA INDICATES, THE DEPTH IS VERY LOW. ANY SOLUTION TO DEPLOY IN THIS AREA CAN ONLY BE SOUGHT AFTER REMOVING SIGNIFICANT AMOUNTS OF THE SLUDGE FROM THE AREA.

4.3.5 Potential for Deployment of a Cleaning Solution

Years and years of discharge of solid waste and accumulation of the same as sludge had made navigation in this area very difficult now. As the bathymetry data indicates, the depth is very low. Any solution to deploy in this area can only be sought after removing significant amounts of the sludge from the area. This activity, in itself could be carried out with the collaboration of the Karachi Port Trust (KPT), that does clean the harbor area periodically, but the magnitude of the clean-up is very small compared to the existing accumulated debris and the continuous inflow of solid waste in to this area.

4.3.5 UAV Aerial Image Collection

Images 4.7: Aerial imagery of Lunilkanwana dor

Image 4.8: Aerial imagery of Lyari River Mouth

4.4 Baba and Bhit Islands

4.4.1 Conditions of the Communities and Impacts of Plastic Pollution

Baba and Bhit Islands are two small and densely populated islands located in the Karachi Harbour. These islands are separated by a creek, cover a six-square-kilometer area near the Karachi Port Trust. The approximate area of the islands is 4 km· and the population is about 25,000. The islands are connected to Karachi via ferry service to Keamari.

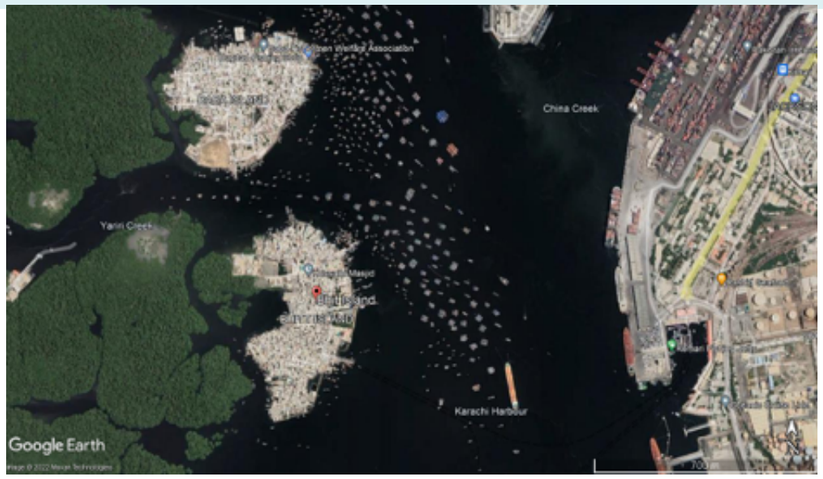


Figure 4.5 Aerial View of Baba and Bhit Islands

These islands are old fishing villages in the harbor which predate the formal establishment of Karachi. They are said to be over 400 years old. There are ethnic groups in Baba & Bhit Island including 90% Kutchi and 10% Sindhi Over 100% of the population is Muslim.

The island communities of Shamspir, Baba, and Bhit are traditional fishing communities that have been living in these areas for centuries. These islands are part of Karachi's Keamari Town All of these communities are Sindhi-Baloch with strong male-dominated lifestyles. Several consultations were held with village elders of these islands to understand and examine the socio-economic conditions of these island folks. According to the village representatives, the fish caught in and around the islands and even in the open ocean has drastically reduced over the past few decades. Previously, they did not have to work hard or go far to catch fish and the shrimps and lobsters were easily found very close to their islands. After the construction of the Karachi Port and increased harbor activities, the waters around these islands have gotten much dirtier. Various types of solid waste accumulate around their islands, including plastics. This trend has not changed for several years now and their children have never seen the clean waters the elders saw when they were young, nor do they enjoy the large volumes of fish cash. With increased harbor activities, the fishing communities' access to their traditional fishing grounds has become limited. Now, they have to go much farther and spend more days away from home to gather a decent volume of fish.

Moreover, another disturbing trend that has been reported in the coastal areas amongst the poverty-stricken fishing communities is the rampant use of drugs and gutka. The addition of various drugs has become common amongst the youth and children of these communities as they face a life of continual hardship and strife. Moreover, when inquired about the health of the local communities, they complained that various ailments have become a lot more common, especially various types of skin infections and respiratory diseases. The local folks admit the situation their living conditions are filthy and unhygienic, but they say they have no choice and the government has not fulfilled any of the commitments made to them in the past. Limited health facilities exist on the island, but even then, doctors are not available all the time, medicines are short and in emergency cases, the only option is to go to the mainland, which can be risky and financially painful for most families.

Images 4.9 & 4.10: Islands completely surrounded by Plastic Pollution

4.4.2 Bathymetry

The depth in the surrounding of the Baba & Bhit Island is showing in figure 1.1. The islands are besieged by interdunal zone and separated by Yari creek having water depth ranged from 1m to 3.7m from west to east respectively. The water depth varied 3.5m to 4.9m from north to south. With a largest tidal range of 3.68 meters, the high tide fills the backwaters and creeks of the harbor area, covers the intertidal zones of the small islands and mudflats in the estuary and, going back the mangroves.

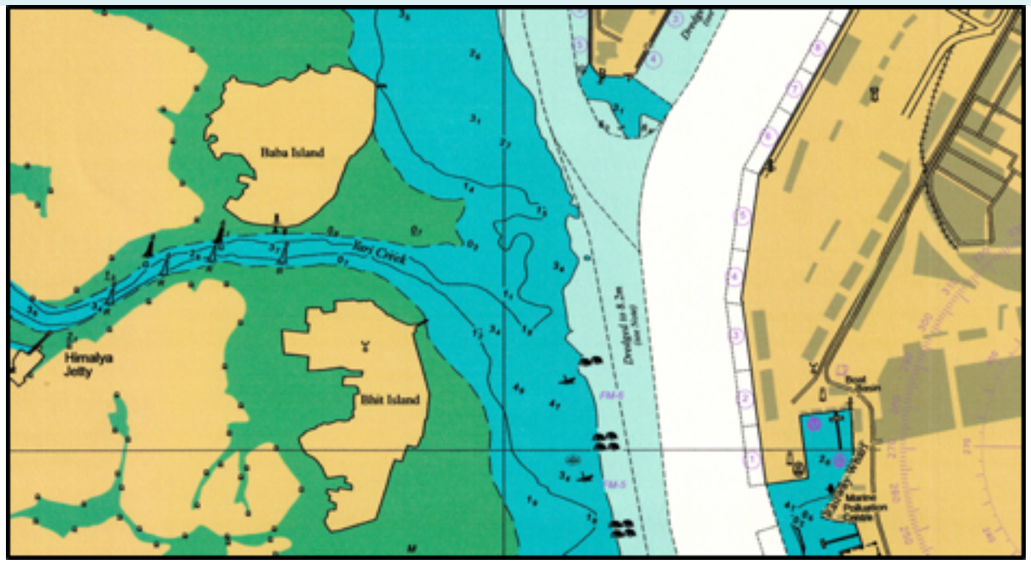


Fig. 4.6 Baba & Bhit Island Bathymetry[8]

4.4.3 Tidal Range

The Pakistan coast has semi-diurnal tides with diurnal inequality. The mean tidal range is 2.3 meters for the Karachi port.

Highest Astronomical Tide (HAT)	3.50 meters
Lowest Astronomical Tide (LAT)	-0.42 meters
Maximum Tidal Range Possible	3.71 meters
Mean High Water Spring (MHWS)	2.91 meters
Mean High Water Neap (MHWN)	2.30 meters
Mean Low Water Neap (MLWN)	0.64 meters
Tide type	0.54 (mixed)
Shallow Water Influence	0.02
Highest tide (1st Jan-31st Dec 2022)	3.43 meters
Lowest tide in this period (1st Jan-31st Dec 2022)	-0.35 meters
Largest tidal range (1st Jan-31st Dec 2022)	3.68 meters
Average Flood time	06 hours 12 minutes
Average Ebb time	06 hours 12 minutes

8 - **Depths** in meters and are reduced to Chart Datum, which is approximately the level of lowest astronomical tide. **Heights** are in meters underlined figures are drying heights in meters and decimeters above Chart Datum; all other heights are above Mean Sea Level. Positions are related to the World Geodetic System 1984 Datum; **Navigational** marks Maritime Buoyage system region-A (Red to Port)

4.4.4 Navigation/ Nautical Map

Positions are related to the World Geodetic System 1984 Datum; Navigational marks Maritime Buoyage system region-A (Red to Port)

Fig: 4.7: Baba & Bhit Island Area Navigation Map

4.4.5 Potential for Deployment of a Cleaning Solution

Site visits and aerial imagery indicate the accumulation of significant amounts of plastic pollution around both these islands. To some extent, the islands provide a buffer between the waste coming from Lyari and the main navigation channel for Karachi Port. As the jurisdiction for waste clean-up in or near the islands is with the Sindh Solid Waste Management Board (SSWMB), a major clean-up operation with SSWMB is required in this area around the islands. After cleanup of the solid waste and plastic pollution around the islands, a detailed feasibility for deployment of a plausible technological solution can be initiated. However, as the islands are very close the navigation channel, detailed site analyses will need to be discussed with the Karachi Port Trust (KPT) and they must be made partners to the cleanup project/programme for sustainable planning and implementation.

5. STAKEHOLDER ENGAGEMENT: CURRENT INITIATIVES AND OPPORTUNITIES

5.1 Assessment of Existing Local Initiatives Working on Removal of Plastic Pollution

As such, there have been no specific initiatives to remove plastic pollution from waterways. However, with the devastating impacts of urban flooding during the monsoon rains of 2020, the Karachi Metropolitan Corporation has made it a top priority to regularly clean the major drains frequently clogged with solid waste, including a large volume of plastics, falling in to Lyari and Malir Rivers. **Most recently, a plan has been finalized to remove large volumes of solid waste from the two biggest drains falling in to Lyari River: Orangi and Gujjar Nallahs. With the support of the National Disaster Management Agency (NDMA), the KMC also plans to remove encroachments on these nallahs, prevent throwing of garbage into these drains by developing protection walls, separate sewerage and storm water lines to avoid mixing and overflow and expand the width of these drains. This project has been approved and about to take-off now with a 6-12 months project period.** Though this project is not specifically targeting plastic pollution, it should contribute significantly to the plastic pollution entering Karachi's water bodies through these drains.

Moreover, several initiatives mentioned below reflect the growing consciousness amongst different stakeholders-government, private sector and NGOs regarding the gravity of the plastic pollution problem. However, there are all standalone and the biggest challenge is that they do not conclude in one solid action or way forward. The system is also missing tangible efforts that reflect solid outcome and changes to the communities. Some initiatives in this regard are listed as forth:

MOST RECENTLY, A PLAN HAS BEEN FINALIZED TO REMOVE LARGE VOLUMES OF SOLID WASTE FROM THE TWO BIGGEST DRAINS FALLING IN TO LYARI RIVER: ORANGI AND GUJJAR NALLAHS.

THIS PROJECT HAS BEEN APPROVED AND ABOUT TO TAKE-OFF NOW WITH A 6-12 MONTHS PROJECT PERIOD.

IN A BEACH CLEAN-UP ACTIVITY CONDUCTED IN SEPTEMBER 2018 ON THE INTERNATIONAL COASTAL CLEAN-UP DAY, A BEVERAGE COMPANY HELPED COLLECT 535 KG OF WASTE, COVERING AN AREA OF 300,000 SQUARE METERS. 60% OF THE WASTE COLLECTED WAS MOSTLY PLASTIC.

- **SEED Ventures in collaboration with Philip Morris International and Entrepreneurship, Youth Development Society conducted a series of 18 drives across Pakistan.** These drives were not meant to specifically clean water from water bodies, however, out of 18 drives, three were carried out in the following areas; Clifton Beach, Turtle Beach, and River Kunhar (Balakot). Through these 18 drives, we collected 6 tons of trash, out of which approximately 4 tons were plastic. These drives were conducted in a span of 4 months. We engaged 3000 volunteers across the country. These initiatives demonstrate the sheer size of the plastic problem in the country. A video is available for viewing if required.

- **In 2018, the Prime Minister of Pakistan, Mr Imran Khan, launched the Clean Green Pakistan Movement (CGPM). This national campaign underpins behavioral change and institutional strengthening while envisaging the need to address five components: plantation, solid waste management, liquid waste management/ hygiene, total sanitation, and safe drinking water.** The CGPM has a specific focus on empowering the citizens to seek access to basic services but also making themselves equally accountable and responsible for Clean Green Pakistan. The Federal Government will make periodic reviews to appreciate the successes through different mechanisms like recognizing the best cities, universities, and institutions through giving awards and certificates for generating healthy competition among the cities and citizens of Pakistan.

- **Beach clean-ups have become a regular activity for environmentally conscious corporations in Karachi as well as specific youth and student groups.** In a beach clean-up activity conducted in September 2018 on the International Coastal Clean-up Day, a beverage company helped collect 535 kg of waste, covering an area of 300,000 square meters. 60% of the waste collected was mostly plastic.

- **Tearfund, a UK based NGO has partnered with the SSWMB to develop two waste segregation units near selected garbage transfer stations in Karachi, where the segregated waste will be brought into the Station, and recyclable elements separated from the nonrecyclables.** This waste will be collected door to door from households by the SSWMB and retrieved from grounds and areas where it is improperly disposed of, and ultimately segregated into different types of wastes. The recyclable items will further be divided into items that can either be sold to manufacturers for re-use, or into items that can be composted (organic wastes e.g., food waste, kitchen waste). Non-recyclable items will be sent to a landfill site for appropriate disposal. Tearfund will arrange and implement a behavioral change and mobilization campaign around waste segregation and management with a focus on clean and green initiatives to aid the SSWMB in their door-to-door pickup of waste. The income generated from the selling of waste will be used to maintain the Hub and cover any running costs, while also being the source of income for any laborers/ workers employed there, all in all, making the Hub self-sustaining.

- **Pakistan's River Ravi Eco-Revitalization Master Plan is an initiative proposed by the Asian Development Bank Pakistan in 2020.** The River Ravi in Pakistan is in a highly deteriorated state. The people of the River Ravi Basin have a different vision for its future. Much improvement can be achieved through water treatment and river restoration, but people and organizations must do their part to care for the River Ravi. The River Ravi Eco-Revitalization Master Plan is a detailed road map for achieving the collective vision.

5.2 Existing Research on the Plastic Pollution Problem in Karachi's Waterways

- **WWF Pakistan has also been encouraging innovative ideas for countering plastics pollution and has funded startups, which are focusing on recycling. They are also quantifying plastic bottling waste in major cities of Pakistan to gauge the scale of plastics in Pakistan and to explore potential avenues for tackling plastic wastage.** In addition to quantification, they are also monitoring plastic waste in public spots across the country like in Margalla hills. WWF also works with the communities to counter plastic pollution; fishermen have been trained to rescue marine species entangled in plastics using a mix of technology and community mobilization and awareness techniques

- **WWF Pakistan gathered a report on the effects that abandoned fishing gear has had on marine life and surrounding habitats in Pakistan.** To create awareness about the adverse impacts of ghost gear and share the findings of the report, WWF-Pakistan organized a webinar that was attended by more than 100 students from Karachi and Lasbella universities.

- **The National Institute of Oceanography (NIO) based in Karachi has a separate department that is dealing with the study of microplastics in water.** Their interest is to understand the effects of plastics in the water over a length of time. The studies we have identified during our desk research are focused on the plastic that is already in the water, and its impact or disadvantage. There are not many papers available on the removal of plastic from water bodies that we have come across. There is potential in this field.

- **In last 2021, Engro Corporation embarked on an ambitious initiative to recycle plastics, reduce carbon and water foot print and improve energy efficiency with support of the IFC.** IFC Pakistan's Resource Efficiency Program will help Engro identify options for working towards a low carbon footprint and circular plastics economy.

- **NovumPack is the local partner of Cardia Bioplastics, an Australian firm that develops bio-degradable packaging and alternate to plastics, bringing about a diverse set of low-carbon packaging options to the industry.** NovumPack, based in Lahore is engaged in similar initiatives aligned with the needs and demands of the Pakistani market

- **In November 2021, a Memorandum of Understanding (MoU) between Engro Polymer & Chemicals and Karachi School of Business and Leadership (KSBL) was signed to establish a Circular Plastics Institute in Pakistan.** This first-of-its-kind academic collaboration will aim to develop an action-oriented and data-driven roadmap for a path towards a zero plastic waste future in Pakistan.

- **UNDP Innovation-AccLab Pakistan has created a learning space to test effective and meaningful development approaches.** Understanding the people, we serve and the larger complex systems like plastics waste is critical for UNDP Pakistan. In an effort to build momentum towards a plastics system that works, Innovation-AccLab Pakistan is working with the local innovators, industry and government to develop systemic solutions to promote the transition towards a circular economy for plastics in which they never become waste or minimize their leakage into environment.

5.3 Stakeholder Roles and Responsibilities

The institutional setting in Karachi has traditionally comprised of various agencies at federal, provincial and local government levels with separate land areas, and separate legal and administrative frameworks. Similarly, the issues of solid waste management, cleaning and management of Karachi's drains, rivers and coastal waters is carried out by a range of Federal, Provincial and local agencies. The table below identifies the key stakeholders in this sector and briefly identifies the role of each institution.

Table 5.1: PROJECT STAKEHOLDERS, STAKEHOLDER ROLES AND RESPONSIBILITIES
F- Federal Government, P-Provincial Government (Government of Sindh), L-Local Government (focused on Karachi), O-Other (Civil Society, Local Communities involved in Informal SWM Sector)

S.No.	Stakeholders	Type of Institution	Functions & Relevance
1	Ministry of Climate Change (MoCC)	F	The apex federal body that develops strategies, policies, and plans to protect biodiversity, forestry, wildlife and ensure projects for addressing the adverse consequences of climate change
2	Karachi Port Trust (Marine Pollution Control Board) KPT (MPCB)	F	This main body under the Ministry of Maritime Affairs is responsible for managing all development and operations of Karachi Port and the larger harbor area. Any major research and/or development in the harbor area cannot take place without permission of KPT. The Marine Pollution Control Department (MPCD) was established in 1996 to regularly clean the harbor area and conduct periodic environmental monitoring.
3	Karachi Water & Sewerage Board (KW&SB)	P	The Karachi Water and Sewage Board comes under the Provincial Government of Sindh but operates as an independent organization. It is responsible for sewage disposal for the city of Karachi and is involved in initiatives for improved sewage disposal. It is also responsible for provision of water to the city of Karachi. The KW&SB is a vertically-integrated entity, with functions including wholesale supply and treatment, transmission and distribution of water, wastewater collection, treatment/disposal, and revenue collection. KW&SB was established under the KW&SB Act, 1996 as an autonomous body with its own Board of Directors, and a Managing Director who was also a Board Members. The KW&SB divides Karachi into 6 water Circles and 20 towns based upon population and the outlet and inlet points of the existing water pipeline network in the city. The KW&SB provides intermittent water to some part of the city.

S.No.	Stakeholders	Type of Institution	Functions & Relevance
4	Local Government Department (LGD)	p	The provincial department that oversees governance at the lowest level including Districts and Union Councils and ensures an enabling environment for smooth functioning DMCs and UCs. Through one of its WB-supported projects (CLICK), the LGD provides technical and financial assistance for improving solid waste management at the local level.
5	National Disaster Management Authority (NDMA)	F	Federal Disaster Management Authority based in Islamabad, but provincial offices in each provincial capital, including Karachi. Currently, the most relevant project that NDMA is engaged in is the 'Revamping and Restoration of Storm Water Drains and Improving Conditions of Lyari and Malir River'. After the intensive urban flooding in August 2020 that resulted in extensive damage to both residential and commercial localities and lay bare the dismal state of storm-water drainage system of Karachi, the Government of Sindh approached the NDMA for major improvements in the system. The project is about to be initiated and has the following objectives: (I) Cleanup of solid waste from the stormwater drains (Mehmoodabad, Gujjar and Orangi Nallah), (ii) separation of sewerage lines from the storm water drains (iii) widening of drain after removing encroachments from the sidelines (iv) construction of 30 feet paved roads and 3 feet tall parapet walls on the sides of drains and (v) Rehabilitation/resettlement of people displaced due to removal of encroachments
6	Pakistan Maritime Security Agency	F	The PMSA is the Coast Guards Branch of the Pakistan Navy. It is a Navy-managed and Navy-controlled law enforcement agency whose mission is to provide protection to the Pakistan's maritime interests and enforcement of maritime law with jurisdiction over the domestic and international waters of Pakistan including the exclusive economic zone. Carries out targeted marine research and supports other federal and provincial agencies where required. Any surveys near security-sensitive installations would require the permission of the PMSA.
7	National institute of Oceanography (NIO)	F	NIO is the main federal R&D institution conducting a variety of research in Pakistan's coastal waters. The most updated data on hydrology, bathymetry, physical oceanography and the like are with this institution.
8	Marine Fisheries Department (MFD)	F	This Federal Institution carries out research on all aspects of marine fisheries and implements projects to not only protect marine species, but also enable greater fisheries production and exports and an enabling environment for the fisheries sector
9	Sindh Solid Waste Management Board (SSWMB)	P	The provincial waste management body responsible for entire waste management process through Sindh. Responsible for collecting, transferring and dumping solid waste all over Sindh, including Karachi. Periodically carries our surveys on volume and type of waste generated in different districts of Karachi.

S.No.	Stakeholders	Type of Institution	Functions & Relevance
10	Karachi Metropolitan Corporation (KMC)	L	Karachi Metropolitan Corporation (KMC) is a public corporation and governing body to provide municipal services in Karachi. KMC is responsible for the collection, conveyance and disposal of storm water, and for maintenance and channelization of major storm water infrastructure within the city. The director of solid waste management in KMC has the responsibility for supervising the existing designated dump sites of KMC. KMC is also responsible for providing transportation support to the DMCs for solid waste collection all over the city.
11	Sindh Environmental Protection Agency (SEPA)	P	Responsible for carrying out environmental impact assessments of development projects within the jurisdiction of Sindh Province. Any major development project with significant environmental impacts will have to go through a rigorous assessment process (IEE or EIA) under the Sindh Environmental Protection Agency Act, 2014.
12	District Municipal Corporations (DMCs)	L	Karachi is divided into 7 districts, each of which has a District Municipal Corporation (DMC), which are headed by Chairmen and Deputy Chairmen. The Sindh government transferred the functions of secondary roads, street lights, parks, basic health, education and local taxes from the KMC to the six DMCs in the city. DMCs are responsible for the associated roadside drainage totaling about 176 Km in length. Other roads are the responsibility of the town councils. DMCs have also the responsibility to maintain proper garbage and sewerage systems to keep the city clean and ensure environmental safety.
13	WWF-Pakistan, IUCN-Pakistan	O	The two largest international NGOs in Pakistan working for biodiversity conservation and environmental protection. Carry out a large number of projects to examine the relationships between environmental degradation, socio-economic development and poverty. Selected research projects on waste in the coastal areas and plastic pollution.
14	Informal recycling sector (waste-pickers/ collectors, waste buyers, recyclers)	O	Up to one-third of the city 's solid waste is separated and recycled through informal processes with support of these poor communities. Overall, in Karachi, nearly 55,000 families are estimated as dependent on the informal solid waste recycling industry for their livelihood.

IN 2019, PAKISTAN BECAME ONE OF 128 COUNTRIES WITH A SINGLE-USE PLASTIC (POLYTHENE) BAG BAN IN PLACE. PAKISTAN'S BAN HALTED THE PRODUCTION OF 600,000 KILOGRAMS PER ANNUM.

5.4 Uptake and Implementation of the GPAP (Global Plastic Action Plan) in Pakistan

Pakistan joined the Global Plastic Action Partnership (GPAP) in 2021. Pakistan is all set to establish a five-year plan that would be launched in the mid of 2022, aiming to fight the root causes of plastic generation and pollution. It certainly involves monitoring at the production stage, ways to minimize its usage, recycling techniques, etc. The Government of Pakistan is aiming to expand its Clean Green Pakistan vision by achieving success in upcoming projects.

In 2019, Pakistan became one of 128 countries with a single-use plastic (polythene) bag ban in place. Pakistan's ban halted the production of 600,000 kilograms per annum. The success of the ban depended on both awareness of the ban, created by Ministry of Climate Change-led educational campaigns for citizens and manufacturers, the free distribution of alternative bags, and media coverage of strict enforcement measures taken by the Pakistan Environmental Protection Agency (EPA), as well as access to cheap alternatives achieved by the identification of indigenously produced reusable bags. Importantly, however, the EPA began to regulate violators at both the consumer and manufacturer level, thus changing behavior. These efforts got results. A survey conducted after a year in September 2020 showed that 80% of the participants felt that the ban had increased their knowledge of plastic pollution. Thanks to regulation, the survey showed that all of the retailers interviewed had shifted towards using alternative bags.

Pakistan is committed to identifying and prioritizing innovative, systemic solutions that tackle plastic leakage across the entire value chain and that support the development of a fair and inclusive society. The Clean Green Pakistan Index (CGPI) is a case in point. The CGPI, launched in November 2019, seeks to improve sanitation services across Pakistan through healthy competition among the cities and citizens. The Index comprises more than 35 performance indicators on five components including solid waste management, against which cities are ranked annually. The indicators were designed and finalized with the municipalities, and targets were set by them ultimately targeting improved governance and enhancing the credibility of data collected. Citizens participate in the competition through an ICT-based champions program that records voluntary actions to keep the cities clean, improve civic amenities, and create in them the spirit and sense of owning their habitats and cities. Top-performing cities and citizens are rewarded by the prime minister to boost morale and sustain continuous improvement. After the successful pilot, the competition was expanded to all provinces and regions (93 cities), ensuring public sector capacities are built to achieve a clean and green Pakistan.

In another example, Pakistan is exploring new coding systems that will facilitate the recycling of post-consumer plastics, providing an opportunity for manufacturers with a consistent system for resin identification. Pakistan has also identified Extended Producer Responsibility (EPR) as an effective measure to stem plastic pollution. EPR is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Pakistan with the support from the EU Swith Asia program-initiated baseline assessment and contextualized the mechanism for local adoption. However, EPR schemes aimed at minimizing plastic waste streams do not function as a standalone policy and, to be effective, need to be flanked by effective monitoring, as well as other economic incentives such as taxes. In addition, building local capacities is also identified as a priority for the effective rollout of EPR.

Pakistan's "Green Stimulus" was designed to offer livelihood opportunities for virus-idled daily wagers, including women and youth, and therefore focus on the dual objective of protecting nature and creating green jobs. The program's focal areas for intervention have included planting more trees, and expanding and reviving our protected areas, but it has also concerned itself with improving urban sanitation – all of which can generate employment while also allowing the country to emerge from the crisis on a nature-positive pathway. The Clean Green Pakistan Movement was reconfigured as a part of the package to offer labor-intensive sanitation jobs and run advocacy campaigns.

Engro Polymer & Chemicals (EPCL) has become the first affiliate member from Pakistan to join the World Economic Forum's (WEF) Global Plastic Action Partnership (GPAP), as part of its sustainability efforts to promote the circular economy and contribute to achieving zero plastics waste. EPCL is a subsidiary of Engro Corporation, which is a strategic investment of Dawood Hercules Corporation, the partner level company of World Economic Forum.

5.5 Local NGOs and Initiatives in the Karachi Region

- The non-profit organization 'United Nations Association Pakistan (UNA Pakistan)' launched the 'Road to Recycle' project, a 1-year initiative aimed at recycling used cooking oil, a waste that contributes to more than 50% of oil waste that leads into the ocean.

- Trashit – a social enterprise that operates in recycling, compost production, zero-waste manufacturing, and sustainable home solutions

- NJC delivers a wide variety of Waste Management solutions to commercial and residential areas throughout the country. We operate collection services in every type of environment from large urban to remote rural areas. NJC collects all types of refuse, using a variety of containers (bins) and refuse collection vehicles (RCVs).

5.6 Renowned Specialized Consultants with Local Knowledge

a) River Engineering and Construction: Techno Consultants, NESPAK

b) Environmental Assessment and Monitoring: Environmental Management Consultants (EMC), NESPAK, GEMS

c) Waste Management Assessment and Planning: Waste Management Company

.

6. RECOMMENDATIONS AND WAY FORWARD

6.1 The Context for Action

Based on a scientific study of plastic waste production in all coastal countries, Jambeck et. al (2015) estimate that annual plastic waste generation in Pakistan is 6.41 million tons, making Pakistan the highest plastic waste producer in South Asia. Even though there are 5,500-6,000 plastic recyclers in the country, the sector is largely unstructured, un regulated and operating in silos, further exacerbating the plastic waste problem. Even though most studies report that plastics account for nearly 10% of all the waste generated in Karachi, a recent study by WWF-Pakistan claim that plastics account for 60% of all the waste that enters Karachi's coastal waters.

Both global and regional awareness on plastics and its implications on the environment are still relatively new. Combating the plastic pollution issue in Pakistan requires enormous efforts at all levels. A supportive policy environment that discourages plastic production and use with a focus on incentives for plastics recycling is needed. Moreover, along with tangible technical solutions to finding alternatives to plastics and river/ocean clean-up initiatives, structured and targeted advocacy and awareness campaigns must be encouraged for action at the grassroots level.

With a population of over 16 million, Karachi is not only the commercial capital of the country, it also produces the highest quantity of solid waste-11,000 tons each day. A district wise analysis of the waste volumes produced in the city shows that plastics are the second largest contributor to the waste problem after organic kitchen waste. The challenges for tackling Karachi's plastic pollution problem are multiple a) reducing the use of plastic b) preventing plastics from ending up in the storm water drains, rivers, and coastal waters c) removal of plastics already accumulated in drains and water bodies.

6.2 Best-suited Locations and Types of Technology to Deploy

Site specific analysis reveals that there is plastic accumulation at all specified points, and it is impacting populations that are residing close to or near those areas. However, the population that is being most impacted are the residents of Shampsir, Baba and Bhit Islands. Not only are their livelihoods being affected, the plastics are also negatively impacting the waters, the aquatic life, and the mangroves. Furthermore, the flotsam and jetsum is detrimental to the ships and boats that are berthed at the harbor.

Based on the understanding that we have developed through the research and a brief review of available technologies, we recommend the following:

i. As discussed in the report, Orangi & Gujjar are the main two drains (nullah) carrying considerable solid waste directly falling into the Lyari river. In the rainy seasons, their flow rates are very high, which not only carries the flowing waste from the back areas but also burdens the existing accumulated waste into the river. Deep cleaning of these drains frequently is essential to enrich the effectiveness of any site-specific solution and restore the required flow in from these drains to the river, especially during the monsoon season. Replaceable sturdy nets installation at the mouths of the Orangi and Gujjar drains can enable catching the solid waste at source. Net catches the trash and plastic, and allows the water pass through easily into the Lyari river. This option can be helpful for the non-perennial river system which flows mostly in the rainy season.

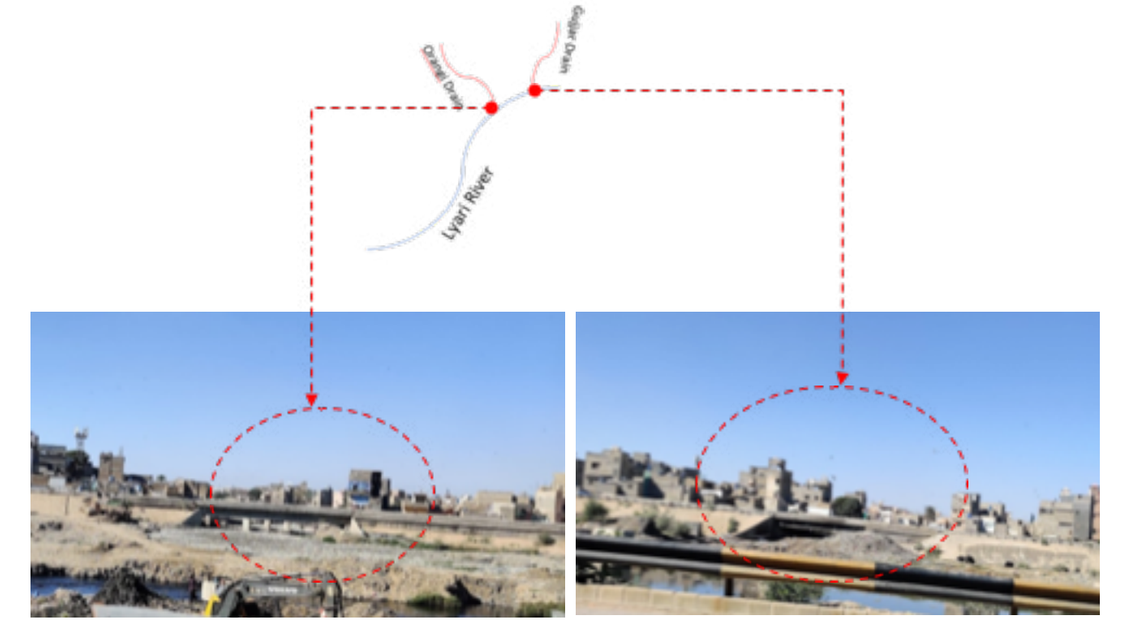


Image 6.1: Schematic showing the two main drains discharging in to Lyari River

Image 6.2 (a): Trash netting solution in Henley Reserve, Kwinana, Australia

Image 6.2 (b): Trash netting solution in Henley Reserve, Kwinana, Australia

Image 6.3- Stormx capture systems

Image 6.4: Box Culvert Net Techs

ii. In order to stop plastic from entering from dry land into the water stream particularly in areas where there is dense population, fencing is proposed. Out of the sites identified, this would be would be District West – Mauripur and Mewashah. We would not recommend a very technical solution in these areas. Lyari river passes in both these locations through areas that are highly populated and where the strip is not essentially being monitored by any authorities. Public sector ownership is necessary, and even if that is there, the cost of security could raise the cost of the project making in unsustainable. River banks are also inhabited by squatter communities that can potentially create problems. Protection of equipment and its upkeep could become a future challenge. The Lyari expressway is a 38km city district express way constructed along the Lyari River. The Lyari river is mostly fenced because of the Lyari expressway and due to this, solid waste open dumping is not possible till the Mauripur. However, from the Mauripur bridge to the Lyari river outfall, both sides are without fencing and majority of the surrounding people and bulk construction waste is directly dumped into the river. There should be fencing from Mauripur bridge to the Lyari river outfall which will prevent the solid waste open dumping directly into the river. The images below provide a graphical illustration of what fencing along this portion of Lyari River may look like.

Images 6.5 (a, b): Proposed Fencing between Mauripur Bridge and Lyari River Outfall

iii. Given the huge volumes of plastic waste surrounding the island communities (Shamspir, Baba and Bhit) in the harbor, bringing about a solution for the island communities should be a priority. It would alleviate the negative impact of plastic pollution on the lives of the fishermen community living there. The communities are literally living around mounds and mounds of plastics accumulated over many years. Boats in the harbor area propel by using petrol or diesel engine. As part of the solution, one suggestion could be replacing the propelling agent with solar- powered batteries that harness the suns' energy – this can help as part of moving towards environmental sustainability. That solar boats will get their energy from the sun by using solar panels and storage batteries to transform sunlight into electrical power, which powers the boat. It's also an economically friendly solution for the dwellers of the harbor area and will also reduce the carbon footprint in the harbor area.

Images 6.6 (a, b) Proposed solar boats for daily commuting between the islands.

iv. Removing plastics from mangroves should be part of the solution as well. During the course of the study, the team noticed large volume of plastic bags stuck in the roots of the mangroves. According to the local folk, this has become a common phenomenon in the western backwaters and no effort is made to protect these forests from aggregation of plastic waste. Mangrove forests are not only a hedge against climate change disasters and nurture a diversity of flora and fauna, but are also a source of livelihood for coastal communities. The solution should also help stop plastic from entering the mangroves area either building barriers for collection there.

v. As mentioned in section 3.3, KPT is manually removing 2.5 Metric tons of waste every day from the harbour area. Any activity undertaken in this area would help to clean the harbor area (and will only add, assist and amplify KPTs efforts to (particularly) MPCD's efforts to keeping the harbor waters clean. Additionally, installing a solution in this area would have more impact as it would also alleviate the negative impact of plastic pollution on the lives of the fishermen community living there. According to one interview that we conducted with the communities on Baba and Bhitt Island, we were told that when they lower their nets to catch fish, the net is often weighed down by what they mistake to be a catch, when sadly it is only a net weigh down by the weight of plastic bags and ocean debris. A skimming technology deployed in the harbor area can help in debris and trash removal from the waters. Additionally, the creation of a waste & recycling value chain is critical to ensure the sustainability of the solution.

6.3 Potential Waste Disposal Methods and Locations

- Currently, two landfill sites are available for solid waste management. The area available at these sites is not adequate to fulfil the landfilling of waste generated in the city. However, the SSWMB already has plans to develop a third landfill site at Dhabeji of 3,000 acres and improve the capacity of several garbage transfer stations.

- Designated waste collection points should be developed in each Mohalla, and these should be purpose-built for waste collection.

- Source segregation should be adopted thereby providing independent containers for organic fraction and recyclables. This will assist primary recycling industries and the development of facilities for biofertilizer production such as compost.

- Providing separate bins for recyclable waste and disposable waste.

- The organic fraction of municipal solid waste from household and fruit and vegetable markets can be used as feedstocks for renewable energy production and biofertilizer.

- The local dwellers are fully aware with areas of the Karachi harbor. They have been settled for many decades in the Karachi harbor area. They have local expertise to move their small boats in the mangrove areas and narrow channels and creeks. They are more aware, where solids waste gets accumulated in the harbor areas. They can easily take their small boats in the everywhere of the harbor areas. They can not only clean the harbor but they can be their long-term cleaning custodian because of their permanent residences in the islands.

- Use of compostable bags instead of single use plastic for the preservation of the fish after catching in the islands. Compostable bags prepared by using material that completely degrades in open environment after certain period of time.

Image 6.8 Proposed compostable bags for the preservation of the fish catch

REFERENCES

• http://www.pppunitsindh.gov.pk/downloads/projects/urban_road/mauripur/EIA_Report.pdf

• https://geistscience.com/JESS/Issue2-16/Article4/JESS1604205.pdf

• https://www.trade.gov/country-commercial-guides/pakistan-waste-management

• https://www.dawn.com/news/1477373/environment-how-plastic-is-killing-us

• https://www.pk.undp.org/content/pakistan/en/home/blog/2020/the-good--the-bad-and-the-ugly-of-plastics-in-pakistan.html

• https://archive.pakistantoday.com.pk/2019/03/14/the-looming-plastic-pollution-crisis/

• http://arifhasan.org/wp-content/uploads/2012/04/193_KALPANA_Paper16Oct08.pdf

• http://www.pmd.gov.pk/cdpc/Pakistan_Climate_2020.pdf

• https://www.dawn.com/news/1578061/why-karachi-floods?fbclid=IwAR0jmOqhBfygF2svoZOE3iB6L0tet5TKLv9VUNbck-Yax2_WdYB1UUU8dMs

• http://www.opp.org.pk/why-karachi-drowns/

• https://fp.brecorder.com/2019/09/20190918518668/

• http://www.kmc.gos.pk/contents.aspx?id=14

• https://www.dialoguepakistan.com/karachis-uncontrollable-plastic-monster-facts-figures-and-solution/

• http://sswmb.gos.pk/cms/

• https://www.unescap.org/sites/default/files/SWM-COMPLETE%20REPORT%20KARACHI%20%20%2012-Mar-13.pdf

• https://www.researchgate.net/publication/349944506_Solid_waste_management_practice_in_Karachi_through_GIS_techniques/link/60ab4c99a6fdcc6d626d3d7d/download

• https://worldpopulationreview.com/world-cities/karachi-population

• https://www.researchgate.net/figure/b-Dust-storm-is-moving-towards-Karachi-Source-NASA-2008-Satellite-sensor-MODIS_fig2_228652446

• https://www.researchgate.net/publication/282545123_Quantities_and_composition_of_shore_debris_along_Clifton_Beach_Karachi_Pakistan/link/5684c6c808ae051f9af0539c/download

• https://www.waste.ccacoalition.org/sites/default/files/files/swmglinesdraft.pdf

• https://www.trade.gov/country-commercial-guides/pakistan-waste-management#:~:text=Local%20and%20municipal%20governments%20are,in%20the%20cities%20is%20collected.

• https://tribune.com.pk/story/2285175/the-politics-of-garbage

• https://msdp.sindh.gov.pk/files/MSDP/Municipal%20Solid%20Waste%20management%20A%20case%20study%20of%20Metropolitan%20Karachi%20with%20lesson%20for%20Jacobabad.pdf

• http://www.cwejournal.org/pdf/vol13no2/Vol13_No2_p_232-241.pdf

• https://www.researchgate.net/publication/282545123_Quantities_and_composition_of_shore_debris_along_Clifton_Beach_Karachi_Pakistan/link/5684c6c808ae051f9af0539c/download

• https://eqa.unibo.it/article/view/11099/12229

• https://link.springer.com/article/10.1007/s13201-019-10049-y

• https://www.dawn.com/news/1510742

• https://www.idosi.org/mejsr/mejsr22(9)14/5.pdf

• Quantities and composition of shore debris along Clifton Beach, Karachi, Pakistan (Article in Journal of Coastal Conservation · July 2015)

• Solid waste management practice in Karachi through GIS techniques (Article · December 2021)

• Municipal Solid Waste Management and Waste to Energy in Karachi Pakistan (Aftab Ahmed 1, Arshad Hussain 1, Shehdev Thahrani 1, Sultan Ahmed 2, Abdul Qadeer Khoso and Bilal Soomro

• Journal of Pollution Effects & Control Plastic Pollution in Pakistan: Environmental and Health Implications

• Article in Journal of Pollution Effects & Control · May 2021

• The fast growing megacity Karachi as a frontier of environmental challenges: Urbanization and contemporary urbanism issues (Article · December 2010)

• https://d2ouvy59p0dg6k.cloudfront.net/downloads/report__situational_analysis_of_water_resources_of_karachi.pdf#page=13&zoom=100,92,97

• http://www.njcwaste.com/

• https://trashit.pk/

• https://una.org.pk/wp-content/uploads/2020/03/Project-brief-Road-To-Recycle.pdf

• http://www.ncpc.com.pk/

• https://news360.tv/en/pakistan/local-ngo-launches-cash-the-trash-in-karachi/

• http://sswmb.gos.pk/cms/

• https://www.engropolymer.com/press-releases/engro-polymer-chemicals-joins-the-world-economic-forums-global-plastic-action-partnership-to-promote-circular-economy/

• https://globalplasticaction.org/

• https://www.weforum.org/agenda/2021/11/4-ways-pakistan-is-tackling-plastic-waste-and-pollution/

• https://www.adb.org/sites/default/files/publication/663441/pakistan-river-ravi-eco-revitalization-master-plan.pdf

• https://www.nestle.pk/nestl-pakistan-joins-efforts-to-clean-up-korang-river

• https://www.wwfpak.org/?364921/Abandoned-fishing-gear-an-immortal-menace-which-must-be-central-in-the-fight-against-plastic-pollution-WWF-Report

• https://www.dawn.com/news/1527779

• The fast growing megacity Karachi as a frontier of environmental challenges: Urbanization and contemporary urbanism issues (Article · December 2010)

• https://d2ouvy59p0dg6k.cloudfront.net/downloads/report__situational_analysis_of_water_resources_of_karachi.pdf#page=13&zoom=100,92,97

• The documented Nalas and Drains map downloaded from SAMAA Archives from a Public dropbox folder - https://www.dropbox.com/sh/b1gorubv0zcuhv0/AABJBQipBu-UUdLBriXkatcja?dl=0&preview=Karachi+map+showing+documented+nullahs+and+drains+for+sewage-Karachi-MAP-SOURCE+CLICK-WB.pdf

Figure taken from:
https://d2ouvy59p0dg6k.cloudfront.net/downloads/report__situational_analysis_of_water_resources_of_karachi.pdf

Irfan, Muhammad & Kazmi, Jamil & Arsalan, Mudassar. (2018). Sustainable harnessing of the surface water resources for Karachi: a geographic review. Arabian Journal of Geosciences. 11. 10.1007/s12517-017-3365-6.

ANNEXURES

1. Karachi Harbour Map Bathymetry 2021
https://1drv.ms/u/s!AsNhSZKKR1OXhJdMtE8eHmkT7y4XBA?e=llZfxS

2. Karachi Nautical & Navigation Map 2021
https://1drv.ms/u/s!AsNhSZKKR1OXhJdLh-qKoEu-vvkEGg?e=eAdAaR

3. Karachi Tides Times and Heights of High & Low Water -2022
https://1drv.ms/b/s!AsNhSZKKR1OXhJdJWm5uONJjzZtUog?e=EvefgQ

4. Karachi Hourly Heights -2022
https://1drv.ms/b/s!AsNhSZKKR1OXhJdKcR8QcoUp7WYLZw?e=WujyET

5. Tidal Range Book 2022
https://1drv.ms/b/s!AsNhSZKKR1OXhJdNcHVOHoTwoh1LZA?e=BE6jEt

6. Karachi Tides Times and Heights of High & Low Water -2021
https://1drv.ms/b/s!AsNhSZKKR1OXhJdYfyt_6wnFTBOpmA?e=iesVyq

7. Karachi Hourly Heights -2021
https://1drv.ms/b/s!AsNhSZKKR1OXhJdXzoVfS3un8Ms8Gw?e=sDobGW

8. Karachi Harbour Bathymetry 1999
https://1drv.ms/b/s!AsNhSZKKR1OXhJdWSWDVp-yeCTrchw?e=jcCJuJ

9. Pictures Link
https://1drv.ms/u/s!AsNhSZKKR1OXhJYBVdN-D1KINKAs_Q?e=aP5bB4

10. PDF document integrated with all the links of videos surveys

11. Excel sheet with 10 years precipitation data for Karachi

Abbreviations

CGPM	Clean Green Pakistan Movement
DMC	District Municipal Corporation
GTS	Garbage Transfer Stations
GoP	Government of Pakistan
GoS	Government of Sindh
KPT	Karachi Port Trust
KW&SB	Karachi Water & Sewerage Board
KMC	Karachi Metropolitan Corporation
MPCD	Marine Pollution Control Department
MoCC	Ministry of Climate Change
NDMA	National Disaster Management Authority
NIO	National Institute of Oceanography
PMSA	Pakistan Maritime Security Agency
SSWMB	Sindh Solid Waste Management Board
SEPA	Sindh Environmental Protection Agency
WWF	Worldwide Fund for Nature

LIST OF TABLES

LIST OF FIGURES

LIST OF IMAGES

LIST OF SURVEY VIDEOS

https://bit.ly/ListOfSiteSurveyVideos

2. **Depths** in meters and are reduced to Chart Datum, which is approximately the level of lowest astronomical tide. **Heights** are in meters underlined figures are drying heights in meters and decimeters above Chart Datum; all other heights are above Mean Sea Level. **Positions** are related to the World Geodetic System 1984 Datum; **Navigational** marks Maritime Buoyage system region-A (Red to Port)


THE
Coca-Cola
COMPANY
Pakistan &
Afghanistan
Region
world without waste
SEED