

## **Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim**

**Final Report**

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# **Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim**

## **Executive Summary**

### **1. Introduction**

Port Qasim in Sindh, Pakistan was established in early 1980s as an alternate to Karachi Port with the added feature of an associated industrial area. The International Finance Corporation (IFC), the private sector arm of the World Bank Group (WBG), has invested in four port terminals and one industrial project in Port Qasim. As Port Qasim Authority (PQA), the federal government agency mandated to manage the port and associated industrial developments, has plans to develop the port further, and the IFC may invest in these.

Environmental and social impacts from existing developments combined with the incremental impacts resulting from proposed future developments, may result in significant cumulative impacts that would not be expected in the case of a stand-alone development. IFC has acquired the services of Hagler Bailly Pakistan (Pvt) Ltd (HBP) to conduct an Ecosystem Service Review (ESR) and a Cumulative Impact Assessment (CIA) for the existing and planned developments at Port Qasim.

The PQA undertook a strategic environmental assessment as part of the strategic planning study in 2001.<sup>1</sup> Since the completion of the study, developments have taken place in Port Qasim area and in surrounding areas. The present Study will thus augment the previous PQA study.

This document provides a summary of the CIA of the planned developments at Port Qasim up to 2050.

#### **1.1 Objectives and Limitations of the CIA**

Environmental and social impact assessment (ESIA) is now an established tool, a mandatory requirement in almost all the countries in the world, for assessing the environmental and social impacts of development projects. The emphasis of ESIA is on the impacts of a single project. Even if all the projects in a geographical location are studied through their respective ESIA studies, they fail to adequately capture the how these individual projects collectively change the environment. Cumulative effects can be additive, or interactive and can result in exceedances of environmental thresholds. The overall objectives of a cumulative impact assessment studies are as follows:

- ▶ Ensure that the cumulative effects of future developments do not exceed a threshold that could compromise the sustainability of Valued Environmental and Social Components (VECs).

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<sup>1</sup> Engineering Consultants International (Pvt.) Ltd., Strategic Planning Study for Port Qasim, Volume 5, Strategic Environmental Assessment, June 2001.

- ▶ Ensure that the value of Port Qasim and feasibility of future developments are not limited by cumulative social and environmental effects.
- ▶ Support the development of regional governance structures for decision making and managing cumulative effects.

The aim of a CIA study is not to assess all impacts of all Projects. The project EIAs address all impacts of a specific Projects. Under Good International Industry Practice Guidelines (GIIP) such as the IFC GPH on CIA a VEC-centered approach is utilized for CIA where impacts on prioritized VECs are considered and addressed. The prioritized VECs include the following:

- ▶ Mangrove Ecosystem and Biodiversity (Mangrove and Mudflat Habitat, Fish, Shrimp, Crab, and Marine Mammals)
- ▶ Livelihood Associated with Mangrove Ecosystem
- ▶ Air Quality

Baselines as part of CIA are limited to determining the status of a VEC, and are typically on the basis of previous baseline studies already carried out. Data in previous baselines did not completely or uniformly characterize the PQA Notified Area, and in some cases quality control information was not available (e.g. for water quality). IFC funded limited field sampling to fill the major gaps and ensure a coordinated data collection methodology. While sampling was limited, the result of the exercise is a more comprehensive and coordinated baseline for the Port Qasim area, compared to previous EIA studies at or close to Port Qasim.

The Study time was originally limited to 4 months, and due to some limitations, the Study was initiated just before start of the Summer Monsoon. The scope of analysis, did not also, then allow collection of seasonal data, temporal data and other aspects, such as bird surveys. Access to areas within the intertidal delta (including, and particular, to the islands) was also limited initially. However, the study time was extended to incorporate sampling of mangroves. Study times were also extended to cater for multiple important meetings and discussions with the Port Qasim Authority, the key stakeholder, on the management and mitigation of impacts.

## 1.2 Port Qasim and Regional Developments

Cumulative effects are those that result from the incremental impact of a project or *developments* when assessed in combination with other *existing* and *reasonably foreseeable future developments* or other activities in a rationally set geographical and temporal scale.

**Exhibit 1** shows the layout of the ‘Study Area’ selected for this study. The land under the jurisdiction of PQA comprises three industrial and commercial zones (Northwestern, Southwestern and Eastern Zones), the Port Area and a recently demarcated LNG Zone. The total area of these zones is in excess of 7,200 hectares. The term *Developments* is used for “the existing, anticipated and reasonably foreseeable developments in the Notified Port Area and PQA Industrial Zones.” Where existing refers to fully constructed industrial facilities in PQA, anticipated includes under construction or planned developments, and reasonably foreseeable developments includes developments that has

been discussed in policy documents, strategies, or development plans and are plausible and likely.

According to the PQA, all the available plots in the land development zones have been acquired by various investors. Approximately 273 projects are operational within the Port Qasim, with another 233 under construction. These include development of a textile city and new power plants.

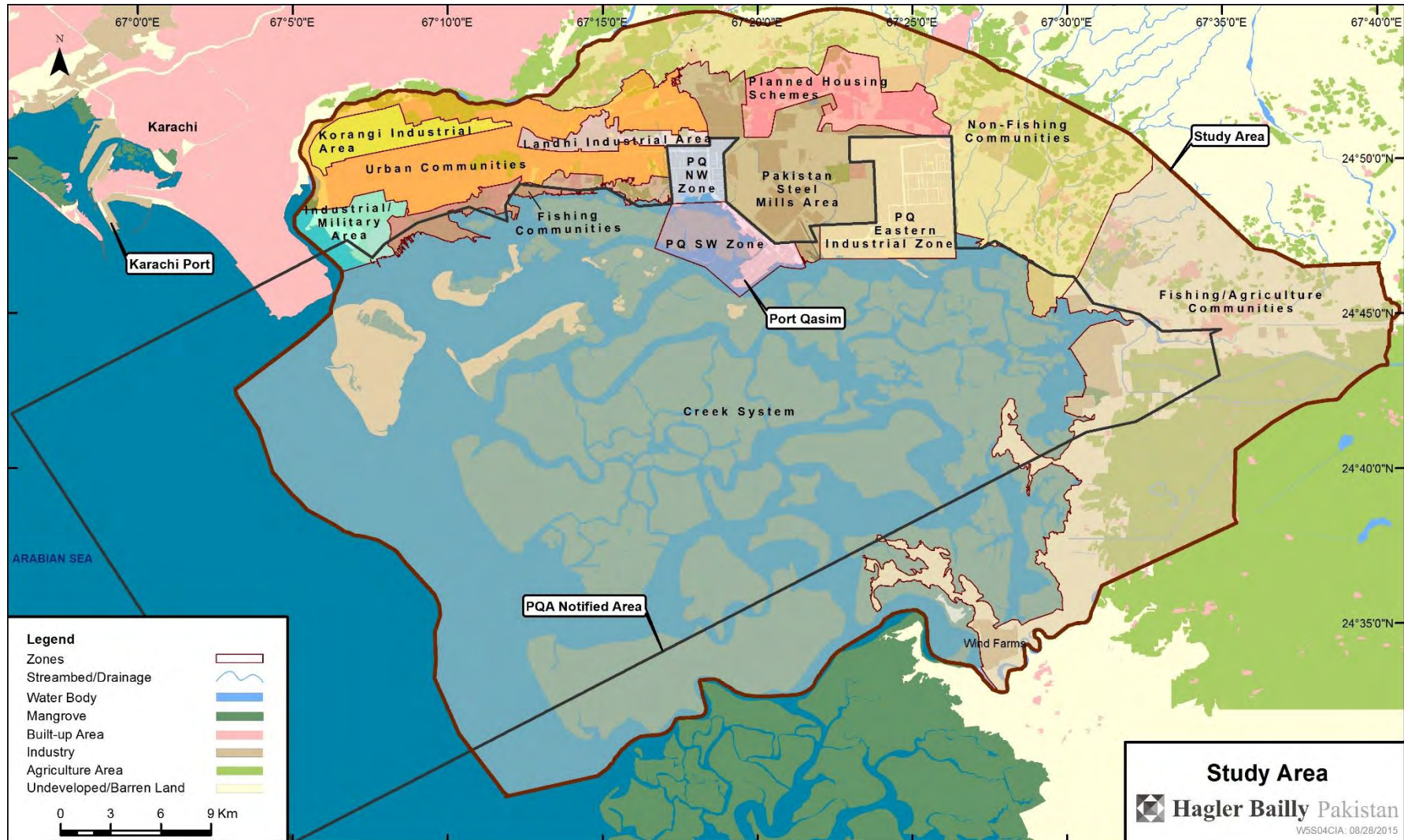
The current industrial activities within the three zones include production of downstream steel products, textiles, petrochemicals, food products, fertilizer, and automobiles. Other activities include grain, fertilizer, bulk, liquid, LPG, and container terminals. A 1,320 MW power plant that will utilize imported coal offloaded at Port Qasim is under construction.

There are plans to expand the port facilities to accommodate larger vessels and increase the cargo handling capacity of the port. These include widening and deepening of existing channels and construction of additional floating terminals.

Reasonably foreseeable developments exist largely outside the current land development zones and include development of a new alternate channel, development of LNG terminals; developments at Bundal and Khiprianwala Islands; land acquisition for additional industrial units; and land reclamation.



**Exhibit 1: Study Area**



Major projects in the vicinity of the PQA industrial zones, which are not located on land under the jurisdiction of PQA but share resources or infrastructure include Pakistan Steel Mills, K-Electric Power Station, Landhi and Korangi Industrial Areas, and Pipri Railway marshaling yard. The anticipated projects in the vicinity of the PQA industrial zones include Lucky Cement Coal-fired Power Plant, partial conversion of K-Electric Power Station to coal, and wind farms located south of Port Qasim (**Exhibit 1**).

### **1.3 Development Scenario**

The CIA, development scenario considered for the CIA is summarized below. The Port Qasim Strategic Plan outlines the plan for development of Port Qasim till 2050. Year 2050 has been selected as the time horizon for the CIA.

#### **1.3.1 Port Qasim**

The PQA has achieved many of the targets set in the Strategic Plan for 2010. It is therefore assumed that in 2050, development of PQA will be largely in line with what has been outlined in the Strategic Plan. However, there have been some recent deviations from the Strategic Plan to cater for market demand and pressures. Some of the limiting factors in the development at the Port include:

- ▶ Development of Gwadar Port and expansion plans at Karachi Port will compete with Port Qasim.
- ▶ Additional coal import facilities are unlikely to be developed at Port Qasim due to development of the Thar Coalfields.

Given the addition of an LNG terminal at the Port, there is requirement for an additional navigational channel. The additional navigational channel is likely to be economically feasible and a requirement for Port operations and management of ship traffic in the future.

#### **1.3.2 Regional Developments**

Port Qasim is in the backdrop of Karachi city. Karachi has seen rapid population growth since the 1947. The city has seen development of land at a proportional rate. While rural communities around PQA have been incorporated in the city, new housing societies are developing or are planned north of Port Qasim. It is assumed that by 2050, all the undeveloped land in the housing societies will be occupied and further societies will be developed to the northeast of the PQA.

National Highway N-5 is currently a dual-carriage 4-lane highway. There is room for additional lanes on both sides of the highway. However, it is assumed that the principal highway connecting Karachi with upcountry will be the Motorway M-9. Therefore, N-5 is unlikely to expand by the same rate as the M-9.

## **2. Stakeholder Consultations**

Scoping consultations and surveys were conducted from June 10 to 14, 2015, along with multiple ad-hoc scoping and management and mitigation consultations between July, 2015 and December 2016. The consultations included two key workshops where

feedback on scoping, baselines and impact assessment, management and mitigation were provided by stakeholders:

- ▶ Preliminary Workshop in June, 2015
- ▶ Main Workshop in February, 2015

Key institutional stakeholders consulted during separate consultations and/or during consultative workshops included the Port Qasim Authority, selected industries at Port Qasim, Bin Qasim Association of Trade and Industry (BQATI), WWF-P, IUCN, Marine Fisheries Department (MFD), Sindh Fisheries Department, Sindh Wildlife Department (SWD) and the Sindh Forest Department (SFD).

The discussions with the community members (particularly Fishing Communities and Fishing/Agriculture Communities) focused on determining the perceptions of the local communities on the Developments and their dependence ecosystem services in Study Area. The community stakeholder consultations were conducted within settlements to ensure, encourage, facilitate, and maximize participation. A summary of issues raised by stakeholders is provided below:

- ▶ Issues raised by the industry included lack of strict adherence to zoning plans by PQA which has resulted in conflicts between present owners and new developers; limited environmental management capacity in PQA particularly with respect to implementation of recommendations of the CIA study; weaknesses in EIA review and approval process followed by the Sindh Environmental Protection Agency (SEPA); limited involvement of PQA in the EIA review and approvals, and absence of a grievance redress system to resolve conflicts among owners, and between owners and PQA.
- ▶ Industry and universities also expressed the need for conducting hydrodynamic and ecological studies to understand the impacts of changing sedimentation patterns on the depth of port channels and on the ecology of the mangroves.
- ▶ WWF-P and IUCN highlighted the importance of the mangrove ecosystems in terms of biodiversity and their ecosystems services, and expressed serious concern on the overall decline in mangrove ecosystems in Sindh associated with decline of freshwater flows and sediments into the Indus Delta. WWF-P cited studies which have shown a decline in diversity of fish in the mangrove areas, particularly shark species, and in mangrove species due to hyper saline conditions and increasing pollution. These institutions also pointed out the absence of well-defined institutional responsibilities and mechanisms for management of the mangrove ecosystems, and limited availability of land suitable for plantations.
- ▶ Both WWF-P and IUCN expressed reservations on the approach adopted towards mangrove plantations by the industry to compensate for loss of mangroves.
- ▶ Stakeholders said that plantations are not a replacement of functioning ecosystems and that mangrove plantations, as offsets, could be carried out on an on-going basis and planted in advance before removal of mangroves.

- ▶ Significant legacy issues persist associated with PQA's perceived mishandling of relocations between 1972 and 1982, in relation to restoration of housing and livelihood when Port Qasim was established.
- ▶ The Fishing/Agriculture Communities located east of Port Qasim complained of use of illegal and destructive fishing methods by the fishermen coming in to fish from west of the Study Area. Conflicts between the two communities have resulted in an incidence of loss of human life.
- ▶ The communities, the industry, and the NGOs believe that discharge of untreated effluents from PQA and other areas results in degradation of the seawater leading to declines in fish population in creeks, which in turn affects the livelihood of the local fishermen.
- ▶ The fishing community stated that PQA disposes the dredged material in the creeks, away from their shipping lanes, resulting in increase in sea water turbidity, affecting fish population and consequently the livelihoods of fishing communities. They also stated that disposal of dredged material in the creeks reduces depth, and makes navigation difficult for the fishermen.
- ▶ The fishing community stated that PQA has restricted their movement in the main PQA navigation channel and declared the shipping channel a formal exclusion zone where fishing is prohibited, thus limiting their livelihoods.
- ▶ The fishing community stated that the jetties within Korangi Creek inhibit access to fishing grounds, along the eastern edge of Korangi Creek.
- ▶ Key respondents from all the consulted communities identified poor educational infrastructure as the major cause of their poor socioeconomic conditions.
- ▶ Both the communities and the industry expressed the concern that the development of PQA industrial zones has greatly affected the ambient air quality due to pollutants released in the air by the industries, affecting health of the communities.

### **3. Environmental Baseline**

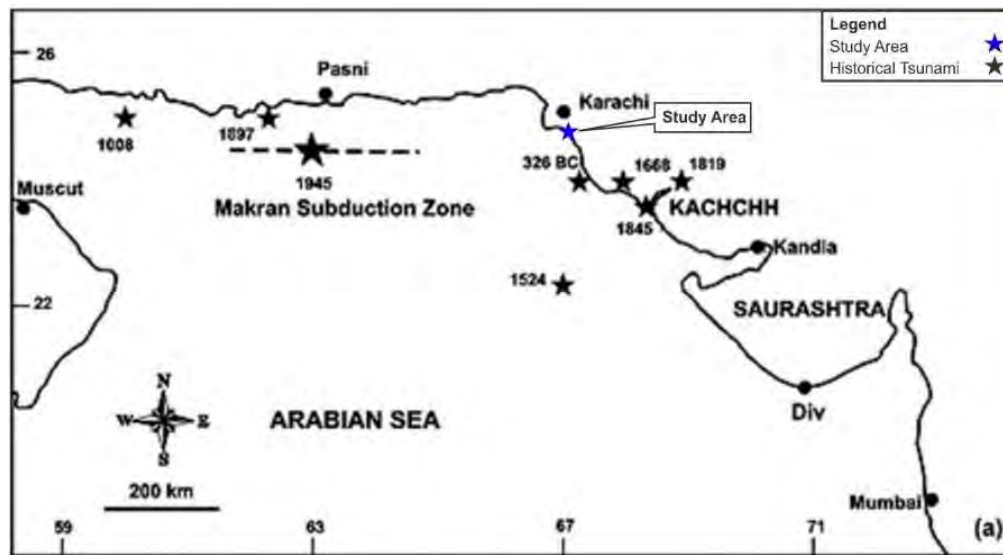
#### **3.1 Physical Baseline**

The baseline study relied on review of literature, previous ESIA reports prepared for projects in the Study Area, and sampling surveys conducted as a part of this study. Port Qasim is located on the northwestern fringe of the Indus Delta system. It is the fifth largest delta of the world, formed by the river Indus and tidal creeks. The majority (29%) of the Study Area is occupied by channels and creeks. Mangroves and mudflats/beaches occupy 19% and 10% of the Study Area respectively, while 19% is barren land. Agricultural areas occupy 9% of the Study Area, whereas 6% and 7% of the Study Area comprises industrial and commercial areas (including Port Qasim) and built-up residential areas, respectively.

### 3.1.1 Tsunamis

The coast of Pakistan is in an area of potential tsunami. While large tsunami genetic earthquakes have been relatively rare, there is potential for a tsunami associated with the Makran Subduction Zone (MSZ) or smaller localised tsunamis associated with several smaller thrust faults around Karachi (see **Exhibit 2**). The relatively recent tsunami generated along the MSZ in 1945 was responsible for 4,000 deaths, and destruction along the sparsely populated coast of Pakistan.

**Exhibit 2:** Historical Tsunamis Generated in the Region (up to 1945)<sup>2</sup>



### 3.1.2 Storms and Cyclones

Severe storms and cyclones seldom cross the coast of Pakistan. The main cyclonic activity in the Study Area takes place in the month of June. All the cyclonic storms that emerge in the Arabian Sea either curve sharply into the Gulf of Kutch or cross the Arabian Sea from East to West and end up at the coast of the Arabian Peninsula. When the cyclones cross the coast they are accompanied by storm surges, generally known as storm tides. The cyclones that cross the coast in the month of June generate winds of approximately 15-18 m/s.

### 3.1.3 Air Quality

The current air quality is influenced by a number of factors. These include industrial activities in PQA; activities outside the PQA Area, such as the Pakistan Steel Mill, the K-Electric Bin Qasim Power Plant; road traffic particularly the National Highway N-5; industrial emissions from Korangi and Landhi; domestic emissions from homes using biomass as fuel and natural wind-blown dust.

The air quality baseline study relied on analysis of secondary data and modeling of emission sources. There was insufficient time to collect primary data as this would have

<sup>2</sup> Shukla et al. "Coastal Geomorphology and tsunami hazard scenario along the Kachchi coast, western India" (2010)

required a year round baseline study. The number of active industrial units within PQA Industrial Zones is estimated to be about 168.<sup>3</sup> Fuel combustion is the predominant source of emission in these units. Residual Fuel Oil (RFO), natural gas and diesel are the main fuels used. Emissions include oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>) and particulate matter (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>).<sup>4</sup> The available historic data spanned a period of 2004-2015 and consisted of short-term (mostly one-day) measurements at 34 locations across the PQA. Results of the analysis are summarized below.

- ▶ The concentration of pollutants at all locations sampled is below the limits prescribed by national and international guidelines and standards including the Sindh Environmental Quality Standards (SEQS) and those of the International Finance Corporation (IFC).
- ▶ The reported concentration of all pollutants (NO<sub>x</sub>, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub>) along the coast is higher in 2004-2010 as compared to 2011-2015. The reason for the decrease in the amount of pollutant is not clear and needs further research.
- ▶ The concentration of key pollutants including (NO<sub>x</sub>, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub>) along the sea coast is higher than the eastern and western industrial zones of PQA Area. This is because of the major port operational activities are taking place along this sampling site.
- ▶ The concentration of particulate matter is nearly same in all data sets. Elevated concentrations of PM is a common occurrence all over Pakistan and is attributed to dry conditions and natural wind-blown dust.

As part of the impact assessment, all the existing sources of gaseous emission in PQA and vicinity were modelled. The simulation of the current emissions largely confirmed the results of the analysis of the historic sampling data. However, the model also suggested that the concentration of NO<sub>x</sub> and SO<sub>2</sub> in the ambient air may already be exceeding the target limits (IFC ambient air quality guidelines in this case as it is more stringent than the SEQS for ambient air). The area in which the limits are exceeded is relatively small, which also explains why it has not been captured in any measurement.

### 3.1.4 Seawater Results and Analysis

The conductivity-temperature-depth data shows that there is little variation along the profile at each site. While this indicates a well-mixed tide dominated system, the salinities are all above 35 practical salinity units (psu) showing that this is primarily seawater with little or no freshwater input.

The levels of arsenic show a spatial trend. Concentration of arsenic at a reference site located further away from Port Qasim was 1.9 micrograms per litre (µg/L) compared to locations closer to the areas where industrial and municipal wastewater is discharged into the creeks where it ranged from 2.4 to 3.7 µg/L. The average concentration of arsenic,

<sup>3</sup> For the purpose of gaseous emission, *active* units are defined as process industrial unit that are emitting gaseous pollutants. The information is based on satellite image analysis and field verification.

<sup>4</sup> The particulate matter is classified on the basis of particle size as follows: total suspended matter (TSP) contains particles of all sizes; coarse respirable particulate matter containing particles of diameter 10 microns or less (PM<sub>10</sub>), and fine respirable particulate matter containing particles of diameter 2.5 microns or less (PM<sub>2.5</sub>).



copper and zinc in the 2015 conducted for this study and sampling conducted by HBP as a part of another EIA were all higher than the concentration at the reference site of 2015. This corresponds to the higher concentration of the heavy metals found in the fish liver and tissue samples compared to permissible limits and the reference site for analysis of fish tissue. Oil and grease, TPH and CN were not detected in any sample. No major differences were found in the analyzed samples for the pH, turbidity, alkalinity, nitrates (except higher at one location), nitrites, phosphorus, phosphate, sulfate, bromide, fluoride and chlorides.

Total coliforms were detected too numerous for count in the seawater samples. However, Faecal *E. coli* and Faecal *Streptococci/Enterococci* were not seen in the analyzed samples.

The relatively good quality of the ambient seawater is likely because of the following:

- ▶ the locations are east of Phitti, Gharo and Korangi Creeks
- ▶ the tidal prism within the Study Area is very large, particularly compared to wastewater flows, therefore diluting the wastewater
- ▶ enhanced mixing and, therefore, dilution of wastewater discharges due to Summer Monsoon winds<sup>5</sup> when sampling was carried out

Regardless of the good mixing and dilution within the estuary, at least during Summer Monsoon, heavy metal contamination is evident within fish tissue and liver (see **Section 3.2.5**).

### 3.1.5 Wastewater Results and Analysis

Sampling conducted by HBP in 2014 for drains carrying effluent from the Eastern Industrial Zone of PQA where bulk of the PQA heavy industry is located showed that all the parameters were within the Sindh Environmental Quality Standards (SEQS) limit and IFC General Environmental, Health and Safety Guideline indicative values for treated sewage discharges (IFC EHS guideline), which is indicative of the pollution levels in wastewater discharged by the industry in the PQA Area.

Sampling carried out for this study in 2015 showed that the total dissolved solids (TDS) were highest in K-Electric drain<sup>6</sup>. TDS were recorded at 41,790 milligrams per litre (mg/L), which does not exceed the SEQS limit of 3,500 mg/L above the concentration of the seawater source. The TDS concentration in wastewater carried by major freshwater streams draining effluents from the other industrial and residential areas located west of Port Qasim exceeded the SEQS limit of 3,500 mg/L. However, the TDS levels were below those of the ambient seawater where the wastewater is discharged.

The maximum value of turbidity was observed at Bhains Colony drain, where it exceeded the SEQS. The concentration of all the nutrients was the highest at Bhains Colony with concentration of nitrate as 64.26 mg/L, nitrite as 8.74 mg/L, total phosphorous as

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<sup>5</sup> Turbulent boundary layer likely to be penetrating along depth due to high winds, as well during tides.

<sup>6</sup> Pakistan Steel Mills does not discharge into this drain, and largely reuses and recycles water on site, with some wastewater, including runoff, draining into Badal Nullah and Gharo Creeks during the wet season.

394.68 mg/L, orthophosphate as 174.25 mg/L and ammonia 1.89 mg/L, with the exception of sulfate which was higher at K-electric drain.

Cyanide concentration in Malir River, Bhains Colony drain, and K-electric drain were below the level of reporting. The bromide and fluoride concentrations were the highest at the Bhains Colony drain whereas the highest chloride concentration was observed at Pakistan Steel Mills drain. Water quality at all locations west of Port Qasim exceeded the SEQS limit for bromide and fluoride. For the Bhains Colony drain and Malir River, the total suspended solids (TSS) were 55 mg/L and 584 mg/L respectively, and above the IFC EHS Guideline of 50 mg/L. The total phosphorous at Bhains Colony was 395 mg/L compared to the IFC EHS Guideline of 2 mg/L.

The heavy metals that are of major concern on the basis of their toxicity even at lower concentrations are arsenic, cadmium, lead and nickel. The concentration of lead and nickel was in compliance with the SEQS at locations where sampling was carried out for heavy metals. The concentration of arsenic and cadmium was highest at the Bhains Colony drain. The concentration of cadmium exceeded the SEQS limit. The level of arsenic, cadmium, copper and zinc in Malir River and Bhains Colony drain were significantly higher compared to freshwater and seawater in the Study Area. This is of consequence, as the arsenic, cadmium, copper and zinc levels in fish tissue and liver were also observed to be elevated (see **Section 3.2.5**).

### **3.1.6 Ocean Currents and Tides**

Currents along the Indus Delta (based on measurements near Karachi) are bimodal. The current switches from south-westerly during the summer monsoon (May to September) to north-easterly during the winter monsoon (October to April). The tides in the area are semidiurnal, with tidal ranges in the area of about 2.7 m.

### **3.1.7 Waves**

The wave regime on the coast varies with seasons. During the winter season, when winds are around 5 m/s, the coastal waters are almost calm and the wave height is less than 1 m. During the southwest monsoons of the summer months, the winds are around 13 m/s and the waves on the coast are more than 3 m high and vary according to the nearshore depths and locations. In other months the waves are between 1.5 to 2.5 m.

### **3.1.8 Wave Induced Currents**

The longshore current is the littoral current in the breaker zone which moves essentially parallel to the shore. The current is usually generated by waves breaking at an angle to the shoreline. The value of longshore current in the Indus Deltaic region is about 1.0 meter per second.

### **3.1.9 Erosion and Sedimentation**

The abandoned channels of the Indus Delta have been reworked, through erosion and sedimentation by tides, into dendritic tidal creeks. The tidal creek network is most extensive and mature east of the present Indus mouths (Khobar and Ghaghhar creeks). In comparison, the deltaic coast closer to Karachi is dense and a less mature channel network. The stronger wave influence along this part is suggested by occurrence of



drumstick-shaped barrier islands typical of island systems significantly influenced by both waves and tides *e.g.* Khiprianwala Island.

In comparison to the shoreline along Phitti, Khuddi and Khai creeks, there are different dynamics within the creeks of the Study area. In addition to influence by waves and tides on erosion and sedimentation along the coast, erosion related to Developments at Port Qasim and ship wake associated with Port Qasim has been reported by the PQA. A comparison of mangrove extent along the banks of the current navigation channel and proposed extension using aerial imagery from 2014 and 2004 indicates the following:

- ▶ Along Kadiro Creek, where the channel is narrow, the net erosion per unit channel-length is  $48.6 \text{ m}^2/\text{m-channel}$ . There is up to 100 m of erosion of mangroves along the banks of this creek<sup>7</sup>.
- ▶ In front of the main Port Qasim bulk terminals where the channel is wider, the net erosion per unit channel-length is  $15.0 \text{ m}^2/\text{m-channel}$ .
- ▶ The channel is again wider moving eastwards where port extension is proposed, the net erosion per unit channel-length is  $15.5 \text{ m}^2/\text{m-channel}$ .

Lower net erosion is evident where the channel is wider. The channel in Kadiro Creek is narrow, where greater impact of ship wake is observed.

### **3.1.10 Sediment Quality Sampling and Analysis**

A total of nine sediment quality samples were collected from June 4, 2015 to June 8, 2015. The sampling locations were chosen considering marine ecosystem, port activities and wastewater inflows from the on-shore industry. All samples were taken from the channel bed, as access to islands (with mangroves) was not possible given conditions due to the prevalence of the Summer Monsoon. Total metals were analyzed in three samples from the Study Area. The observations from the results are as follows:

- ▶ Manganese and Strontium were detected at concentrations higher than three times its average crustal abundance in all samples and exceeded the sediment quality guidelines, target values and standards.
- ▶ Values of all other analyzed metals were below the reported guidelines or target values.

## **3.2 Ecological Baseline**

The baseline study relied on review of literature, previous ESIA reports prepared for projects in the Study Area, and sampling surveys conducted as a part of this study for mangroves, fish, and shrimp.

### **3.2.1 Mangroves**

Port Qasim is located on the northwestern fringe of the Indus Delta system, which is the fifth largest delta of the world. The area covered by mangroves in the Indus Delta is about 129,000 ha, which is about 97% of the total mangrove area in Pakistan. Of this, approximately 31,000 ha of mangroves are under the Port Qasim Authority, which is

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<sup>7</sup> The aerial imagery does not include area recently reclaimed by PIBT

approximately a quarter of the entire mangrove area in the country. A number of protected areas designated by the Sindh Wildlife Department are located in the proximity of the Study Area, of which the nearest and adjacent is the Keti Bandar North Wildlife Sanctuary located at a distance of approximately 22 km from the Study Area. The Indus Delta Ramsar Site also lies adjacent to the Study Area.

Historical records indicate that the distribution and extent of mangroves in the Indus Delta has changed significantly over the past several hundred years as the river has shifted its position. In more recent times, the reduction in fresh water flows due to diversions of water for agriculture is the main factor responsible for the extent and change in mangrove distribution. One source estimates that the mangroves in the Indus Delta have declined from approximately 600,000 ha in 1932 to just over 100,000 ha in 2010. Another estimates that over the three decades from 1980 to 2010, the rate of loss of mangroves in Pakistan has been over 2% per year, which is amongst the highest in South Asian countries. This is expected to threaten the long term sustainability of mangroves in the Indus Delta. Others factors affecting mangroves include pollution from industrial and municipal areas, dredging, felling of mangroves, encroachments of settlements around Karachi's mangroves, sea intrusion caused by sea level rise, dumping of waste, and over-exploitation of mangroves for fuel, fodder and grazing by camels. The dense mangrove cover in Pakistan has declined significantly due to multiple stresses since 1932. Recent trends since 2003, however, show a slight increase. There is greater persistence and regeneration of mangroves in the northwestern part of the Indus Delta -within the Study Area -compared to other parts of the Indus Delta. Possible reasons are low salinity and nutrient rich wastewater, as well as monsoon floods, flowing into the tidal creeks from from the Malir River catchment. Mangrove cover in Pakistan has changed the most as compared to the other countries, and mangroves in Pakistan remain critically threatened. The perception amongst policy makers and developers in Pakistan of mangroves as wastelands has resulted in large areas of mangroves being cleared.

Initiatives to restore up to 100,000 ha of mangrove forests have been taken in 2012 involving the Sindh Forest Department and the IUCN. However, it is unclear to what extent these initiatives have been successful. Mangroves enjoy a special legal status under the Forest Act of 1927, however for all practical purposes, the right of PQA to develop the mangrove area under its jurisdiction is recognized.

Based on a simplified approach, mangroves in the Study Area were classified as Healthy Mangroves with trees in good health and dense cover, Unhealthy Mangroves with generally reasonable health but sparse canopy, and Mangroves with Die Back with poor condition and very open canopy cover. Spatial and temporal analysis conducted on the basis of Google Earth™ satellite imagery and field sampling indicated the following:

- ▶ Healthy Mangroves are largely present along the banks of the creeks, whereas mangroves inland and further away from the banks tend to be Unhealthy Mangroves.
- ▶ Mangroves along the coast, closer to Port Qasim and to the areas that receive municipal and industrial effluents are healthier, possibly due to presence of fresh wastewater, fertilization by nutrients and better protection.

- ▶ Proportion of Unhealthy Mangroves is higher at Study Sites distal from Port Qasim. This could possibly be due to lower delivery of nutrients, a decline in both fresh water flows and sediment from the Indus Delta, and lower level of protection from fodder and fuel wood extraction.
- ▶ The mangroves in proximity to the Port Qasim and areas where municipal and industrial effluents are discharged into the sea have shown an improvement over time. This temporal trend reverses moving away from the coast towards the open sea.

Damage due to anthropogenic activities including collection of fodder and fuel wood was observed at all locations sampled in September 2015, but was higher at locations closer to the mainland. Evidence of insect and disease attack was observed at all locations sampled. Some of the observed harmful insects have the potential to cause damage to relatively large areas of mangrove forests. Seedling density was highest in Healthy Mangroves closer to Port Qasim, where abundance of snails was also observed. Analysis of Google Earth images from January 2011 to June 2015 show that dumping of dredged material resulted in the destruction of a significantly large area that was once covered by Healthy Mangroves.

The Study Area includes 35,546 ha (355 km<sup>2</sup>) of mangroves. To date loss of mangroves due to clearing and land reclamation is estimated at 448 ha (4.48 km<sup>2</sup>). In addition to this loss of mangroves due to erosion along Kadiro Creek over the last 10 years has been estimated as 44 ha. Mangroves covering about 120 ha (1.2 km<sup>2</sup>) have been buried under disposed dredging material. An additional 1,324 ha (13.2 km<sup>2</sup>) is planned to be cleared by 2050 as per PQA plans.

### **3.2.2 Marine Benthic Invertebrates (MBI)**

MBI organisms are a good indicator of ecological disturbances. While a clear link between sediment heavy metal and MBIs cannot be established, overall the Port Qasim Area creeks are a disturbed area, and therefore both species diversity and species richness are relatively low. Based on information available in previous ESIA's and secondary literature, none of the marine invertebrates species reported from the Study Area are threatened or included in the IUCN Red List of Threatened Species. Moreover, their distribution is not limited to any specific site or habitat type and is widespread.

### **3.2.3 Fish Diversity and Abundance**

The area supports a high diversity of fish species. A total of 126 marine species found at Ketī Bandar in a recent study are expected to be present in the Study Area. A total of 66 species were observed during limited sampling within the Study Area for this study. Anecdotal reports (WWF-P and Marine Fisheries Department) indicate the presence of 180 fish species in the Port Qasim area. The two species that occur in brackish water at Ketī Bandar are unlikely to occur in the Study Area as the brackish water zone has been much reduced due to a reduction in inflows of fresh water. Fish diversity was observed to be lower near Port Qasim closer to the shoreline, and improved within the creeks moving away from the shoreline. Possible reasons for this pattern are over fishing closer to the mainland, and higher levels of pollution from waste waters discharged into the sea.

### 3.2.4 Shrimp and Crab

Mud crabs were observed during low tide in the mudflats in June 2015. In addition, three species of crabs were collected in the sampling exercise carried out in September 2015 in the creeks in the Study Area. Three shrimp species were also collected during the same exercise.

### 3.2.5 Heavy Metal Contamination in Fish, Crab, and Shrimp

Based on studies carried out by HBP in 2008 at Port Qasim, arsenic (2.50 mg/kg) as well as cadmium (2.49 mg/kg) and zinc (134.0 mg/kg) were above limits prescribed by the FAO. In the case of fish tissue samples, only the concentrations of the arsenic were above the prescribed limit at both Ketī Bandar and Port Qasim (1.29 mg/kg and 1.50 mg/kg respectively). Comparisons of the two sites indicated that levels of heavy metals at the Ketī Bandar site were lower in the case of almost all heavy metals, for both liver and tissue samples. This was with the exception of silver in liver samples and mercury in tissue samples. The results indicate that the Ketī Bandar site had comparatively lower heavy metal pollution as compared to the Port Qasim site. Based on sampling and analysis carried out in 2015 as part of this study, arsenic was found to be slightly above the prescribed limit in one out of three fish tissue samples and above the prescribed limit in a crab sample. The results indicate that the fish tissue and liver contamination has occurred and there is bioaccumulation of heavy metals in the fish in the Study Area.

### 3.2.6 Marine Mammals and Reptiles

Fishermen interviewed in June 2015 during the ecology field surveys conducted for this study reported that they have seen turtles in the Study Area; however the evidence is anecdotal. Although there have been rare sightings of turtles of conservation importance in the Study Area, preliminary investigations show that these turtles do not use the Study Area for breeding or nesting.

Three cetacean species (Indian Ocean Humpback Dolphin *Sousa plumbea*, Bottle-nosed Dolphin *Tursiops truncatus*, and Finless Porpoise *Neophocaena asiaeorientalis*) have been reported from the Indus Delta. Kiani and Waerebeek (2015)<sup>8</sup> have recorded the presence of an important population of the Indian Ocean Humpback Dolphin *Sousa plumbea* in a number of creeks in the Indus Delta creek system including within the Study Area. The sightings have been reported from November 2005 and May 2009 (see **Section 5.6** of the **Ecological Baseline**). The Finless Porpoise is listed in the IUCN Red List as Vulnerable. While the Indian Ocean Humpback Dolphin has not yet been assessed by the IUCN, given the threats it faces its status is likely to be Vulnerable.

### 3.2.7 Avifauna

The mangrove habitats provide abundant food and shelter to a number of species of resident and migratory birds. The Ramsar site which is continuous with the PQA Study Area regularly supports more than 60,000 migratory waterfowl including some

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<sup>8</sup> Muhammad Shoaib Kiani and Koen Van Waerebeek, A Review of the Status of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) in Pakistan. *Advances in Marine Biology*, Vol. 72, pp 201-228, Oxford: Academic Press, 2015,

threatened species like the Greater Knot *Calidris tenuirostris*, the Dalmatian pelican *Pelecanus crispus* and Marbled Teal *Marmaronetta angustirostris* all of which are listed as Vulnerable in IUCN Red List and the Painted Stork *Mycteria leucocephala* and Cinereous Vulture *Aegypius monachus* which are listed as Near Threatened. Other species include the Greater flamingo *Phoenicopterus ruber*, the Lesser Flamingo *Phoenicopterus minor*, the Wigeon *Anas phenelope*, Black tailed Godwit *limosa limosa*, Pochard *Aythya farina* and Common coot *Fluca atra*. Of the birds reported from the Korangi-Phitti Creek System, three are included in the IUCN Red List and listed as Near Threatened. These are Painted Stork *Mycteria leucocephala*, Black Tailed Godwit *Limosa limosa*, and Eurasian Curlew *Numenius arquata*..

### 3.2.8 Critical Habitat Assessment

Critical Habitats are areas with high biodiversity value. The Mangrove and associated mudflats and creeks within the Study Area qualifies as Critical Habitat in alignment with IFC Performance Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources on two criteria:

- ▶ Criterion 3: (Tier 2) The presence of Migratory and/or congregatory species.
- ▶ Criterion 4: Highly threatened and/or unique ecosystems. This ecosystem is both unique and critically endangered.

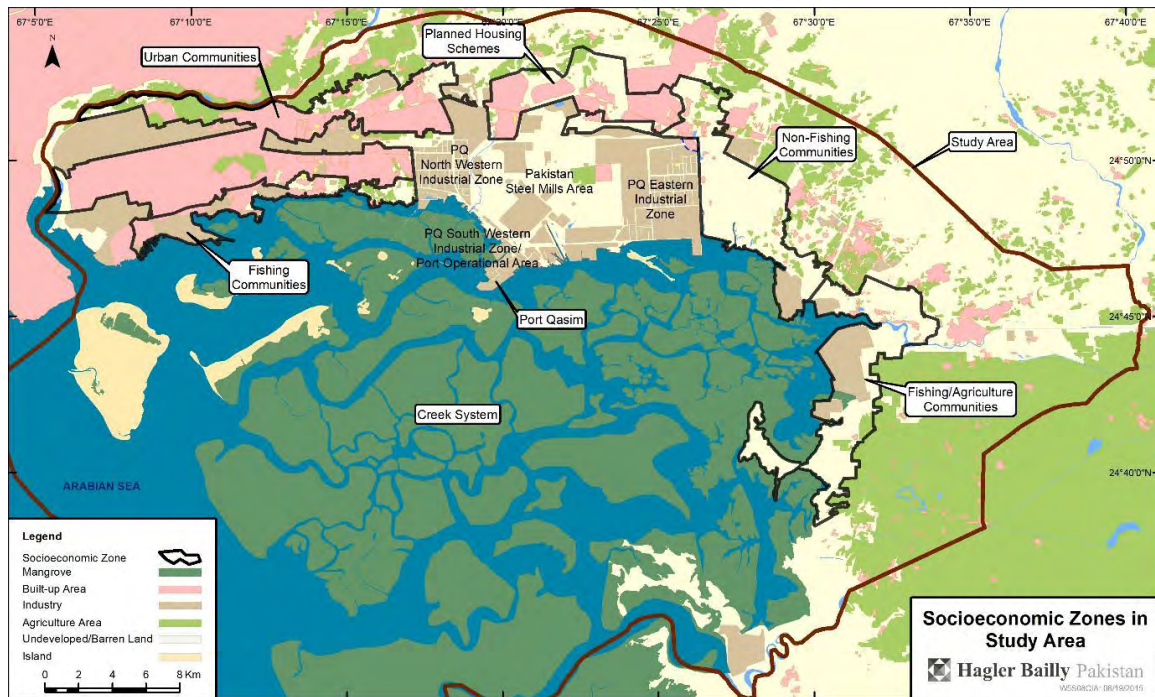
It also meets the criteria of Critical Habitat according to the Asian Development Bank's (ADB) Safeguard Policies as the area is of significant economic importance to local communities.

### 3.3 Socioeconomic Baseline

The baseline study relied primarily on information collected through surveys conducted by HBP in the communities as a part of this study. Information from secondary sources consisting mainly of previous ESIAs done by HBP, and others as well as published reports, and literature was also consulted. The Study Area was divided into the following Socioeconomic Zones (see **Exhibit 3**):

- ▶ Fishing Communities
- ▶ Non-fishing Communities
- ▶ Urban Communities
- ▶ Planned Housing Schemes
- ▶ Fishing/Agricultural Communities

**Exhibit 3: Socioeconomic Zones in the Study Area**



Almost 90% of the residents of the **Fishing Communities**, mainly Ibrahim Hyderi and Rehri Goth, are directly or indirectly connected to the fishing business as a source of livelihood including fishing in creeks/mangroves of PQA Area and in open sea, fish processing, ship building and net making, and providing recreational fishing and tourism services to the visitors from Karachi. The infrastructure in the Fishing Communities zone is poorly developed with limited health and educational facilities, below par road networks and poorly maintained electricity transmission lines.

**Non-Fishing Communities** are located in the northeast of the Study Area with most of the population concentrated near Ghaghar Phattak. Their livelihood is mainly daily wage labor in the industries located in PQA industrial and commercial zones, towns of Gharo and Dhabeji, and Karachi city. The lack of economic resources and permanent sources of income has resulted in compromised socioeconomic conditions of these communities resulting in poor health and low level of education, and an overall reduction in the quality of life.

**Planned Housing Schemes** located in the north of the Study Area include densely populated settlements having relatively well-developed infrastructure. Two urban (Gulshan-e-Hadeed and Pakistan Steel Town) and one semi-urban (Pipri) settlements fall in this zone. Pakistan Steel Town is equipped with all the basic facilities which include drainage and sanitation system, police station, electricity and natural gas transmission infrastructure, and a 100-bed hospital. Pipri is a less developed, with poor infrastructure. Electricity and gas transmission networks exist.

**Fishing/Agriculture Communities** in the east of the Study Area are located at a distance of 60 km from Karachi city on Bhambore road leading to Mipur Sakro. The livelihoods

of these communities are dependent on fishing in the Gharo and Bhambore creeks and farm labor.

### **3.3.1 Socioeconomic Profile**

The population of the surveyed clusters of the Socioeconomic Zones is estimated at 396,395. The majority of the population (96%–97%) residing in and around the Study Area are Muslim. Castes represented within the PQA Area include Mirbehar, Jat, Khaskheli, Syed, Baloch, Brohi, Larak, Musani, Punjwani, Waryani, Qasimani, Malkani, Shah, Kalmati, Khosa and Zohrani. The two commonly spoken languages in the Socioeconomic Zones are Sindhi and Urdu. Due to existence of a few Pakhtoon and Baloch settlements, a small number of people speak Pashtu and Balochi as well.

#### ***Housing and Utilities***

Most of the houses (nearly 62%) of the rural settlements in both Fishing Communities and Non-Fishing Communities are masonry structures, while the remaining are wood and straw huts. The huts are in a very poor condition and need repairs, especially after seasonal rains in the area. The housing in the Planned Housing Schemes comprises masonry construction only. In the Fishing Communities, 88% of the households reported access to natural gas, while remaining 12% of the households reported reliance on mangrove wood for cooking and heating purposes. In addition, commercial sale of mangrove wood was also reported. The Non-Fishing and Fishing/Agriculture Communities do not have access to natural gas supply. They collect wood from mesquite forests and other vegetation in their surroundings to meet their heating and cooking requirements.

#### ***Water Supply***

During the socioeconomic survey, it was noted that the water to the Fishing Communities, Planned Housing Schemes and the only settlement of Haji Ibrahim in Non-Fishing Communities is supplied by the Karachi Development Authority (KDA) through its supply system. The other source of water in the Socioeconomic Zones is groundwater, which is mostly brackish and not fit for drinking and mainly used for washing, bathing and cooking purposes.

#### ***Health and Education***

The settlements of Ibrahim Hyderi and Steel Town are the only settlements having separate government girls' and boys' colleges (up to 14<sup>th</sup> grade) providing higher education. The two major settlements in Fishing Communities, Ibrahim Hyderi and Rehri Goth have girls' and boys' primary and secondary schools. The residents of the villages in the nearby surroundings of Rehri Goth visit colleges of either Ibrahim Hyderi or Karachi city located at an approximate distance of 5 km and 15 km from these villages. Education facilities in the surveyed Non-Fishing Communities include primary, middle and secondary schools run by the provincial Education Department, Human Development Foundation (HDF), Fauji Fertilizer Bin Qasim Ltd. (FFBL) and Sindh Education Foundation (SEF). The government provided educational facilities in the surveyed settlements comprise of six primary, two middle and two high schools. FFBL has also established a girl's elementary school in Haji Jhangi Khan, where education up to class eight is provided to girls.

Health facilities are reported to be inadequate and lack of technical medical staff and absence of doctors from duty has resulted in poor health status of the communities. The health centers of the Fishing Communities are limited to Ibrahim Hyderi and Rehri Goth with only government and private health centers functioning in the area. The residents of these communities visit health centers including public and private hospitals located in Karachi city at a distance of about 15 km.

### **Livelihood and Assets**

The primary sources of livelihood (for the residents of communities located in the Socioeconomic Zones are as follows:

Primary Sources of Livelihood (% of Households)

<i>Livelihood</i>	<i>Fishing Communities</i>	<i>Non-Fishing Communities</i>	<i>Fishing/Agriculture Communities</i>	<i>Planned Housing Schemes</i>
Fishing (own boats)	4%	-	2%	-
Fishing (labor)	68%	-	38%	-
Boat Building/Repair	4%	-	-	-
Non-Fishing Wage Labor	24%	65%	32%	54%
Employment in PQA and Pakistan Steel Mill	-	16%	-	46%
Government Employment	-	1%	-	-
Small Business (Hotel/Shop)	-	18%	-	-
Farm Labor	-	-	29%	-
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

The household survey conducted as part of this assessment shows that the average income of households engaged in fishing ranges from PKR 7,000 to PKR 20,000 per month, depending upon the size of boat, boat ownership and fish catch. There is a general sharing arrangement, whereby half of the total catch goes to the boat owner while the income generated from the other half is equally divided among the fishing labor. Average crew size is 20 persons on a 24 ft boat and 45 persons on boats exceeding 32 ft. Average income of the households providing wage labor is PKR 10,000 per month. The per capita income for the communities is estimated to be PKR 2,551 per month.

Almost all the fishermen are working as fishing labor, with only a small number of fishermen owning boats, as a result, the fishermen have low income levels. The total commercial fish catch in Sindh increased from 1947 onwards, this was followed by a decreasing trend after 1993. The decrease is attributed a reduction in the quantity of fin fish caught. Estimated fish catch and its distribution, given some assumptions, for the Study Area is summarized below:



### Estimated Fish Catch by Fishing Locations<sup>9</sup>

<i>Landing Site</i>	<i>Fishing Location</i>	<i>Annual Fish Catch (in metric tons)</i>	<i>% of Fish Catch</i>
Ibrahim Hyderi	Mangrove	20,301	29
	Open Sea	19,565	28
Rehri	Mangrove	14,599	21
	Open Sea	14,599	21
Bhambore	Mangrove	1,045	1
	Open Sea	0	
<b>Total</b>		<b>70,110</b>	<b>100</b>

### Distribution of Fish Caught by Communities Living in Study Area on the Basis of Boat Sizes

<i>Fishing Location</i>	<i>% age of Catch</i>
Mangroves	51
Open Sea	49

The total fish catch from the Socioeconomic Zones, including fish for food and trash fish (fish mesh used in manufacturing process of dairy and poultry feed), is estimated to be 61,026 metric tons in 2014. Applying the market rates for these categories of fish, the annual market value of the fish caught in the Study Area is estimated at PKR 7,332 million.

Reliable data could not be collected for shrimp catch through the socioeconomic survey or otherwise. Applying an average market rate of PKR 787/kg<sup>10</sup> for the total of 4,413 metric tons of shrimp estimated on the basis of MFD data for three types of shrimp reported, annual market value of shrimp catch is estimated at PKR 3,473 million. Crab catch is estimated at 34,131 kg as calculated from the data recorded during the socioeconomic survey. The annual market value of crab catch is estimated at PKR 7.8 million.

Korangi and Landhi Industrial Areas are home to Pakistan's' largest textiles, pharmaceutical, cosmetic, steel, chemical, automobile and flour mill industries. These industries provide multifaceted job opportunities to the residents of the communities located in their immediate vicinity.

<sup>9</sup> There are a number of limitations in the analysis carried out. However, the estimated incomes on the basis of the estimated fish catch generally correspond with the per capita incomes calculated on the basis of separate socioeconomic surveys carried out within the Study Area. Further monitoring of the fish catch, most of which goes unreported, is recommended to establish a better state of the "pressure" on the "ecosystem" due to factors external and outside the control of the Port Qasim Authority.

<sup>10</sup> Market rate varies from PKR 300 to PKR 1,200 per kg depending on the size and quality of shrimp.

### **3.3.2 Overview of Community Dependence on Ecological Resources**

The mangrove forests in Pakistan provide important ecosystem services. The livelihoods of the Fishing Communities are almost entirely dependent (75% of households) on fishing and fishing related activities, with little diversification of income sources. About 51% of the fish catch in these communities comes from the creeks and mangrove areas. In the Fishing/Agriculture Communities, 40% of the households are dependent entirely on fishing in the creeks and mangrove areas. In the Fishing Communities, a small number of households in Rehri Goth collect fodder from the mangroves for their livestock and 12% of the households are dependent on wood collected from the mangroves for fuel use.

### **3.3.3 Absolute Vulnerability**

To ascertain the absolute vulnerability status of the communities, a vulnerability matrix was filled in discussion with key informants at each settlement as a part the settlement level socioeconomic survey. Socioeconomic zones within the Study Area were ranked based on their current status for vulnerability. The results of the vulnerability survey are summarized below.

### Vulnerability Levels in Study Area

Zone	Vulnerability Level							
	Access to Social Services	Out Migration	Economic Opportunities	Access to Credit	Assets	Mobility	Disaster Preparedness and Response	Overall Vulnerability Level
Fishing Communities	Moderately Resilient	Resilient	Moderately Vulnerable	Moderately Vulnerable	Highly Vulnerable	Vulnerable	Critically Vulnerable	Vulnerable
Non Fishing Communities	Highly Vulnerable	Moderately Resilient	Critically Vulnerable	Moderately Vulnerable	Highly Vulnerable	Critically Vulnerable	Critically Vulnerable	Highly Vulnerable
Fishing/Agriculture Communities	Highly Vulnerable	Moderately Resilient	Vulnerable	Moderately Vulnerable	Vulnerable	Critically Vulnerable	Highly Vulnerable	Vulnerable
Planned Housing Schemes	Moderately Resilient	Moderately Vulnerable	Critically Vulnerable	Resilient	Vulnerable	Moderately Resilient	Moderately Vulnerable	Moderately Vulnerable

Color Coding: Red – Critically Vulnerable, Brown – Highly Vulnerable, Yellow - Vulnerable

The highest levels of vulnerability were observed in the Non-Fishing Communities, followed by the Fishing Communities and Fishing/Agriculture Communities. The Planned Housing Schemes have relatively lower level of vulnerability in comparison to populations in other Socioeconomic Zones studied.

## **4. Impact Assessment**

The impact assessment carried out for this study assumed a ‘Business as Usual’ scenario, assuming continuation of current practices and trends in environmental management of the Study Area, as evidenced by general lack of proactive environmental management in the past.

### **4.1 Air Quality**

As stated earlier, the concentration of NO<sub>x</sub> and SO<sub>2</sub> in the ambient air may already be exceeding the target limits (IFC ambient air quality guidelines in this case as it is more stringent than the SEQS for ambient air). The impact zone—the area in which the target limits are exceeded—is currently relatively small. The zone falls over an area which is presently either unoccupied or is covered by industrial units. However, this situation will change in future. With the anticipated development of PQA industrial zones, installation of power plants, increase in shipping, road and rail traffic, the impact zone as well as the impact intensity of these two pollutants will increase significantly under the business-as-usual scenario of emission controls. **Although, currently no communities are affected, it is predicted that by 2050 air quality in several communities in the north and northwest of the PQA will be severely affected.**

Particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) are not likely to be a concern from PQA activities. However, it may be noted that the concentration of these pollutants are already high due to natural sources and to some extent due to air-borne dust from traffic movement.

### **4.2 Mangrove Ecosystem and Biodiversity**

Impacts due to Developments in PQA Area

1. Mangroves in Indus Delta constitute a ‘Critical Habitat’ under the IFC Performance Standards. About 0.3% of the existing mangrove area has been lost to development of Port Qasim, directly, in past. The direct loss will expand to 2.1% of the existing mangrove in the Study Area by 2050 if all the planned Developments take place, which is relatively small. However, **considering the classification of mangroves in the Indus Delta as Critical Habitat, the impact would be significant requiring a net gain in habitat (credible offsets) to comply with the IFC Performance Standard 6 and ADB Safeguard policies.**
2. PQA presently does not have a well-defined policy or guidelines for dumping of dredge material. While the mangrove area already lost to dumping of dredge material to date is relatively small, **there is a risk of additional damage to mangroves due to unregulated dumping of dredge materials in future, particularly from dredging of the second channel to accommodate future port traffic.**

3. The Study Area includes habitat for cetaceans, including the Indian Ocean Humpback Dolphin *Sousa plumbea* and Finless porpoise *Neophocaena asiaeorientalis* which are of conservation importance. The degradation of the near-shore habitats due to increased pollution, shipping activity and developments, could therefore result in adverse impacts on the population of these species. Collisions between ships and cetaceans has also been reported to be a serious issue. Noise during construction in the port from piling and drilling operations can also cause disturbance and harm to the cetaceans.
4. Impact of **accidental releases of oil and other toxic products** from tankers and other ships delivering cargo to Port Qasim and consequential impact on abundance of marine life is a potential concern.

#### Impacts Due to Others

1. Given the established practice of harvesting mangroves for fodder in the local communities, expanding populations in the coastal area, and high cost of commercial fuels, the harvesting pressures are expected to remain high. **The loss of mangroves due to harvesting by local communities could intensify if proper controls are not maintained on a continuous basis.**
2. Mudflats the Study Area are feeding areas for both resident and migratory birds, and are potential areas for replantation of mangroves. **Mudflat habitats in the Study Area are likely to face risks similar to those for mangroves, particularly from urban developments by organizations and institutions other than PQA.**
3. In the long term, if the release of industrial effluent into the creek systems remains unchecked and unregulated, and if the industrial activity in the catchment of Malir River multiplies, **accumulation of heavy metals in the sediments is likely impact marine fauna as well as affecting their suitability for human consumption.**
4. **Clearing of mangroves and deposition of toxic metals in the creeks will impact the abundance of fish and crabs, and consequently the livelihoods of local communities.** The significance of these impacts will increase over time if effective regulatory regimes to control land use and flow of toxic pollutants into creeks are not established.
5. **The loss of freshwater into this part of the delta will affect the long term sustainability of the entire mangrove ecosystem.**

#### 4.3 Livelihoods Related to Mangroves - Income from Fish, Shrimp and Crab

##### Impacts due to Developments in PQA Area

1. **Operation of Port Qasim has hindered the access of fishing communities, particularly those that use small fishing boats, to the preferred fishing areas. The dredging and operation of a new shipping lane as planned by PQA will further restrict their access.**

### Impacts Due to Others

1. **Non-sustainable fishing practices by the local community including use of prohibited fine mesh nets are the principle threat to the diversity and abundance of fish in the Study Area.** Total fish catch has declined to as much as 63% of peak level in 1993 by 2014.
2. Fishery and associated activities such as boat building and repair is a principal source of livelihood for a large population in the Study Area, which includes poor and vulnerable households. **If non-sustainable fishing practices and overfishing continue, the fish catch and the corresponding incomes could decline to 33% of present day level in 15 years.** PQA has limited leverage over non-sustainable fishing practices which fall in the mandate of the Marine Fisheries Department.

## 5. Mitigation Actions and Management Measures

As opposed to a 'Business as Usual' scenario for impact assessment discussed above, a 'Collaborative Management' scenario was assumed for development of mitigation and management measures. This scenario assumes proactive environmental management by PQA in its zone of influence, combined with collaboration with other institutions that have an influence over the Study Area and/or impact its environment. The long term outcome of this scenario in terms of ecosystem services and environment will be maintenance and possibly enhancement of coastal ecosystem functions and services, and sustainable livelihoods.

The following management approach is proposed to achieve a transition from the 'Business as Usual' scenario to the 'Collaborative Management' scenario:

An **environmental management framework** consisting of a set of mitigation actions and management measures including environmental zoning of the Study Area

An **institutional and policy framework** that purposes strengthening of key departments in PQA and defines the roles, responsibilities and mandates of participating institutions in environmental management of the Study Area

A **financial management framework** that generates and provides funds for environmental management and defines mechanisms for transparent and effective utilization of an account

A **monitoring and evaluation framework** that relies on continuous professional, scientific and independent monitoring of the extent to which the environmental management objectives are being achieved and identifies of causes of poor performance or failure

### 5.1 Environmental Management Framework

#### Principal Actions and Measures by PQA

- Preparation and implementation of an Environmental Zoning Plan for PQA Notified Area
- Preparation and implementation of guidelines for disposal of dredge materials

- ▶ Assessment of risk to cetacean populations due to collisions with ships and from noise from construction activities in the port, and if required preparation and implementation of guidelines for management of these risks
- ▶ Preparation and implementation of spill contingency plans for the port
- ▶ Regular monitoring of air quality, water quality, and health of mangroves in the Study Area
- ▶ Setting an example for other polluters outside the Notified Area including industries and residential areas by achieving compliance with SEQS, and applying pressure on them through regulators and stakeholders to discourage them from discharging effluents and gaseous emissions into the Study Area
- ▶ Setting up hydrodynamic and sediment models for prediction of impact of proposed developments and operations on circulation, sedimentation and erosion, and consequentially on ecosystems and ecosystem services
- ▶ Continuation of plantation of mangroves to offset clearing to address land use change as a driver for ecosystem change, although a proper replantation strategy and planning is need to ensure offsets are sustainable e.g. through secondary management.
- ▶ Building up environmental management capacity to regulate the port operations and businesses operating in the Notified Area to manage environmental impacts on an individual and collective basis.

#### Principal Actions and Measures by Others with Participation from PQA

- ▶ Preparation and implementation of an Environmental Zoning Plan for areas west of the PQA Notified Area where residential and other developments are being considered
- ▶ Regulating fishing activities by local communities in collaboration with the concerned government departments and sustainable harvesting practices are introduced and established
- ▶ Active watch and ward (patrolling) and regulatory pressure is applied on communities to either stop fodder and fuel wood extraction from mangroves or maintain harvesting at sustainable levels
- ▶ Conducting research on mangrove ecosystems to support development of appropriate management strategies
- ▶ Conducting studies on release of environmental flows from Kotri Barrage to achieve a balance between the ecology in the Indus Delta and the needs of the communities living in the delta, and the agriculture in the upstream areas.

## 5.2 Institutional and Policy Framework

Principal actions proposed are:

**Addition of a Member Environment in the Board of PQA** through prescribed procedures to strengthen the oversight and supervision capacity of the PQA Board on

environmental matters. The person should ideally have a private sector background with longstanding experience in environmental policy and management in a large corporation.

**Formation of an Environmental Committee in PQA:** The Environmental Committee will report directly to the Chairman, and will have representation from the industry and terminals operators in PQA and DGs Technical, Operations, and Planning. The Chairperson of the Committee can be taken from the private sector to enhance participation and involvement of the industry.

**Outsourcing of Specialized Technical Functions:** Due to various constraints, it is difficult to engage and maintain high level technical expertise required for achieving the long term objectives of the Collaborative Management scenario on regular payroll of PQA. Outsourcing of specific tasks in specialized areas such as hydrography, hydrodynamic and sediment modeling, air quality modeling, ecological management, laboratory services, and community liaison is proposed.

Strengthening and capacity building of the following departments and sections in PQA:

**Environment and Safety Department:** Capacity to manage physical, ecological and socioeconomic aspects of environment, environmental monitoring, review of ESIAS, and coordination with industry in PQA and external stakeholders.

**Hydrography Section in the Technical Division:** Capacity to manage and supervise collection of hydrography data in and around the port area.

**Dredging Department:** Capacity to manage development of hydrodynamic and sediment transport models and to operate and interpret the results for predicting changes in sedimentation and erosion patterns, and providing advice on design of new facilities.

**Restructuring of Environment Department:** A position of Manager Environment is proposed, who will manage and coordinate the following functions for which one or more Deputy Managers will be engaged: ESIAs and Environmental Management, Ecology, Monitoring and Laboratory, and Community Liaison.

**Placement of E&S Department under the DG - Technical:** This is recommended to maintain coordination among the functions of environment, hydrography, and dredging for the reasons listed above.

### **5.3 Financial Management Framework**

Principal actions proposed are:

- ▶ **A separate Account for environmental management** titled Port Qasim Environmental Management Account can be established with appropriate legal cover under the rules of the PQA.
- ▶ **The Account will be managed by the Environmental Committee** with representation from industry as discussed in the previous section.
- ▶ **Inflows into the Account can include mandatory or voluntary contributions from the land holders in PQA** on the basis of defined fees or incremental land charges, fines and penalties collected by PQA on account of environment, pollution charges, and contributions from donors.



- **The amounts in the Account can be used to support activities for implementation of protection and management of environment** such as outsourcing of specialized technical functions, protection and patrolling, research and monitoring, community engagement, effluent treatment, clean-ups, and restoration.

***Budgetary Implications for Implementing the Recommendations***

Major items in one-time and capital costs for environmental management include setting up and calibrating the hydrodynamic and sedimentation model, setting up air quality model, purchase of low draft patrolling boats, and installation of buoys for cordoning of sensitive fish breeding areas. The indicative budgetary requirement for these is estimated at USD 1.23 million.

Major items for annual recurring costs include hydrodynamic and sediment flow monitoring, air and water quality monitoring, ecological monitoring, surveillance to control illegal and non-sustainable fishing and harvesting of mangroves, awareness and education of local communities, and special studies for environmental management. Annual indicative budgetary requirement for these is estimated at USD 293,000<sup>11</sup>.

Given a current revenue base of PQA from shipping as well as land charges of about USD 57 million, the capital or one-time costs for environmental management are estimated 2.2% of the PQA revenues, while the recurring costs correspond to 0.5% of the annual PQA revenues.

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<sup>11</sup> Excluding additional PQA staff costs.

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# 1. Introduction

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Port Qasim was established in early 1980s as an alternate deep sea port to Karachi Port with the added feature of an associated industrial area. The International Finance Corporation (IFC), the private sector arm of the World Bank Group (WBG), has invested in four port terminals and one industrial project in Port Qasim in Sindh, Pakistan. The Port Qasim Authority (PQA) is the federal government agency mandated to manage port<sup>1</sup> and associated industrial developments, has plans to develop the port further by acquiring additional land and providing incentives to the private sector to develop new jetties and industrial units. The IFC may invest in other projects planned by the Port Qasim Authority.

Port Qasim was conceptualized to include port facilities as well as industrial areas. The present port facilities at Port Qasim include, among others, fifteen berths and jetties for handling iron ore, coal, chemicals, liquefied natural gas (LNG), crude oil, liquefied petroleum gas (LPG), grain, fertilizer, liquid cargo, and bulk containers. Of the port and associated industrial area nearly 40% is currently either occupied or industrial units are being constructed on it. Currently, 273 projects are operational and another 233 are under construction.<sup>2</sup>

Recognizing that environmental and social impacts from existing developments combined with the potential incremental impacts resulting from proposed future developments may result in significant cumulative impacts that would not be expected in the case of a stand-alone development, the IFC has acquired services of Hagler Bailly Pakistan (Pvt) Ltd (HBP) to conduct an ecosystem service review (ESR) and a cumulative impact assessment (CIA) for the existing and planned developments at Port Qasim.

The PQA undertook a strategic environmental assessment as part of the strategic planning study.<sup>3</sup> The strategic assessment discussed the key environmental and social issues in qualitative terms and proposed various mitigation measures. Since the completion of the study 15 years ago, developments has taken place in Port Qasim area and in surrounding areas. In the same period, new tools for environmental assessment have been developed which provide a better understanding of potential environment and social risks associated with a development in a complex ecological systems such as the Port Qasim Area. The present study will thus augment the previous PQA study.

This document provides the CIA of the existing and planned developments at Port Qasim.

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<sup>1</sup> Under an Act of Parliament called the Port Qasim Authority Act 1973

<sup>2</sup> Information on Port Qasim has been obtained from the following sources: 1) Engineering Consultants International (Pvt.) Ltd., *Strategic Planning Study for Port Qasim*, June 2001. 2) Presentation given to IFC Delegation by Port Qasim Authority, June 2015.

<sup>3</sup> Engineering Consultants International (Pvt.) Ltd., *Strategic Planning Study for Port Qasim*, Volume 5, Strategic Environmental Assessment, June 2001.

## **1.1 Rationale for Cumulative Environmental and Social Assessment**

Environmental impact and social assessment (ESIA)<sup>4</sup> is now an established tool, and a mandatory requirement in almost all the countries in the world for assessing the environmental and social impacts of development projects. The emphasis of ESIA is on the environmental and social impact of a single project. Even if all the projects in a geographical locations are studied through their respective ESIA studies, how the projects will collectively change the environment is not captured in the studies. This assertion is based on the understanding that environment and ecosystems are non-linear systems. The cumulative impact of a number of projects will not be equal to the sum of incremental impacts of individual projects—it is likely to be more. Therefore, considering the limitations of ESIA studies, the countries and organizations, understanding the importance of environment and a possible change in it as the key factor to impact its biophysical integrity, now emphasize and direct the project proponents and donors to conduct assessment of cumulative environmental and social impacts of the projects.

Cumulative impacts are those that result from the incremental impact of a project or developments when assessed in combination with other existing and reasonably foreseeable future developments in a rationally set geographical and temporal scale. Cumulative impacts of a project are limited to those impacts only which are generally recognized as important on the basis of scientific concerns and concerns of the local communities located around the project area which can be affected by the project development and other developments in their vicinity.

This Cumulative Impact Assessment study considers these concepts to identify and assess the possible environmental and social impacts related to the development of port and industrial facilities at Port Qasim in combination with other developments in the Study Area.

CIA signifies a systematic impediment in environmental and social impact assessment (ESIA) because the spatial horizon of impact assessment is expanded and multifaceted as compared to ESIA, and the interactions between human activities and Valued Environmental and Social Components (VECs)<sup>5</sup> increase in number and intricacy. The overall objectives of a cumulative environmental assessment studies are:

- ▶ Safeguard the subject and future development's cumulative social and environmental impacts and risks to not exceed a threshold that could compromise the sustainability of Valued Environmental and Social Components (VECs);
- ▶ Ensure that the subject and future development's value and feasibility are not limited by cumulative social and environmental impacts and risks; and

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<sup>4</sup> Alternatively also called Environmental Impact Assessment (EIA)

<sup>5</sup> The IFC Good Practice Handbook on Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. 2014 defines VECs as environmental and social attributes that are considered to be important in assessing risks; including physical features, habitats, wildlife populations (e.g. biodiversity), ecosystem services, natural processes (e.g., water and nutrient cycles, microclimate), social conditions (e.g. health, economics), or cultural aspects (e.g., traditional spiritual ceremonies).

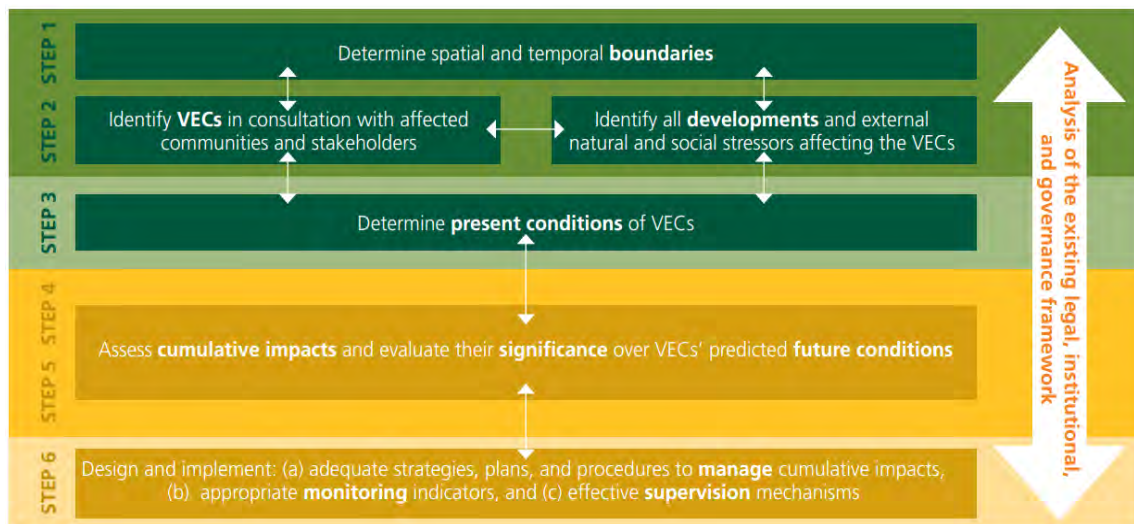
- Support development of regional governance structures for decision making and managing cumulative impacts.

## 1.2 Study Methodology

There are a number of guidelines for conducting cumulative environmental and social impact assessments. The methodology used in this study has been adapted from the guidelines of International Finance Corporation<sup>6</sup>. The key steps of the Study are shown in **Exhibit 1.1**.

Key in the methodology is the identification and mapping of Valued Environmental and Social Components. Additional detail on methodology are provided in each section, particularly in **Section 7** where VECs are identified.

**Exhibit 1.1: Study Steps**



Source: International Finance Corporation. Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. 2014

## 1.3 Study Limitations

The aim of a CIA study is not to assess all impacts of all Projects. The project EIAs address all impacts of a specific Projects. Under Good International Industry Practice Guidelines (GIIP) such as the IFC GPH on CIA a VEC-centered approach is utilized for CIA where impacts on prioritized VECs are considered and addressed. The prioritized VECs include the following:

- Mangrove Ecosystem (Mangrove and Mudflat Habitat, Fish, Shrimp and Crab)
- Livelihood Associated with Mangrove Ecosystem
- Air Quality

<sup>6</sup> International Finance Corporation. Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. 2014



Baselines as part of CIA are limited to determining the status of a VEC, and are typically on the basis of previous baseline studies already carried out. Data in previous baselines did not completely or uniformly characterize the PQA Notified Area, and in some cases quality control information was not available (e.g. for water quality). IFC funded limited field sampling to fill major gaps and ensure a coordinated data collection methodology. While sampling was limited, the result of the exercise is a more comprehensive and coordinated baseline for the Port Qasim area, compared to previous EIA studies at or close to Port Qasim.

The Study time was originally limited to 4 months, and due to some limitations, the Study was initiated just before start of the Summer Monsoon. The scope of analysis, did not also, then allow collection of seasonal data and other aspects, such as bird surveys which were not reflected in the budgeting due to the time. Access to areas within the intertidal delta (including, and particular, to the islands) was also limited initially. However, the study time was extended to incorporate sampling of mangroves. Study times were also extended to cater for multiple important meetings and discussions with the Port Qasim Authority on the management and mitigation of impacts.

## 1.4 Terminologies

Following terminologies are used in this document:

Port Qasim Notified Area	The areas falling within the limits of Port Qasim as notified by the Government of Pakistan under the Port Qasim Authority Act 1973. <sup>7</sup>
PQA Industrial Zones	The three industrial zones on which PQA has jurisdiction to develop and manage. These include: <ul style="list-style-type: none"> <li>▶ Northwest Industrial Zone</li> <li>▶ Eastern Industrial Zone</li> <li>▶ Southwest Zone, which also include Port Operations Area (also referred to as Port Area) and commercial area</li> </ul>
Developments	The existing, anticipated and reasonably foreseeable developments in the Notified Port Area and PQA Industrial Zones. These include manufacturing units, berths, trestles, jetties, warehouses, power plants, material yards, storage tanks, roads, pipelines, railway tracks, land reclamation, dredging and development of new shipping channels. It also includes auxiliary and supporting infrastructure for the above.
Existing Developments	Those developments that are actively causing, or are likely to be causing an impact on the environment and ecosystem services. These include all fully constructed industrial facilities in PQA Industrial Zones.

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<sup>7</sup> It is not certain whether *Port Area* includes the industrial area under the PQA or not. If needed, the definition will be modified.

Under construction Developments	Those developments that currently under construction in the PQA Industrial Zones and once completed are likely to cause impact on the environment and ecosystem services.
Anticipated Developments	Include those developments that are planned, have possibly received environmental approvals from the Sindh Environmental Protection Agency and are, very likely to be constructed,
Reasonably Foreseeable Developments	Those developments that has been discussed in policy documents, strategies, or development plans and are plausible and likely. The key distinction is that it should not be considered speculative. <sup>8</sup>
Stakeholders	Persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively. Stakeholders may include locally affected communities or individuals and their formal and informal representatives, national or local government authorities, politicians, religious leaders, civil society organizations and groups with special interests, the academic community or other businesses. <sup>9</sup>
Study Area	The area where Developments are planned or are anticipated; or where the environmental or social impacts of the Developments are likely to take place; or where the direct beneficiaries of the ecosystem services likely to be impacted by the Developments are present.

## 1.5 Limitations

The aim of a CIA study is not to assess all impacts of all Projects. The project EIAs address all impacts of a specific Projects. Under Good International Industry Practice Guidelines (GIIP) such as the IFC GPH on CIA, a VEC-centered approach is utilized for CIA where impacts on prioritized VECs are considered and addressed. The prioritized VECs for the Study Area, irrespective of the developments of PQA, include the following:

- 
- <sup>8</sup> In one of the court decisions, the U.S. Court of Appeals for the First Circuit the definition as follows: [O]nly those effects that are “likely” (or “foreseeable” or “reasonably foreseeable”) need be discussed, ... and, as in other legal contexts, the terms “likely” and “foreseeable,” as applied to a type of environmental impact, are properly interpreted as meaning that the impact is sufficiently likely to occur that a person of ordinary prudence would take it into account in reaching a decision. *Sierra Club v. Marsh*, 976 F.2d 763, 767 (1st Cir. 1992), as cited in *Assessing Indirect Effects and Cumulative Impacts under NEPA*. 2011. Center for Environmental Excellence by AASHTO (American Association of State Highway and Transportation Officials).
- <sup>9</sup> International Finance Corporation “*Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets*” World Bank Group, Washington, D.C. United States of America, May 2007.  
[http://www1.ifc.org/wps/wcm/connect/938f1a0048855805beacfe6a6515bb18/IFC\\_StakeholderEngagement.pdf?MOD=AJPERES](http://www1.ifc.org/wps/wcm/connect/938f1a0048855805beacfe6a6515bb18/IFC_StakeholderEngagement.pdf?MOD=AJPERES)

- ▶ Mangrove Ecosystem (Mangrove and Mudflat Habitat, Marine Mammals, Fish, Shrimp and Crab)
- ▶ Livelihood Associated with Mangrove Ecosystem
- ▶ Air Quality

Baselines as part of CIA are limited to determining the status of a VEC, and are typically on the basis of previous baseline studies already carried out. Data in previous baselines did not completely or uniformly characterize the PQA Notified Area, and in some cases quality control information was not available (e.g. for water quality). IFC funded field sampling to fill major gaps and ensure a coordinated data collection methodology. In addition extensive literature review was carried out. While sampling was limited, the result of the exercise is a more comprehensive and coordinated baseline for the Port Qasim area, compared to previous EIA studies at or close to Port Qasim. Similarly, since the approach is VEC-based, the cumulative impact assessment considers the cumulative impacts of multiple projects on these only. This approach allows scoping down the cumulative impact assessment to areas of higher priority (i.e. prioritized VECs) compared to other VECs.

The Study time was originally limited to 4 months, and due to some procedural limitations, the Study was initiated just before start of the Summer Monsoon. Therefore, this did not allow collection of seasonal data, or allow for budgeting of bird surveys. Access to areas within the intertidal delta (including, and particular, to the islands) was also limited initially. However, the study time was extended to incorporate sampling of mangroves. Study times were also extended to cater for meeting requests by PQA, on the management and mitigation of impacts.

## 1.6 Study Team

The Study team for the CIA is provided in **Exhibit 1.2**, along with their designations and responsibilities.

**Exhibit 1.2: Key Study Team Members**

<i>Name</i>	<i>Role</i>	<i>Responsibilities</i>	<i>Affiliation</i>
Vaqar Zakaria	Team Leader (Environmental and Social Specialist)	Overall quality control on all impact assessment sections and mitigation and management planning	Hagler Bailly Pakistan
Bilal Khan	Project and Team Coordinator (Water and Environment Specialist)	Team management, study and field survey methodologies and designs, physical and socioeconomic impact assessment, and mitigation planning.	Hagler Bailly Pakistan
Hidayat Hassan	Environmental and Social Specialist	Air quality impact assessment and mitigation planning	Hagler Bailly Pakistan
Kamran Minai	Environmental Specialist/Ecologist	Ecology baseline and impact assessment; support to specialist on ecological surveys (mangroves and fish)	Hagler Bailly Pakistan

<i>Name</i>	<i>Role</i>	<i>Responsibilities</i>	<i>Affiliation</i>
Aziz Karim	Physical Environment Specialist	Physical baseline surveys and baseline reporting	Hagler Bailly Pakistan
Sadia Asghar	Physical Environment Specialist	Support in physical baseline and air quality modelling	Hagler Bailly Pakistan
Dr M Rafique	Fish Specialist and Aquatic Ecologist	Fish surveys and baseline	Pakistan Museum of Natural History
Dr Shahid Amjad	Aquatic Ecologist	MBI surveys and baseline	Hagler Bailly Pakistan (consultant)
Dr Ismail Bhatti	Botanist	Mangrove surveys and baseline	Pakistan Museum of Natural History
Steven Davie	Ports and Shipping Engineer	Hydrodynamics baseline, mitigation and management planning	Tetra Tech Inc
Mehrunisa Malik	Socioeconomic Specialist	Socioeconomic surveys and baseline reporting	Hagler Bailly Pakistan (consultant)
M Salman Ahmed	Socioeconomic Specialist	Socioeconomic surveys and baseline reporting	Hagler Bailly Pakistan
Hussain Ali	Civil and Environmental Specialist	Support on surveys and community consultations	Hagler Bailly Pakistan
Waris Ali	Field Logistics and Safety Coordinator	Field logistics	Hagler Bailly Pakistan

## 2. Port Qasim and Regional Developments

This section describes the existing and anticipated Developments<sup>10</sup> at Port Qasim<sup>11</sup>. The land under the jurisdiction of the Port Qasim Authority (PQA) comprises three industrial and commercial zones and the Notified Port Area. The industrial and commercial zones are divided into three geographic zones:

- ▶ Southwestern Industrial Zone including Port Operations and Commercial Areas
- ▶ Northwestern Industrial Zone
- ▶ Eastern Industrial Zone<sup>12</sup>

In addition to this an LNG Zone has recently been demarcated by the Port Qasim Authority<sup>13</sup>.

The total area of these zones based on PQA sources are as shown in **Exhibit 2.1**. The industrial zones and the PQA Notified Area are shown in **Exhibit 2.2**.

The Northwestern Industrial Zone is largely zoned for light industries, edible oil processing and storage, and LPG storage. The Eastern Industrial Zone is zoned for chemicals and process industries, and medium to heavy industries. However, these are broad categorizations and exceptions can be found in both zones.

All the available plots in the land development zones have been acquired by various investors. Approximately 273 projects are operational within the Port Qasim Northwestern, Southwestern and Eastern Zones, with another 233 under construction<sup>14</sup>.

**Exhibit 2.1: Area of Port Qasim Industrial and Commercial Zones<sup>15</sup>**

<i>Zone</i>	<i>Area (hectares)</i>
Northwestern Industrial Zone	1,131
Southwestern Industrial Zone/Port Operational Zone	2,525
Eastern Industrial Zone	2,896
<b>Total PQA Industrial Area</b>	<b>6,552</b>
<b>Additional Reclamation Area within Eastern Industrial Zone</b>	<b>1,034</b>
<b>Total Notified PQA Area</b>	<b>139,483</b>

<sup>10</sup> See **Section 1.3** for terminologies.

<sup>11</sup> As of August 2015

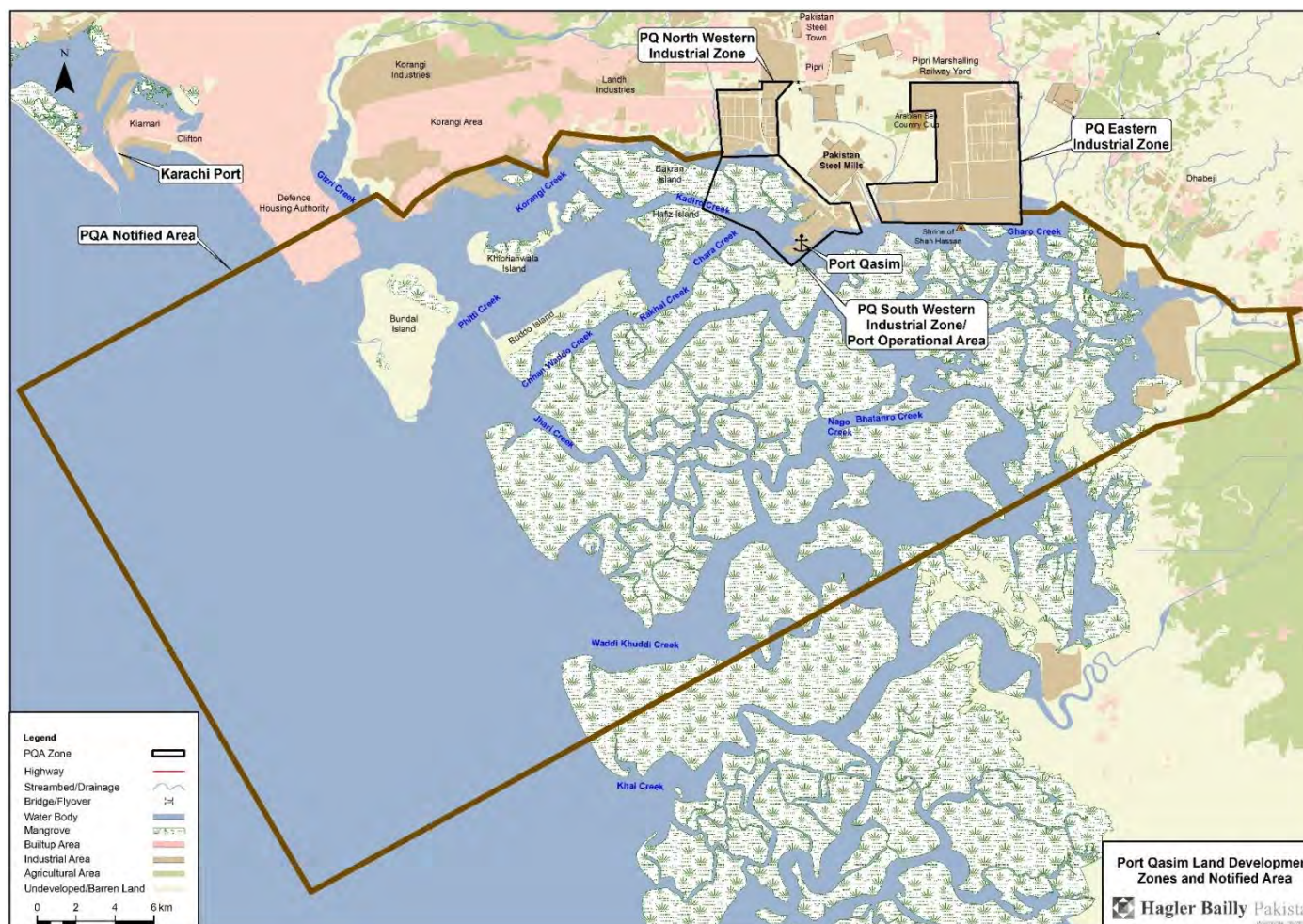
<sup>12</sup> Source: PQA Strategic Plan, 2001

<sup>13</sup> No project has been set up in the LNG Zone. However, the Engro Elengy Terminal has subsequently been set up in the South Western Industrial Zone.

<sup>14</sup> Source: Port Qasim Authority Presentation to IFC Delegation, 2015

<sup>15</sup> Areas are based on **Figure 2.1.1 of PQA Strategic Plan 2000-2050**. Note that different maps and sources, such as the Business Development Plan, provide different areas. **Figure 2.1.1 of the PQA Strategic Plan 2000-2050** is the most accurate outline of areas where PQA is currently developing.

**Exhibit 2.2: Port Qasim Land Development Zones and Notified Area<sup>16</sup>**



<sup>16</sup> The Port Qasim Notified Area depicted in maps does not coincide with an area of 69,000 hectares as mentioned in the Port Qasim Business Development Plan, 2010

## **2.1 Existing and Under Construction Developments**

The current land development intensity in the three industrial zones is shown in **Exhibit 2.3** and is discussed below.

### **2.1.1 Northwestern Industrial Zone**

The major existing and under construction developments include the following:

- ▶ Agha Steel Industry, Downstream steel products
- ▶ Denim International 2, Garments
- ▶ Pak Petrochemical Industries, Pak Petrochemical 2
- ▶ Tripack Films Limited, Films Plant
- ▶ National Foods, National Foods Plant
- ▶ Shujahabad Agro, Agricultural Chemicals Plant
- ▶ Indus Motors, Automobile Plant

### **2.1.2 Eastern Industrial Zones**

The major existing and under construction developments include the following:

- ▶ Engro Polymer and Chemicals, Chlor-Vinyl Chemical Complex
- ▶ Engro Fertilizer, Engro Zarkhez (NPK Blending Plant)
- ▶ Fauji Fertilizer Bin Qasim, Bin Qasim Fertilizer Complex
- ▶ Geolinks, Hazardous and Non-Hazardous Waste Incineration Plant
- ▶ Linde Pakistan, ASU Plant, Hydrogen Plant, and Carbon Dioxide Plant
- ▶ Lotte Chemicals Pakistan, Purified Terephthalic Acid Plant
- ▶ Port Qasim Electric Power Company, 1,320 MW Coal-fired Power Plant (under construction)
- ▶ FPCL Power Company, Coal Power Plant (under construction)
- ▶ Geolinks, Hazardous and Non-Hazardous Waste Incineration Plant
- ▶ Textile Institute of Pakistan
- ▶ TransAsia Group, Refinery (land reclaimed but construction has been suspended for the past 5 years)
- ▶ Proctor and Gamble, Laundry Plant
- ▶ Sabirs Group, Sabirs Feeds
- ▶ ASG Metals Limited, ASG Steel Manufacturing Plant
- ▶ Exide Pakistan Limited, Exide Sulfuric Acid Plant

### **2.1.3 Southwestern Zone**

Existing and under construction terminal developments include the following:

- ▶ Fauji Akbar Portia (FAP), Grain and Fertilizer Terminal (FAP terminal)
- ▶ Dubai Port World (DP World), Qasim International Bulk Terminals (QICT)
- ▶ Dubai Port World (DP World), 2<sup>nd</sup> Container Terminal (QICT 2)
- ▶ Felda Westbury Qasim Limited (FWQ), Liquid Cargo Terminal (LCT)
- ▶ Fauji Oil Terminal and Distribution Company (FOTCO), Oil Terminal (FOTCO terminal)
- ▶ Pakistan Steel Mills, Iron Ore and Coal Berth (IOCB)
- ▶ Engro Vopak Terminal Limited, Bulk Liquid Chemicals Terminal (EVTL)
- ▶ Elengy Terminal Limited, Liquefied Natural Gas Terminal
- ▶ Sui Sothern Gas Company LPG Limited (SSGC), LPG terminal (SSGC Terminal)
- ▶ Marginal Wharfs
- ▶ Pakistan International Bulk Terminal (PIBT) for coal, clinker and cement (under construction)

## **2.2 Anticipated Developments in PQA Zones and Notified Area**

There are plans to expand the port facilities to accommodate larger vessels and increase the cargo handling capacity of the port, as well as other industrial development. The anticipated developments include (**Exhibit 2.4**):

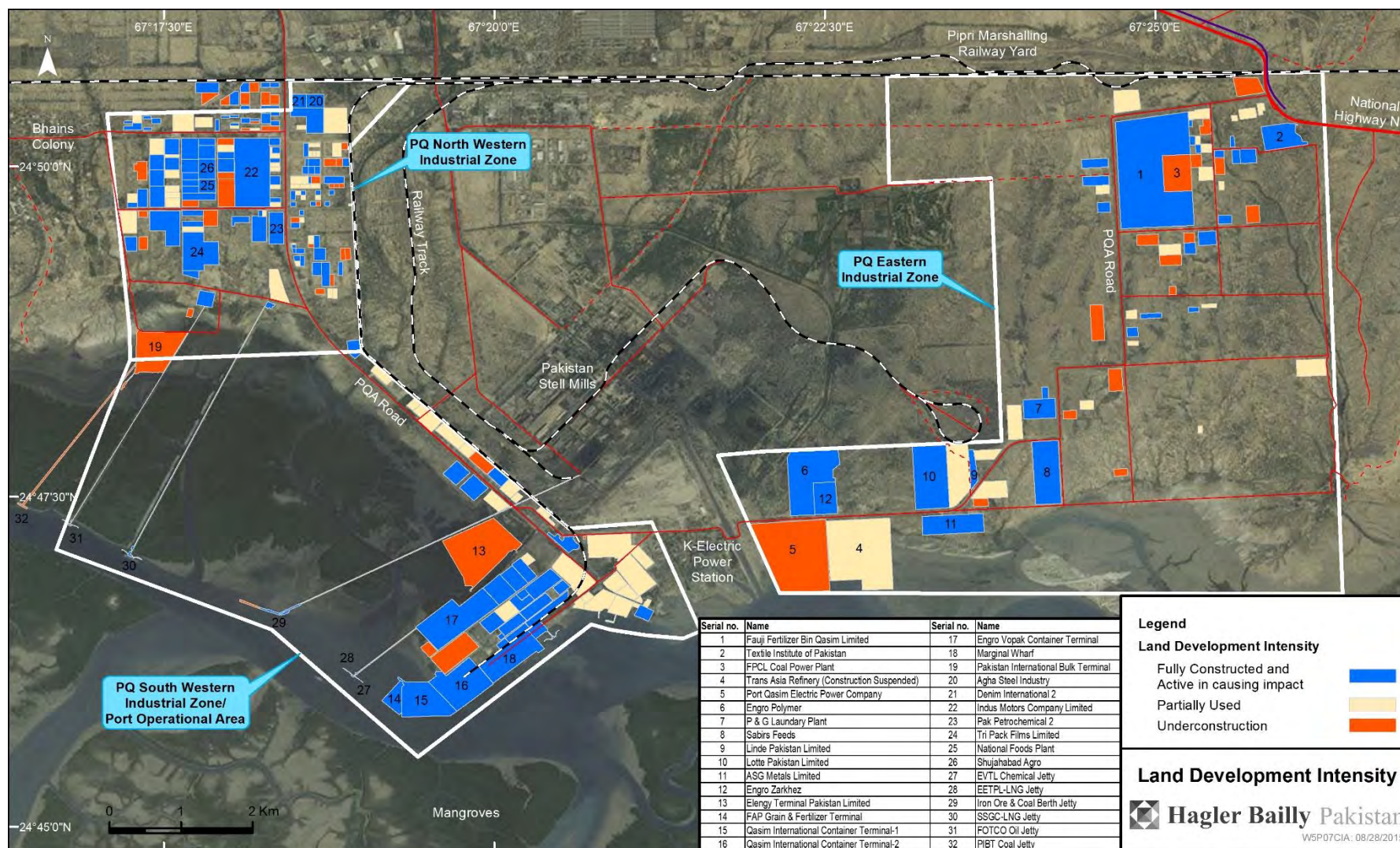
- ▶ Widening and deepening of existing channels and dredging for a new alternate channel:
  - ▷ Deepening of the existing navigation channel (along Phitti and Kadiro Creeks) for all-weather 14 meter draught
  - ▷ Extension of the existing navigation channel to extend to the under-construction Port Qasim Electric Power Company Power Plant
  - ▷ Dredging for a new, alternate navigation channel (along Chara, Rakhal and Chhan Wado Creeks)
- ▶ Construction of additional floating terminals:
  - ▷ Coal terminals<sup>17</sup>
  - ▷ Iron ore and coal berth 2 (second steel jetty)
- ▶ Development of industrial and power generation units within the Northwestern Zone and Eastern Zone, including the following:
  - ▷ Textile City, which includes a dedicated 25 km long water channel, power generation plant and an effluent treatment plant
  - ▷ Siddique Sons Limited, 350 MW Coal-fired Power Plant
  - ▷ Engro PowerGen Limited, 225 MW RLNG Power Plant

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<sup>17</sup> Tender Notice, [http://www.pqa.gov.pk/downloads/tenders/eoi\\_corrigendum\\_no.3\(3\).pdf](http://www.pqa.gov.pk/downloads/tenders/eoi_corrigendum_no.3(3).pdf)

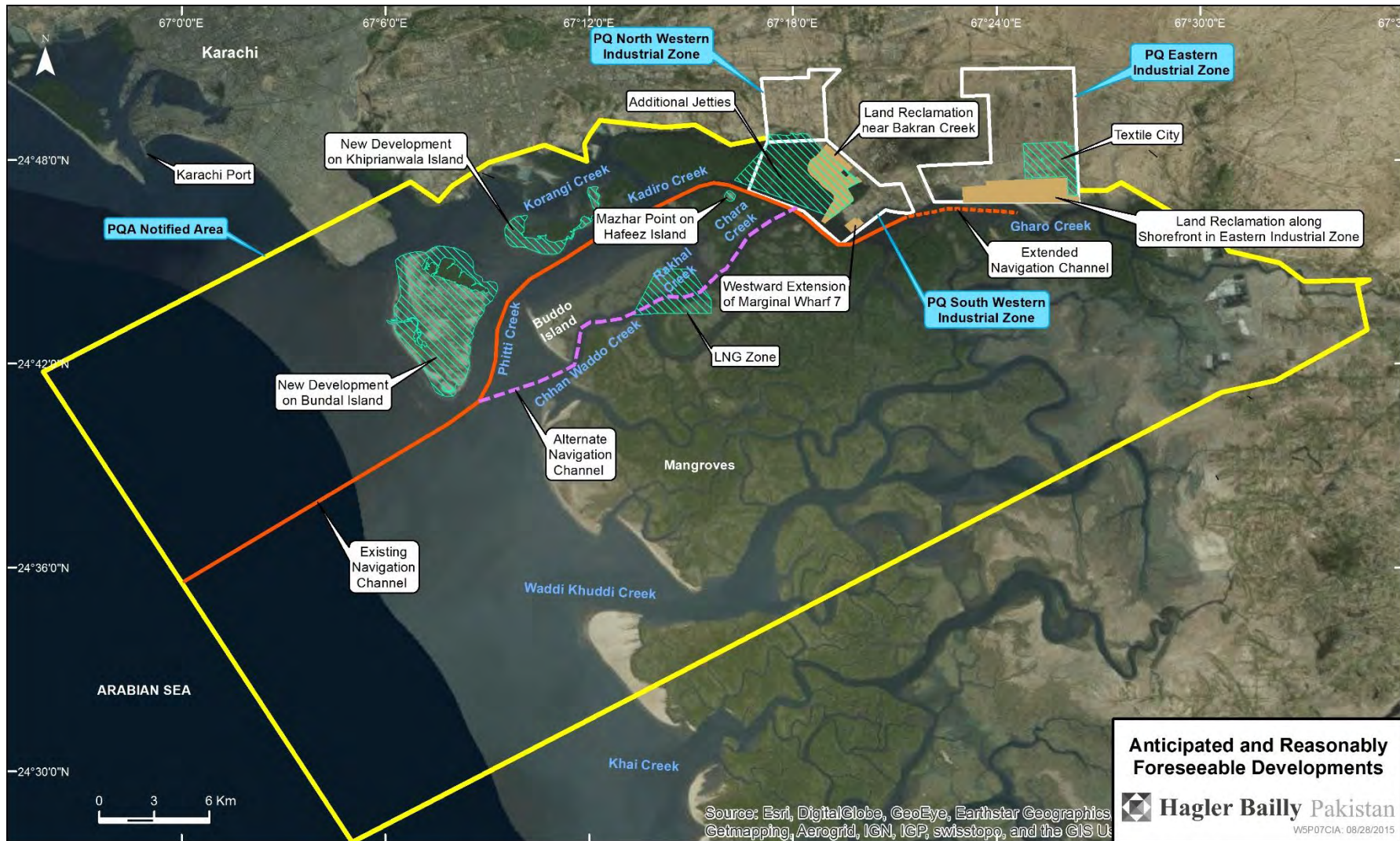


**Exhibit 2.3: Land Development Intensity in Port Qasim Zones**





**Exhibit 2.4: Anticipated and Reasonably Foreseeable Developments**



## **2.3 Reasonably Foreseeable Developments**

Reasonably foreseeable developments exist largely outside the current land development zones and include:

- ▶ Dredging for a new, alternate navigation channel (along Chara, Rakhal and Chhan Wado Creeks)
- ▶ Development of LNG terminals within the LNG Zone; covering approximately 711 hectares along the alternate navigation channel.
- ▶ Developments at Bundal and Khiprianwala Islands (e.g. recreational developments or deep water berths for liquid bulk, dry bulk and container ships and related industrial development) and Ziarat Shah Islands.<sup>18</sup>
- ▶ Developments at Mazhar Point on Hafeez Island (across Gharo Creek from the South Western Zone).
- ▶ Land acquisition (non-shorefront) along eastern edge of Eastern Industrial Zone, approximately 485 hectares (1,200 acres).
- ▶ Land reclamation along shorefront in Eastern Industrial Zone.
- ▶ Land reclamation in other areas identified in the Strategic Planning Study for Port Qasim (**Section 2.8.5** of Strategic Planning Study for Port Qasim 2000-2050) including Bakran Creek.

## **2.4 Existing Environmental Facilities at Port Qasim**

There are a number of centralized environmental services and facilities that the Environment and Safety Department of the PQA provides to the industries (see **Appendix A** for further information). These include:

- ▶ Sludge and waste management system for ships
- ▶ Oil spillage control and handling<sup>19</sup>
- ▶ A vigilance team to inspect and regulate on environment, and ensure adherence to industry EIAs and environment agreement clauses<sup>20</sup>
- ▶ Wastewater treatment facility for a limited number of industries in vicinity of the treatment facility
- ▶ Fire-fighting services

The PQA Environment and Safety Department has also been involved with NGOs, such as the IUCN and WWF, and industrial groups operating within the PQA in setting up a nursery in the Port area and replantation of mangroves in degraded areas. The Environment and Safety Department is involved in plantation of trees in the PQA Zones

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<sup>18</sup> See Strategic Planning Study 2000-2050 for Port Qasim, 2001

<sup>19</sup> PQA has also participated in training and provided support and manpower on handling discharge of oil to FOTCO.

<sup>20</sup> One terminal operator and eight industrial companies have been penalized through fines by the vigilance team.

and has also provided facilities to universities and facilitated research work on mangroves.

## **2.5 Transport Infrastructure**

### ***Existing Transport Infrastructure***

The National Highway (N-5) and Pakistan Railways main line running east-west in the north of the Port Qasim Zones provide the main link to Karachi and the rest of Pakistan (**Exhibit 2.5**). Access to the port area and the industrial zones is through a black-top road that connects to the National Highway (N-5) at two points. A railway branch line from Pipri Junction, located north of the PQA connect the Pakistan Steel Mill to the main line.

### ***Anticipated Transport Infrastructure Development***

There are plans of upgradation of the transport links to Port Qasim. These include (**Exhibit 2.5**):

- ▶ Rehabilitation and widening of National Highway (N5) and Link Road connecting the National Highway (N5) to the Super Highway (M-9).
- ▶ Rail connection passing by Northwestern Industrial Zone for terminals, for the Pakistan International Bulk Terminal (PIBT) and other possible terminals.
- ▶ Rail connection to the Southwestern Industrial Zone.
- ▶ 26 km long dual carriage way from National Highway T-junction passing through Western and Eastern zones.

## **2.6 Major Projects near the PQA**

Major projects in the vicinity of the PQA industrial zones, which are although not located on land under the jurisdiction of PQA but share resources or infrastructure include:

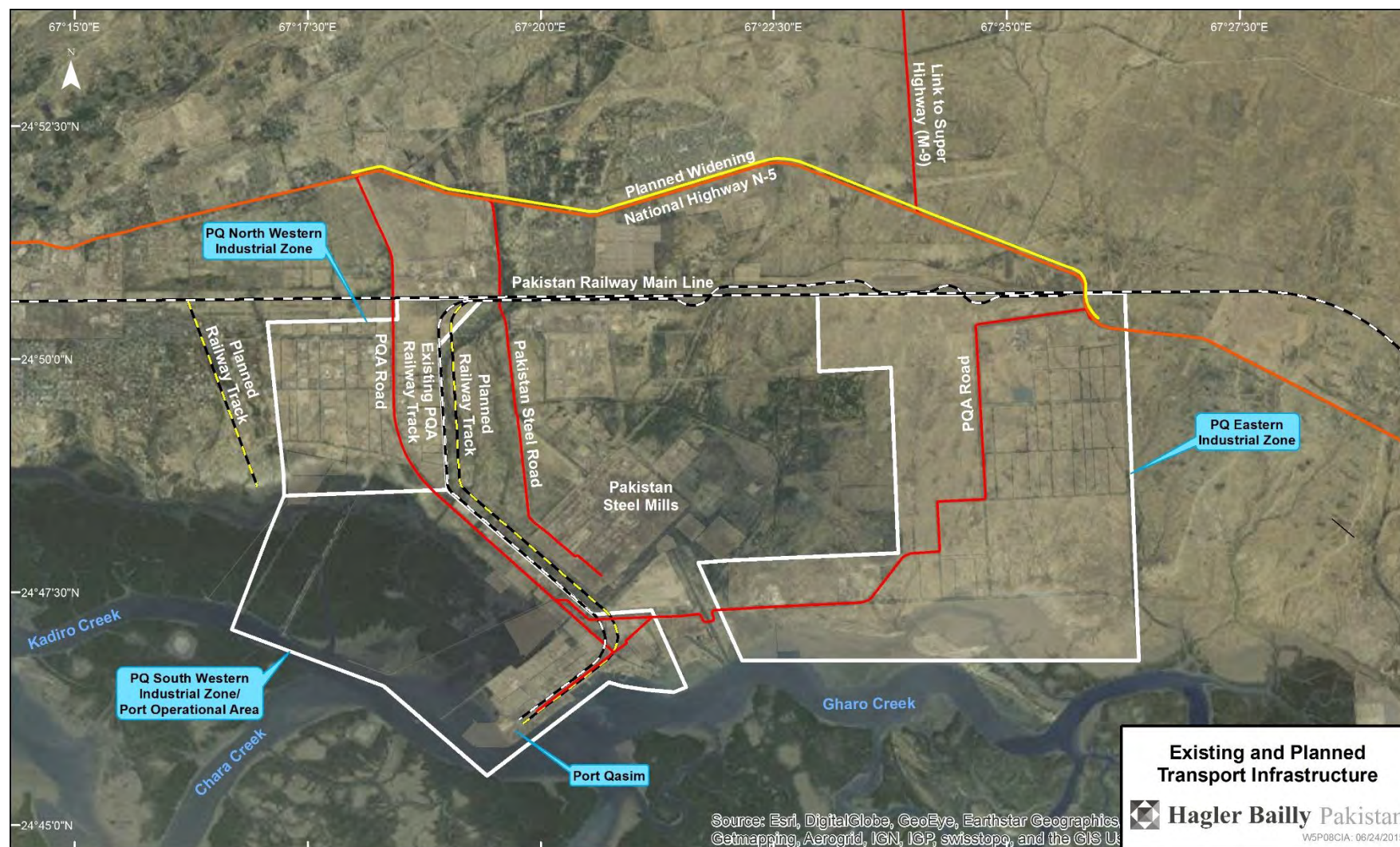
- ▶ Pakistan Steel Mills
- ▶ K-Electric Power Station, Gas and Oil-fired Power plant (about 1,800 MW)
- ▶ Landhi Industrial Area
- ▶ Korangi Industrial Area
- ▶ Pipri Railway marshaling yard
- ▶ Planned housing schemes near National Highway (N-5), including Pakistan Steel Township, Shah Latif Town, New Mali Housing Schemes, and Railway Colony

The anticipated projects in the vicinity of the PQA industrial zones include:

- ▶ Lucky Cement, 660 MW Coal-fired Power Plant
- ▶ Partial conversion of K-Electric Power Station to coal
- ▶ Wind farms, south of Gharo



**Exhibit 2.5: Existing and Planned Transport Infrastructure**



## **2.7 Regional Development Scenario**

The development scenario for the CIA is presented in this section.

The Port Qasim Strategic Plan outlines the plan for development of Port Qasim till 2050. While there have been some recent deviations from the plan, to cater for market demand and pressures, the plan has largely been followed. The PQA achieved targets set in the Strategic Plan for 2010.

Further development at the Port will be limited by the following:

- ▶ Development of Gwadar Port, along with developments at Karachi Port, will compete with Port Qasim. While Gwadar Port is currently not fully functioning, it is expected to be fully operational within the next 10-15 years. Expansion is planned at Karachi Port for additional berths, including additional container terminals and storage facility, as well as coal handling facilities.
- ▶ Development of Thar Coalfields (with four blocks currently allocated and in relatively advanced stages of planning or development) including mines and power plants at each block. Power plants associated with each block having a capacity upwards of 1200 MW, and up to 3960 MW for one block, are going to start producing power within the next 5-10 years. Therefore additional coal import facilities are unlikely to be developed at Port Qasim.

Given current levels of growth in Pakistan, particularly the focus on development of coal-fired power plants, it is expected that all developments anticipated and reasonably foreseeable identified in **Section 2.2** and **Section 2.3** will go through. However, beyond this, additional coal-fired power plants utilizing imported coal, other than some smaller units, are unlikely at Port Qasim due to competition from power plants at the Thar Coalfields and multiple hydropower developments such as the Diamer Bhasha Hydropower Project (~4500 MW) and the Dasu Hydropower Project (~4000 MW).

Given the addition of an LNG terminal at the Port, there is requirement for an additional navigational channel. The development is likely to be economically feasible and a requirement for Port operations and management of ship traffic.

### **Key Regional Developments**

Port Qasim is in the backdrop of Karachi city. Karachi has seen exponential population growth since the 1940s and the current annual rate of growth is 5%.<sup>21</sup> The city has seen development of land at a proportional rate. While rural communities, along the Port Qasim Notified Area, have seen urbanization, there is development of planned housing communities north of Port Qasim as well, such as the New Malir Housing Scheme.

In addition to housing developments, a number of industrial areas have been developed in the region, including the Landi Industrial Area, Korangi Industrial Area, and the relatively new Korangi Creek Industrial Park. These developments are surrounded by urban communities. There is little potential for further development or rezonation of residential land to industrial, particularly in areas west of Port Qasim.

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<sup>21</sup> <http://worldpopulationreview.com/world-cities/karachi-population/>

### **3. Study Area and Temporal Boundaries for Impact Assessment**

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This section describes the Study Area (spatial boundary) and temporal boundary for impact assessment.

#### **3.1 Study Area (Spatial Boundary)**

The regional setting of Port Qasim is shown in **Exhibit 3.1**. A map of selected Study Area is provided in **Exhibit 3.2**. The Study Area is selected to include the following:

- ▶ Notified PQA Area
- ▶ Surrounding communities that have reliance on natural resources within the Notified PQA Area
- ▶ Surrounding communities that obtain livelihood or may be impacted by Development at Port Qasim
- ▶ Surrounding industrial areas and developments that may impact selected Valued Environmental and Social Components (VECs)

Using available information, the Study Area has been divided into various zones largely on the basis of predominant land-use (see **Section 4.2**) and resource-use, as well as documented variations in socioeconomic setting (see **Section 5**).

For clarity, the overall Study Area is enlarged and shown across three maps that show the zones in central, western, and eastern Study Areas (**Exhibit 3.3**, **Exhibit 3.4** and **Exhibit 3.5**, respectively). These zones include the following:

- ▶ Fishing communities
- ▶ Non-fishing communities
- ▶ Urban communities
- ▶ Planned housing schemes
- ▶ Fishing/agricultural communities
- ▶ Military/Industrial Area
- ▶ Port Qasim Industrial Zones
- ▶ Korangi and Landhi Industrial Areas

#### **3.2 Temporal Boundary**

The temporal extent for coverage within the Cumulative Impact Assessment has been selected to be till 2050. The boundary is chosen such that it includes the time-period covered in the Strategic Planning Study for Port Qasim 2000 to 2050 (2000).

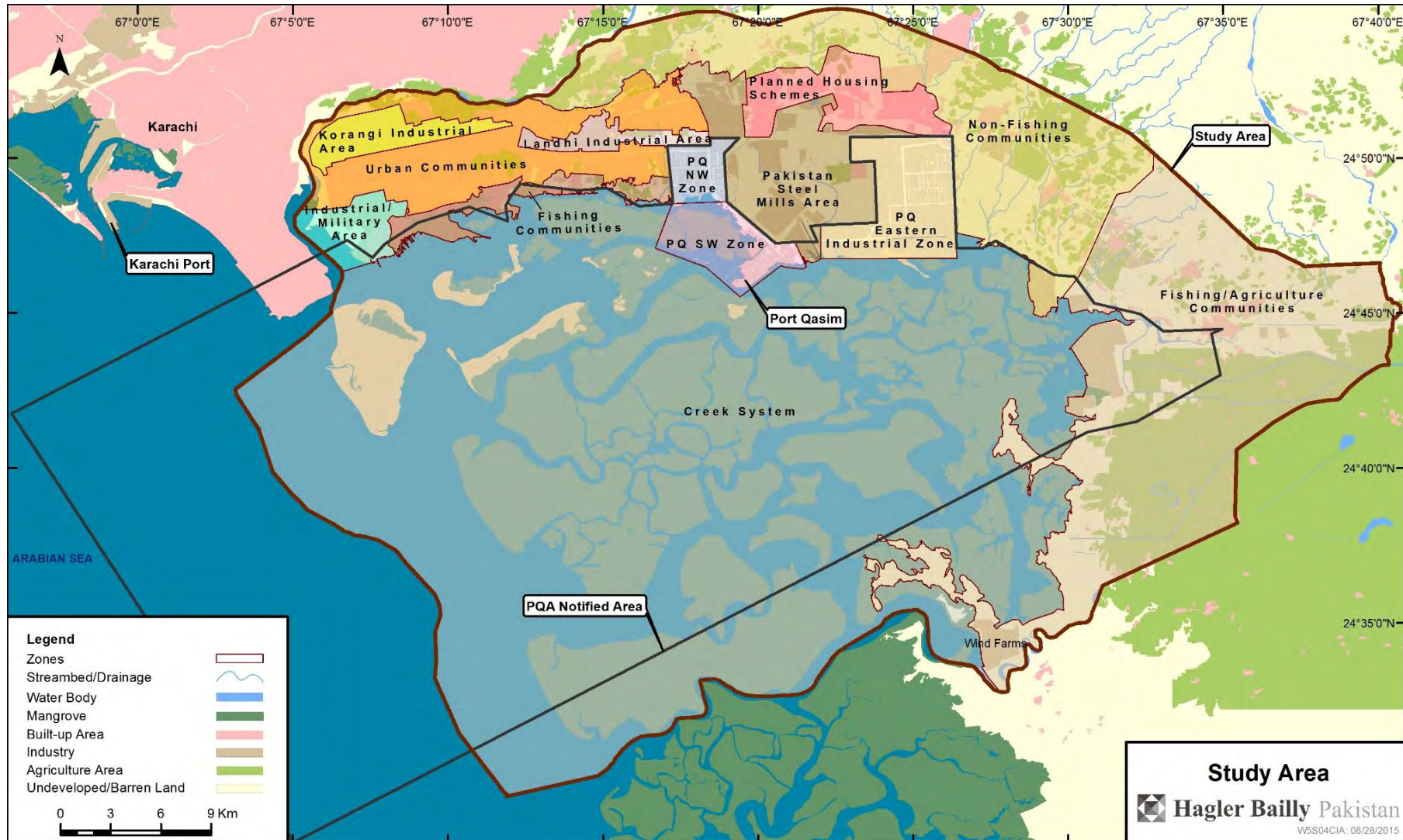


Exhibit 3.1: Regional Setting



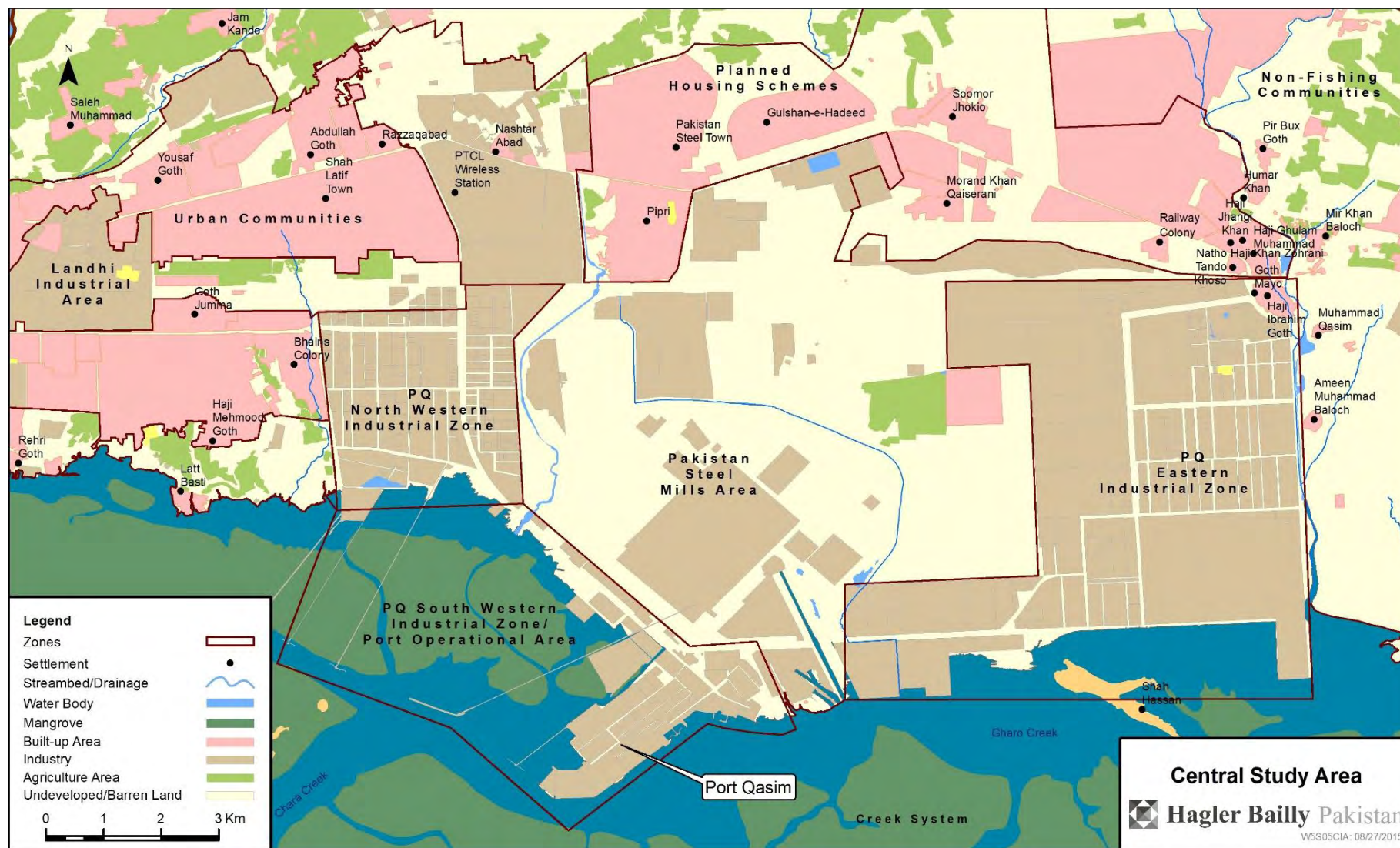


**Exhibit 3.2: Study Area**





**Exhibit 3.3: Central Study Area**



**Exhibit 3.4: Western Study Area**

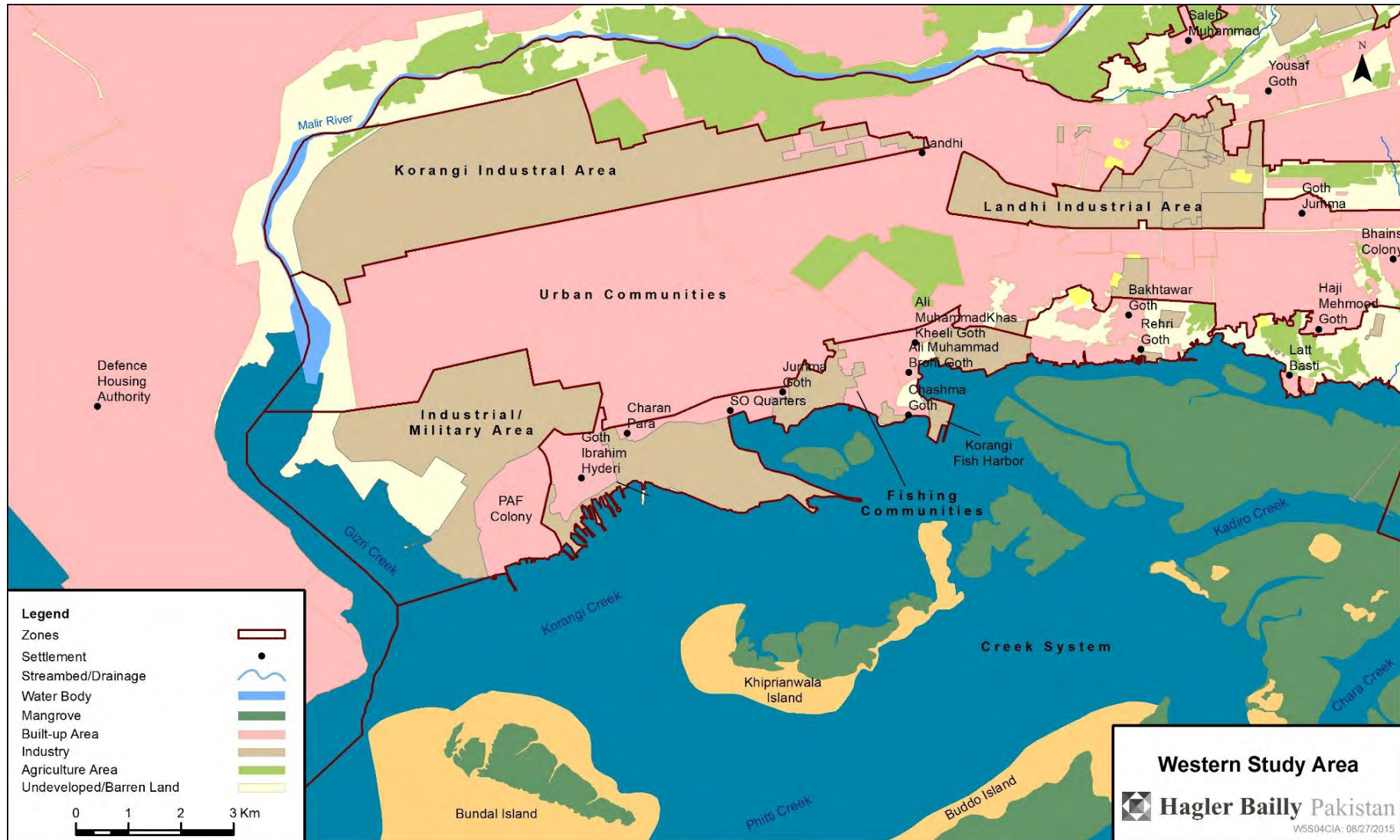
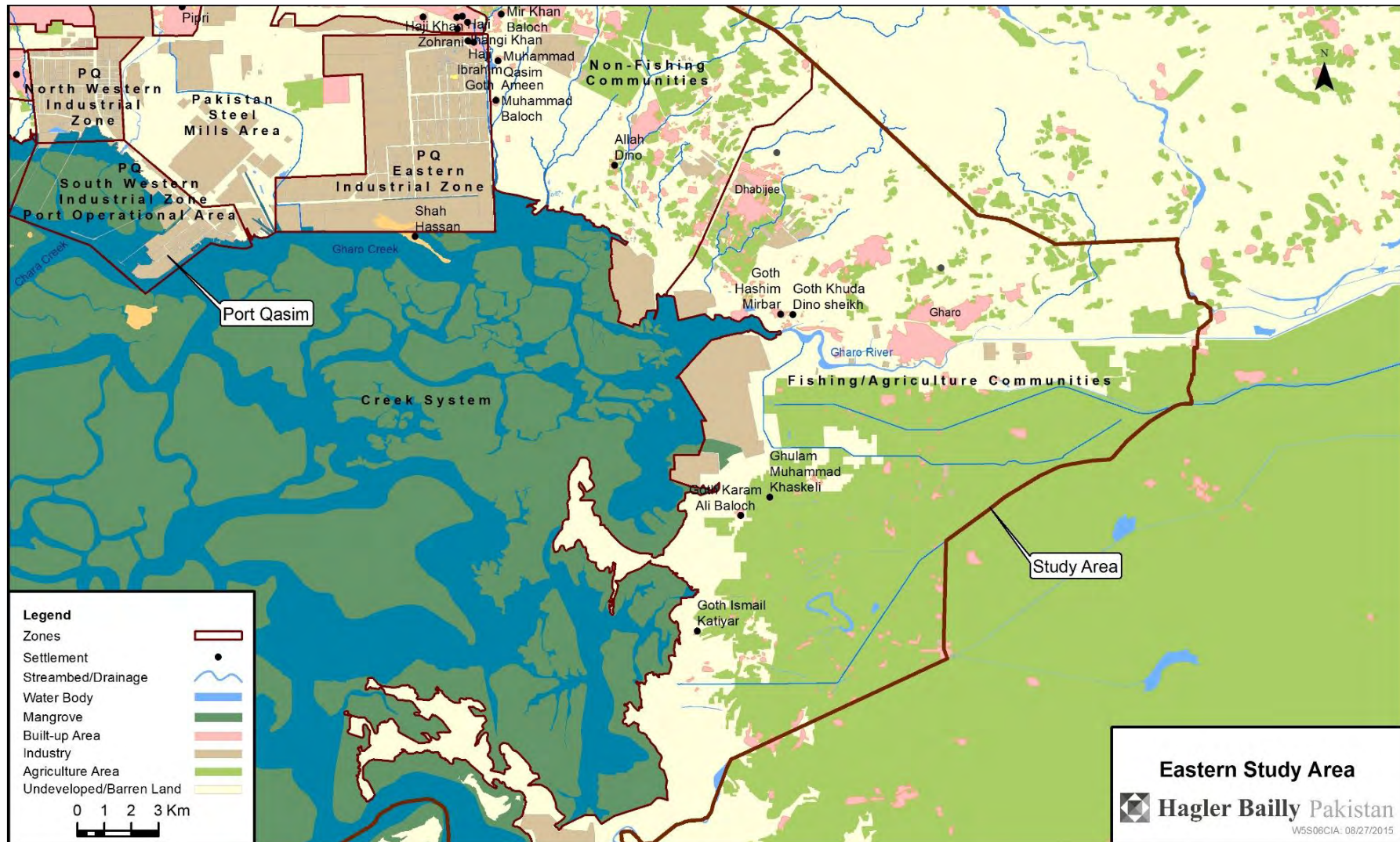




Exhibit 3.5: Eastern Study Area



## 4. Physical Baseline

### 4.1 Topography

The topography in the Study Area is shown in **Exhibit 4.2**. The topography is relatively gentle, with increasing elevation towards the north of the Study Area. The land bordering the intertidal delta (i.e. mangroves and mudflats) within the Study Area, and the east of the Study Area, has an elevation less than 5 m above mean sea level (amsl). The land in the northern periphery of the Study is largely between 10 and 60 m amsl.

### 4.2 Land Cover and Use

The land cover and use in the Study Area was classified using aerial imagery<sup>22</sup>, followed by ground-truthing to confirm the classified areas.

#### **Land cover and use within Study Area**

The land cover and use classifications and associated areas are provided in **Exhibit 4.1**. The related map is provided in **Exhibit 4.3**. The percentage breakdown of the land use and cover within the Study Area is shown in the pie chart in **Exhibit 4.4**.

The analysis indicates that the majority (29%) of the Study Area is occupied by channels and creeks of the non-active part of the Indus Delta. Mangroves and mudflats/beaches occupy 19% and 10% of the Study Area respectively, while 19% is barren land.

Agricultural areas occupy 9% of the Study Area, whereas 6% and 7% of the Study Area comprises industrial and commercial areas (including Port Qasim) and built-up residential areas, respectively.

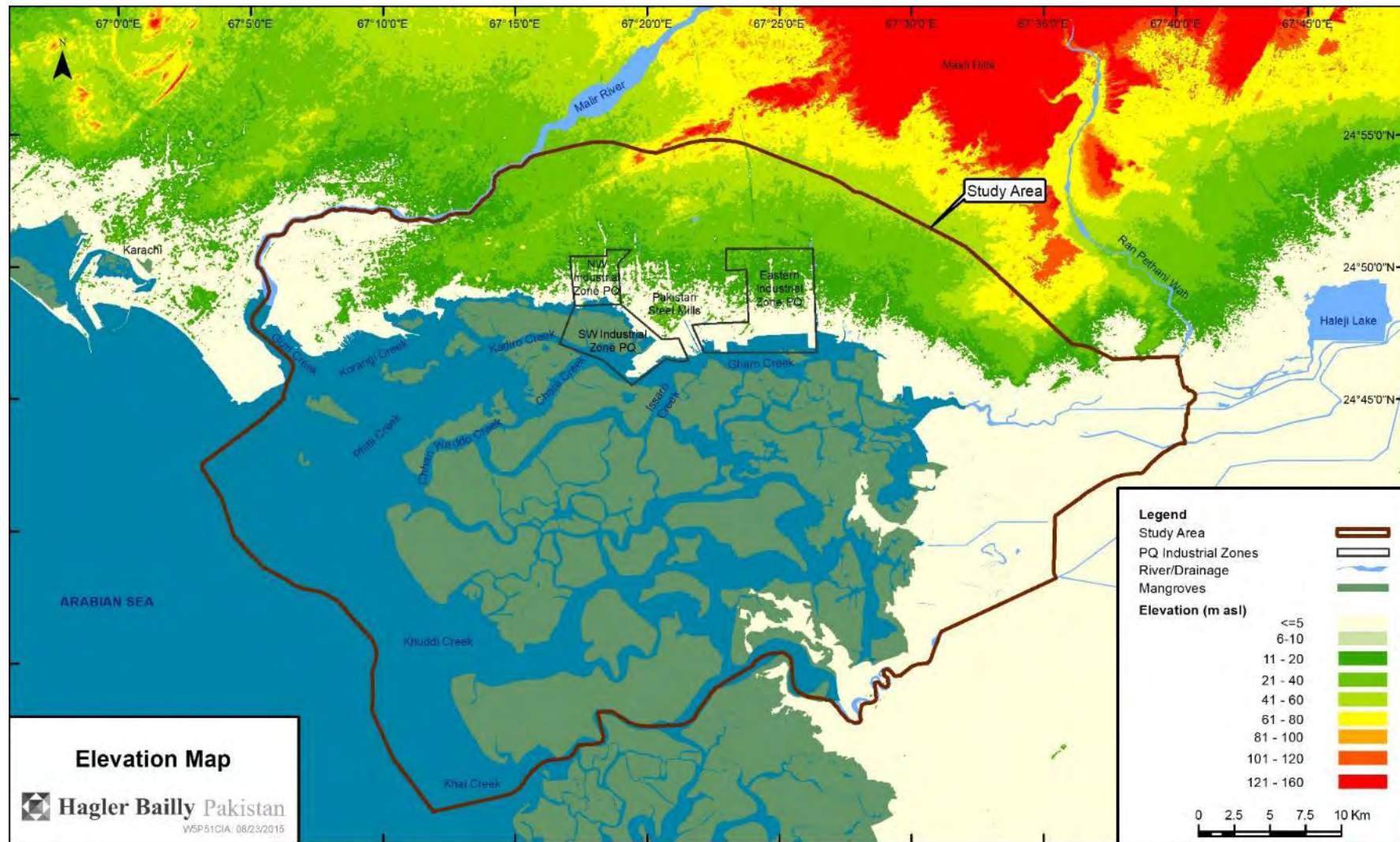
**Exhibit 4.1:** Land Cover and Use Class within Study Area

<i>Land Cover and Use Class</i>	<i>Area (Hectares)</i>
Industrial and Commercial Areas	10,210
Built-up Residential Areas	11,938
Agricultural Areas	17,130
Surface Water Bodies (Fresh and Wastewater)	541
Graveyards	42
Saline Channels and Creeks (Intertidal)	53,765
Mangroves	35,546
Mudflat and Beaches	18,915
Barren Land	35,517
<b>Total Study Area</b>	<b>183,605</b>

<sup>22</sup> Based on satellite imagery from 2014 and ground truthing in June 2015.



**Exhibit 4.2: Topography in the Study Area**

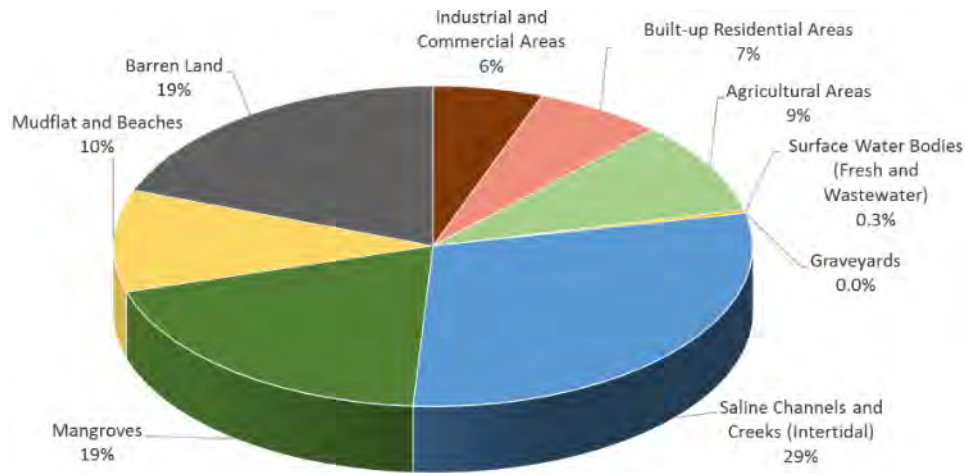




**Exhibit 4.3: Land Cover and Use in the Study Area and Port Qasim Authority Notified Area**



**Exhibit 4.4: Land Cover and Use by Percentage**



#### **Land Cover and Use within Notified PQA Area**

The major land cover and use classifications (i.e. mangroves, mudflats and beaches, and saline channels and creeks) within the PQA Notified Area and their percentages are provided in **Exhibit 4.5**. The majority (65%) of the PQA Notified Area comprises of saline channels and creeks of the non-active Indus Delta. The remainder is occupied largely by mangroves (22%), mudflats and beaches (9%) and other areas (4%) such as industrial, commercial, residential and agriculture.

**Exhibit 4.5: Land-Use within Notified PQA Area**

<i>Land-Use Class</i>	<i>Percentage</i>
Mangroves	22%
Mudflats and Beaches <sup>23</sup>	9%
Saline Channels and Creeks (Intertidal)	65%
Other (e.g. industrial, commercial, residential agricultural, etc)	4%
<b>Total PQA Notified Area</b>	<b>100%</b>

### **4.3 Geology**

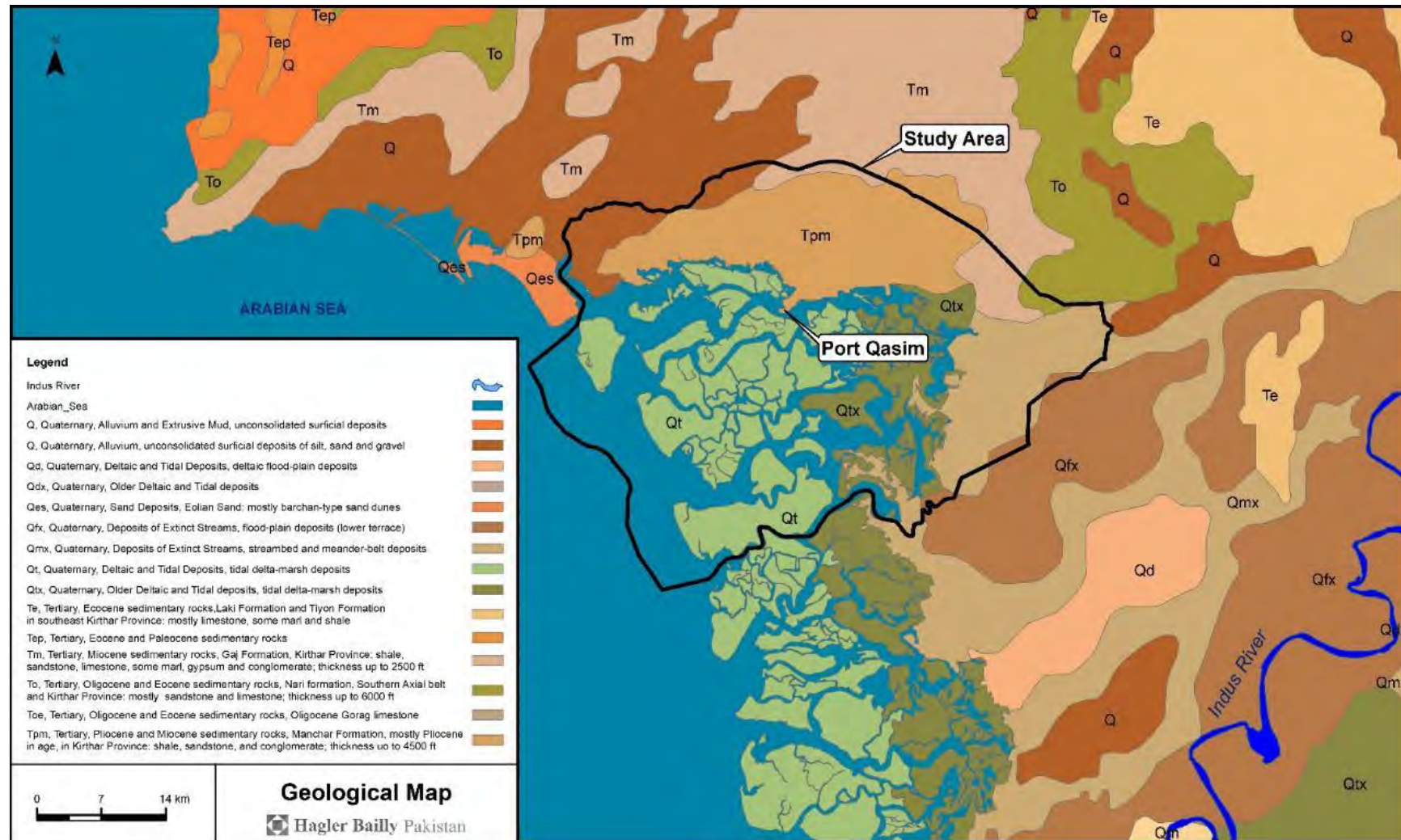
The lithological units within the Study Area, and in the region, are shown in **Exhibit 4.6**.

Within the Study Area, quaternary unconsolidated sedimentary sand, silt and gravel deposits (Qt, Qtx and Qmx in **Exhibit 4.6**) bound fold belts (Tpm in **Exhibit 4.6**) in associated with the southern extension of the Kirthar Range. Within the Study area the quaternary unconsolidated deposits are associated with the non-active part of the Indus Delta as well as tides.

<sup>23</sup> Based on ground truthing carried out on September, 2015, stunted mangroves cannot easily be deciphered from mudflats and beaches using aerial imagery.



**Exhibit 4.6: Lithology in the Study Area**



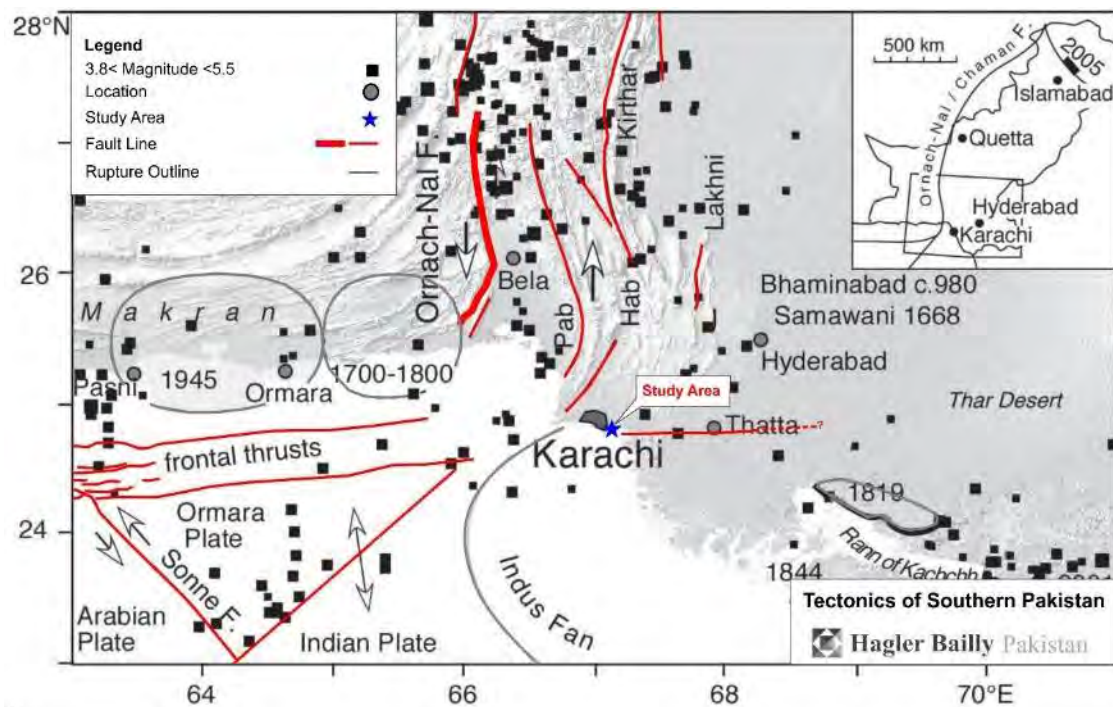
Source: Geological Survey of Pakistan (GSoP) and United States Geological Survey (USGS). "Geological Map of Pakistan [Scale: 1:2,000,000]" (1964)

#### 4.3.1 Faults, Earthquakes and Seismic Hazard

Port Qasim is located adjacent to an active tectonic setting, and is approximately 190 km east of the triple continental junction between the Arabian, Eurasian and Indian plates. A tectonic map of southern Pakistan, with the Study Area indicated, is provided in **Exhibit 4.7**.

Three structures associated with major crustal movements west of the Study Area include the strike-slip Ornach–Nal Fault, the strike-slip Sonne Fault and frontal thrusts associated with the Makran Subduction Zone (MSZ) in the Indian Ocean. Additionally, smaller intraplate faults associated with subduction are present in the vicinity of Karachi and the Study Area. These include the east-west striking Kutch Fault that extends from Karachi and along the Rann of Kutch.

**Exhibit 4.7: Tectonics of Southern Pakistan<sup>24</sup>**



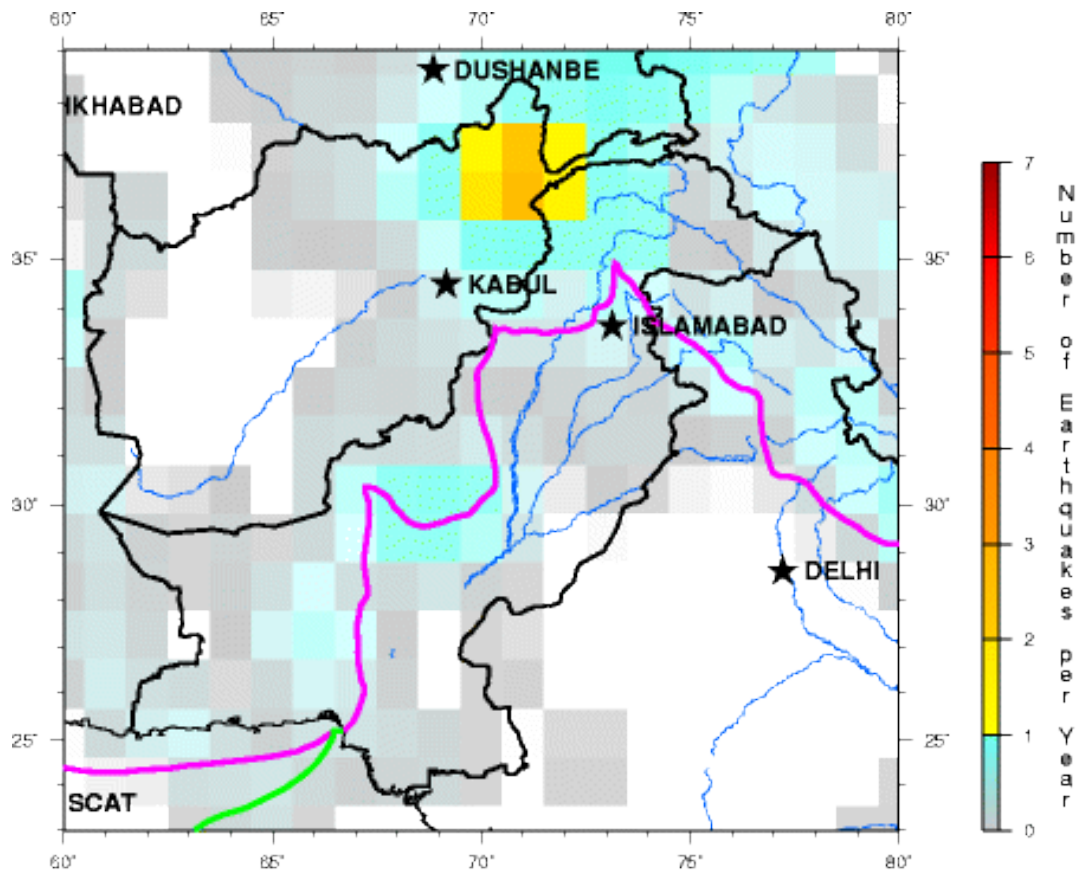
The Study Area experiences an earthquake density of less than 1 per year (**Exhibit 4.8**). Earthquake epicenters, for magnitudes between 3.8 and 5.5  $M_L$ <sup>25</sup>, have been recorded along the Pab fault, Hab Fault, Ornach–Nal fault, smaller micro faults east of Karachi and in the offshore areas southwest of Port Qasim (**Exhibit 4.8**).

Based on the Global Seismic Hazard Map Project (GSHAP), the peak ground acceleration (PGA) of 10% in 50 years is  $1.6 \text{ m/s}^2$  (**Exhibit 4.9**).

<sup>24</sup> Adapted from Bilham *et al.* "Seismic Hazard in Karachi, Pakistan: Uncertain Past, Uncertain Future" *Seismological Research Letters* 78 (2007). Note, a number of lateral thrust faults exist along the Rann of Kutch. Some of these may extend to Karachi. Only the Kutch fault based on one interpretation is shown in the Exhibit.

<sup>25</sup>  $M_L$ : Richter scale

**Exhibit 4.8: Earthquake Density of Pakistan<sup>26</sup>**



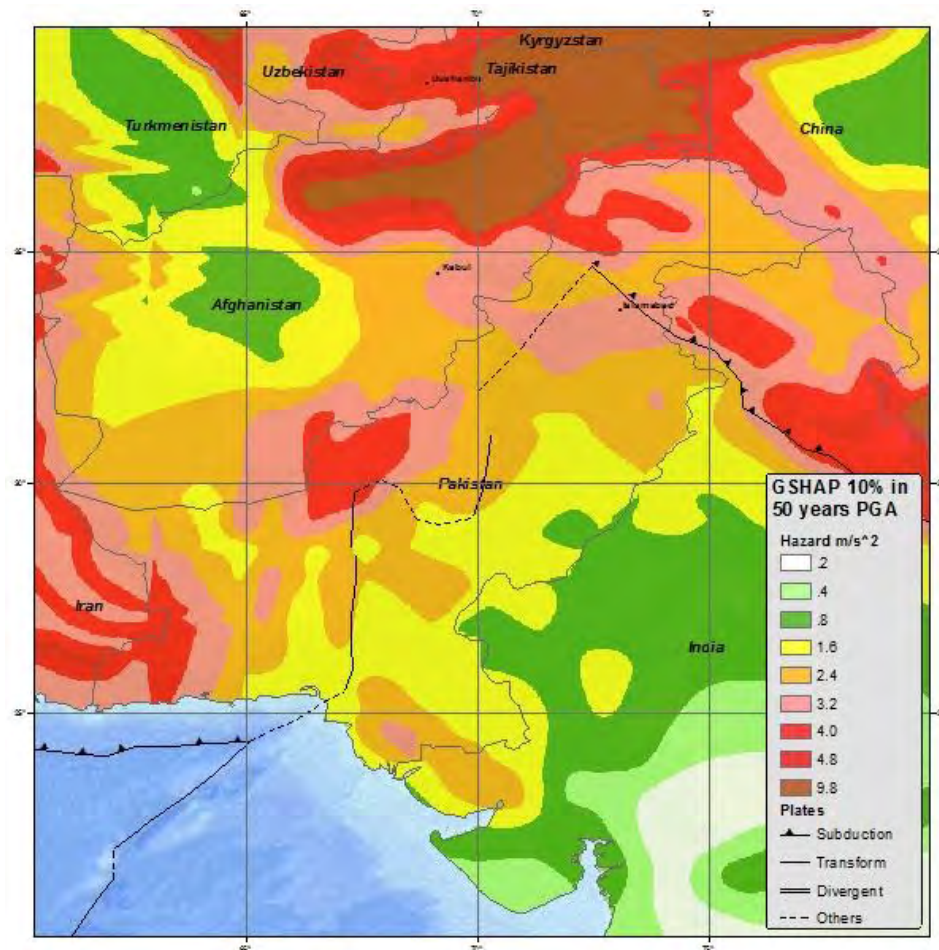
Number of Earthquakes per Year, Magnitude 5 and Greater, All Depths

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green

<sup>26</sup> United States Geological Survey (USGS), "Earth Quake Density of Pakistan", accessed 15 September 2014, <http://earthquake.usgs.gov/earthquakes/world/pakistan/density.php>



**Exhibit 4.9: Seismic Hazard Map of Pakistan<sup>27</sup>**



### 4.3.2 Tsunamis

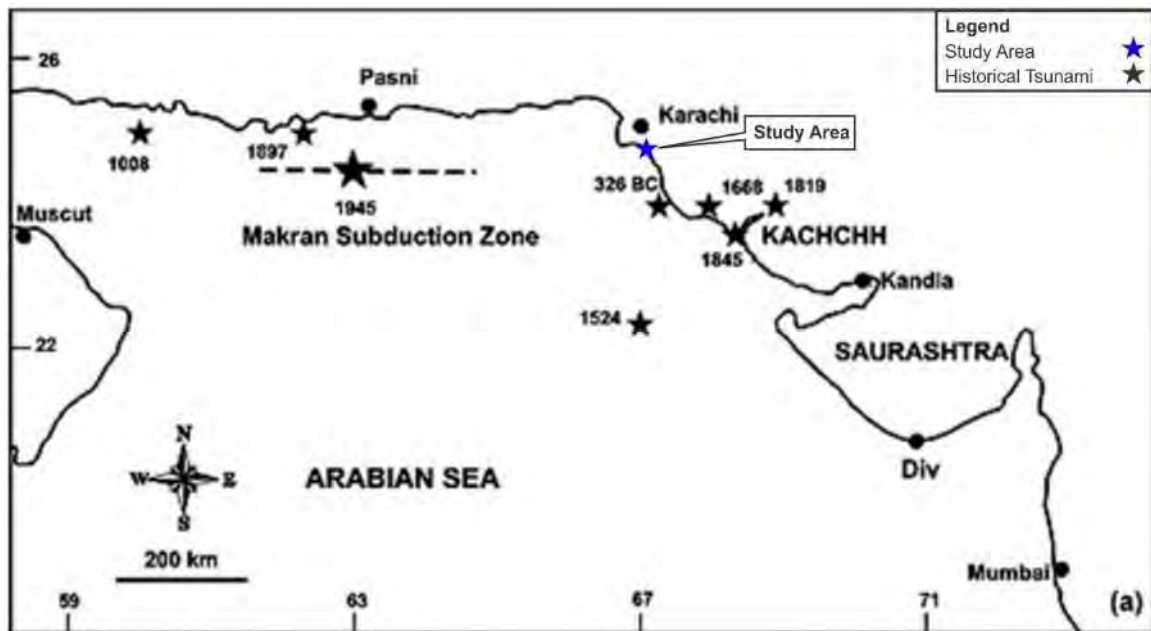
The coast of Pakistan is in an area of potential tsunami. While large tsunamigenetic earthquakes have been relatively rare, there is potential for a tsunami associated with the Makran Subduction Zone (MSZ) or smaller localised tsunamis associated with several smaller thrust faults around Karachi<sup>28</sup>.

A map of historical tsunamis that have been generated, some in close proximity to the Port Qasim Area, is shown in **Exhibit 4.10**. These are associated with both the MSZ, as well as localized and smaller faults along the Karachi coast extending east towards India.

<sup>27</sup> United States Geological Survey (USGS), "Seismic Hazard Map of Pakistan" (based on GSHAP), accessed 15 September 2014, <http://earthquake.usgs.gov/earthquakes/world/pakistan/density.php>

<sup>28</sup> Pararas-Carayannis. "The potential of tsunami generation along the Makran Subduction Zone in the northern Arabian Sea. Case study: the earthquake and tsunami of November 28, 1945", Science of Tsunami Hazards 24 (2006).

**Exhibit 4.10:** Historical Tsunamis Generated in the Region (up to 1945)



Source: Shukla et al. "Coastal Geomorphology and tsunami hazard scenario along the Kachch coast, western India" (2010)

The relatively recent tsunami generated along the MSZ in 1945 was responsible for loss of life, approximately 4000 deaths, and destruction along the sparsely populated coast of Pakistan. It is reported that this tsunami was around 1.5 m at Karachi<sup>29</sup> and the associated earthquake of intensity was 8.1  $M_w$ . The 1945 event was followed by another tsunami-related tidal wave in 1953.

Other than tsunamigenic earthquakes along the MSZ, the smaller localized faults extending from Karachi to India can cause "localised" tsunamis<sup>30</sup>. Smaller faults east of Karachi have potential to generate localized tsunamis that may impact Port Qasim<sup>31</sup>.

#### 4.4 Climate

The climate at Port Qasim is characterized as hot and dry during summer, and mild during winter with heavy, sporadic, rainfall during the monsoon. The southwest monsoon prevails from April to October in the Project area and the Indian Ocean. The monsoon is characterized by a reversal in wind direction during the remaining months; and, heavy rainfall over most of the Indian Subcontinent.

The general characteristics of the seasons based on this data is provided in **Exhibit 4.11**. **Exhibit 4.12** and **Exhibit 4.13** shows the monthly temperature and rainfall based on the long term data (1928-1990) measured at Karachi Airport Meteorological Station. The hottest months are between mid-March to June in which the maximum average monthly

<sup>29</sup> Active Faults of the World.

<sup>30</sup> Billham et al. "Southern Pakistan Geology and Tectonics" (2007)

<sup>31</sup> Billham et al. "Southern Pakistan Geology and Tectonics" (2007)

temperature exceeds 40 °C. The winters are mild with temperature dropping to 6 °C in January. Karachi receives approximately 217.3 mm of rain annually. Almost 80% of the rain is concentrated in the monsoon season. **Exhibit 4.14** provides a wind rose based on data for Karachi Airport.

**Exhibit 4.11: Seasonal Characteristics of the Climate of Karachi**

<i>Season</i>	<i>Temperature</i>	<i>Rainfall</i>	<i>Wind</i>
Summer (Mid-March to mid-June)	The summers are hot with temperature increasing from March 26.2 °C rising up to 40 °C in June.	There are less frequent rain showers in summer with no more than 1 or 2 rainy days in summer. Average total amount of rain in summer is around 10 mm	The wind speed in summer is variable. It is around 2.5 m/s in March and rises upto 18 m/s in April and drops to 4 m/s for the rest of the season. The direction mostly remains towards West
Monsoon (Mid-June to mid-September)	The temperature in monsoon remains high but relatively lower than summer and oscillates around 32 °C.	Almost 80 % of the yearly rain occurs in the monsoon with July and August being the wettest month.	The wind direction in the monsoon is mostly towards East
Post-Monsoon Summer (Mid-September to November)	The average temperature post monsoon drops and average minimum temperature may reach 12 °C. in November	The post-monsoon remains mostly dry and rainfall in the November is around 1.8 mm	The wind speed in Septembers is around 3.7 m/s and drops to 1.4 m/s in November.
Winter (December to mid-March)	The winter is mild with January being the coolest month where average minimum temperature falls to 6 °C.	Like the other season except monsoon there is little occasional rainfall. The rainfall in winter is less than 50 mm	The wind speed in the winter season increase from 1.4 m/s in December to 2.6 m/s in March. The wind direction for most part winter season is towards North-East and changes its course towards West in early March

**Exhibit 4.12: Mean Monthly Temperatures (°C) of Karachi Airport  
Meteorological Station**

Month	Mean of Monthly		Highest Recorded*		Lowest Recorded*	
	Maximum	Minimum	Value	Date	Value	Date
Jan	29.1	6.1	32.8	16/1/1965	0	21/1/1934
Feb	32.0	7.7	35.0	29/2/1960	2	11/2/1950
Mar	36.1	12.2	39.0	26/3/1977	8	2//3/1939
Apr	40.1	17.7	44.0	16/4/1947	13	5/4/1940
May	41.5	22.2	48.0	9/5/1938	18	9/5/1960
Jun	40.1	25.4	47.0	18/6/1979	22	3/6/1940
Jul	37.5	25.0	42.0	3/7/1958	22	22/7/1938
Aug	35.5	23.9	41.7	9/8/1964	23	12/8/1933
Sep	37.4	22.7	43.0	30/9/1951	18	30/9/1950
Oct	39.3	16.1	43.0	1/10/1951	10	30/10/1949
Nov	35.6	11.2	38.5	1/11/1986	6	29/11/1938
Dec	31.0	6.8	33.9	8/12/1963	2	30/12/1932
Annual	36.3	16.4	48.0	9/5/1938	0	21/1/1934

\* Highest and lowest recorded temperatures are based on data collected at the Karachi meteorological station since it was established in 1928-1990

**Source:** Pakistan Meteorological Department

**Exhibit 4.13: Rainfall measured at Karachi Airport Meteorological Station**

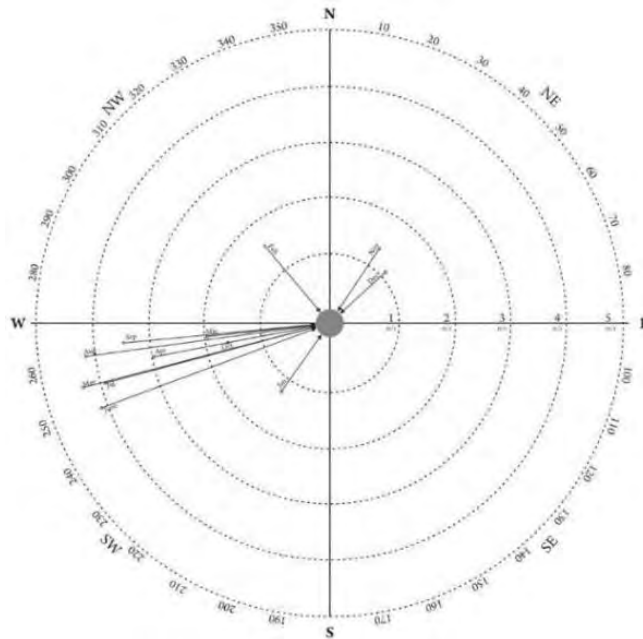
Month	Mean Monthly (mm)	Wettest Month*		Mean Number of Rainy Days
		Value (mm)	Year	
Jan	6.0	66.8	1976	0.5
Feb	9.8	96.0	1979	0.6
Mar	11.7	130.0	1967	0.4
Apr	4.4	52.8	1935	0.3
May	0.0	33.3	1933	0.0
Jun	5.5	85.9	1936	0.7
Jul	85.5	429.3	1967	2.6
Aug	67.4	359.4	1944	2.5
Sep	19.9	315.7	1959	0.7
Oct	10.0	98.0	1956	0.1
Nov	1.8	83.1	1959	0.2
Dec	4.4	63.6	1980	0.7
Annual	217.3	745.5	1944	9.4

\* Based on data collected at the Karachi station since it was established in 1928-1990

\*\* 'Rainy day' is defined as a day on which at least 0.1 mm of rain is recorded

**Source:** Pakistan Meteorological Department

**Exhibit 4.14:** Wind Rose of Karachi city based on 30 years wind data (1961-1990)



#### 4.4.1 Storms and Cyclones

Severe storms and cyclones seldom cross the coast of Pakistan. **Exhibit 4.15** shows the monthly intensity and location of cyclonic activities. The main cyclonic activity in the Project Area takes place in the month of June. All the cyclonic storms that emerge in the Arabian Sea either curve sharply into the Gulf of Kutch or cross the Arabian Sea from East to West and end up at the coast of the Arabian Peninsula. When the cyclones cross the coast they are accompanied by storm surges, generally known as storm tides. The cyclones that cross the coast in the month of June generate winds of approximately 15-18 m/s.

**Exhibit 4.15:** Month-wise Intensity and Location of Storms in Arabian Sea

Month	Intensity of Storms On an arbitrary scale of 0-4	Primary Area of Activity
January	0 (No Storms)	—
February	0 (No Storms)	—
March	0 (No Storms)	—
April	2	Southern Arabian Sea
May	3	Southern Arabian Sea
June	3	Northern Arabian Sea
July	1	Northern Arabian Sea
August	1	Northern Arabian Sea
September	2	Northern and Central Arabian Sea
October	4 (Severe)	Southern and Eastern Arabian Sea
November	4 (Severe)	Southern and Eastern Arabian Sea
December	1	Southern and Eastern Arabian Sea

Source: Marine Investigators, Report on Arabian Sea for Hagler Bailly Pakistan (1998)



## 4.5 Air Quality

The ambient air quality within the Study Area is deteriorating due to ongoing industrial activities in its eastern, northwestern and southwestern industrial zones, port operational activities in its southwestern zone, and activities outside the boundary of the notified PQA Area. These activities include the Pakistan Steel Mill, the K-Electric Bin Qasim Power Plant, traffic on the roads particularly the National Highway N-5, the industrial emission from the industrial areas of Korangi and Landhi, and domestic emission particularly from the homes using biomass as fuel for cooking.

The objective of the air quality baseline is to assess and characterize the pollutants in the ambient air and to characterize the potential emission sources associated with the emission. The air quality study approach relies on secondary data assessment of emission sources. Collection of primary data was not considered necessary and was not possible as a full characterization would require collection of data in all seasons for which time was not available. The seasonal reversal in wind direction and variation in its speed (**Section 4.4**) is likely to result in considerable spatial variation in air quality between different seasons.

In the first part of the study, reported here, the available data on ambient air quality is analyzed and the major emission sources are identified. In the second part, presented as part of the impact assessment, the emission from the major sources is modeled to assess the spatial and temporal variation in the air quality.

### 4.5.1 Emission Sources

#### ***Industrial Emission in PQA Industrial Zones***

The number of active industrial units within PQA Industrial Zones is estimated to be about 168.<sup>32</sup> Using the available information on the size of the plants and the nature of industrial processes, major emission sources have been identified and shown in **Exhibit 4.16**. The list of the industrial units is provided in **Exhibit 4.16**. Fuel combustion is the predominant source of emission in these units. Residual Fuel Oil (RFO), natural gas and diesel are the main fuels used in these plants.

#### ***Industrial Emission Outside PQA Industrial Zones***

The industrial emission sources outside PQA Industrial Zones, but within the Study Areas, are discussed below. The emission from the following sources are characterized and discussed in detail in **Appendix E**.

##### **Pakistan Steel Mills**

Pakistan Steel Mill, spread over an area of 7,551 ha (18,660 acres) with 4,200 ha (10,390 acres) for the main plant, 3,265 ha (8,070 acres) for the township and 81 ha (200 acres) for the water reservoir Pakistan Steel is Pakistan's largest industrial complex, comprising component units numbering more than 20. PSM specializes in the production of flat steel products including, billets, slabs, hot rolled coils, cold rolled coils, galvanized

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<sup>32</sup> For the purpose of gaseous emission, *active* units are defined as process industrial unit that are emitting gaseous pollutants. The information is based on satellite image analysis and field verification.

iron products and corrugated sheets. PSM has a production capacity of 1.1 million ton of steel per annum. The plant was commissioned in mid 1980s.

#### **K-Electric Bin Qasim Power Plant**

K-Electric operates 1,260 MW Bin Qasim Power Station 1 (BQPS-1) and 560 MW Bin Qasim Power Station 2 (BQPS-2). Both power stations are located within the same premises, a 70.8 ha (175 acres) property owned by K-Electric. BQPS-1 comprises six dual-fired (oil and gas) units each with installed power generating capacity of 210 MW whereas BQPS-2 is a natural gas fired power plant based on gas and steam turbines.

#### **Landhi Industrial Area**

Landhi Industrial Trading Estate (LITE) is located west of the PQA Industrial Zone. LITE covers about 4,452 ha (11,000 acres) and houses about 1,100 industrial units<sup>33</sup> producing textiles, heavy machinery, automobiles, chemicals, pharmaceuticals, and ceramics. With 125 units, textiles constitute a major proportion of the economic activity in the LITE area.

#### **Korangi Industrial Area**

Korangi Industrial Area (KIA) is situated to the west of PQA Industrial Zone, adjacent to LITE. With an area of over 3,440 ha (8500 acres) and an estimated 4,500 industrial, commercial, and service concerns, it claims to be one of the largest industrial estate in Pakistan. It is estimated that the number of industrial units in KIA is about 1,500. Major industrial units operating in the KIA include the Pakistan Refinery Limited, the National Refinery Limited, leather tanneries, and more than 350 textile units. Other units include jute, wool, leather, pharmaceuticals, cosmetics, sanitary, chemicals, engineering, rubber products, paint, food and automobiles industry.<sup>34</sup>

#### **Traffic**

Traffic on the National Highway N-5 and the traffic originating or terminating at PQA industrial zones is a major source of emission in the Study Area. The Average Daily Traffic (ADT) for light vehicles (motor cycles, cars and pickups) and heavy vehicles (buses and trucks), in both direction are as follows:<sup>35</sup>

- ▶ Between Karachi and Port Qasim: 9,700 light; 6,600 heavy (16,300 total)
- ▶ Between Port Qasim and location to the east: 1,800 light; 2,400 heavy (4,200 total)
- ▶ On N-5: 31,600 light; 8,500 heavy (40,100 total)

Therefore, well over 60,000 vehicles pass through or near Port Qasim Industrial Zone every day.

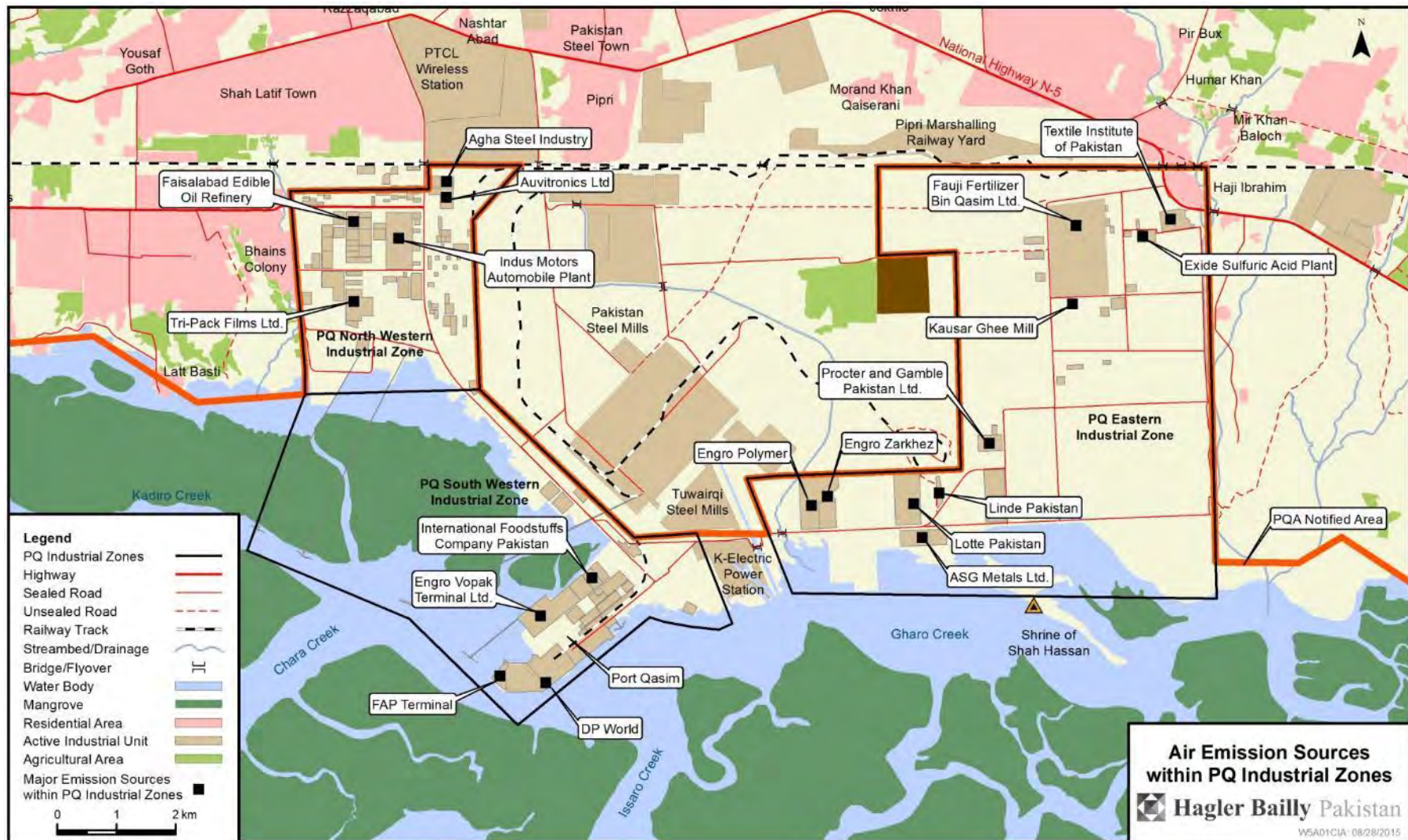
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<sup>33</sup> Website of Landhi Association of Trade and Industry (<http://landhi.org/aboutus/landhifacts.php>, Accessed August 2015)

<sup>34</sup> Korangi Industrial Estate website (<http://www.kati.pk/>, accessed August 2015)

<sup>35</sup> Environmental Impact Assessment of Bin Qasim Coal Conversion Project. September 2013.

**Exhibit 4.16: Air Emission Sources**



**Exhibit 4.17: Potential Sources of Air Emissions within Industrial Zones of  
Notified PQA Area**

<i>Industrial unit</i>	<i>Type of Industrial unit</i>	<i>Area covered (acres)</i>
<b>Eastern Industrial Zone</b>		
ASG Metals Ltd. (manufacturing plant)	Steel unit	50
Engro Zarkhez (NPK <sup>36</sup> plant)	Fertilizer unit	31
Engro Polymer (PVC <sup>37</sup> plant)	Chemical unit	103
Exide Pakistan Ltd. (Sulphuric Acid Plant)	Chemical unit	10
Fauji Fertilizer Bin Qasim Ltd.	Fertilizer unit	310
Kausar Ghee Mill	Edible oil unit	10
Linde Pakistan (Hydrogen and Carbon dioxide plant)	Gas unit	10
Lotte Chemicals Pakistan (Purified Terephthalic Acid plant)	Chemical unit	95
Procter and Gamble Pakistan Ltd. (Ariel plant)	Chemical unit	27
Textile Institute of Pakistan	Textile unit	38
<b>Northwestern Industrial Zone</b>		
Agha Steel Ltd.	Steel unit	10
Auvitronics Ltd. (manufacturing plant)	Automotive unit	25
Faisalabad Edible Oil Refinery Ltd.	Edible oil unit	15
Indus Motors Automobile Plant	Automotive unit	107
Tri-pack Films Ltd. (production plant)	Chemical unit	51
<b>Southwestern Industrial Zone</b>		
International Foodstuffs Company Pakistan	Edible oil unit	12
<b>Terminals in Southwestern Industrial Zone</b>		
DP World (Qasim International Container Terminal 1 and 2)	Terminal	202
Engro Vopak Terminal Ltd.	Terminal	23
Fauji Akbar Portia Terminals	Terminal	202

#### 4.5.2 Sources of Air Quality Data and Locations

The ambient air quality data was collected from various published environmental impact assessment reports of industrial developments in the industrial zones of PQA Area and literature. The data from these secondary sources is presented as a compiled table in **Appendix B.2** shows the sampling locations, sampling durations and concentration of pollutants at all sampling locations. The pollutants considered for analysis are nitrogen

<sup>36</sup> NPK indicates macro nutrients nitrogen, phosphorous and potassium

<sup>37</sup> PVC indicates polymer poly-vinyl chloride

dioxide (NO<sub>2</sub>), nitrous oxide (NO)—collectively the oxides of nitrogen (NO<sub>x</sub>)—sulfur dioxide (SO<sub>2</sub>) and particulate matter (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>).<sup>38</sup> Carbon monoxide (CO) and ozone (O<sub>3</sub>) are not included as available information on these is limited. The sampling locations are shown in **Exhibit 4.18**.

#### 4.5.3 Data Analysis

Temporal and spatial analysis has been carried out on the data.

##### ***Temporal Divisions and Spatial Averaging***

For analysis of temporal variation data was separated for two divisions:

1. 2004-2010
2. 2011-2015

For analysis of spatial variation, the area was divided into five zones:

1. Eastern industrial zone of notified PQ area (2011-2015)
2. Northwestern industrial zone of notified PQ area (2011-2015)
3. Along the coast (2004-2010)
4. Along the coast (2011-2015)
5. Reference point taken at Gharo, which is distant to Port Qasim and has relatively good air quality.

A sampling point along Gharo (see **Exhibit 4.18**) was taken as reference to compare it with the areas having extensive industrial activities.

##### ***Calculation of Weighted Average for Each Zone and Temporal Division***

Since the duration of sampling is not provided, or varies, for the sampling locations, duration-weighted averages were calculated using the following formula:

$$\text{Concentration (in zone)} = \frac{\sum_i^n k_i c_i}{\sum k}, \text{ where } k = \text{duration of each concentration}$$

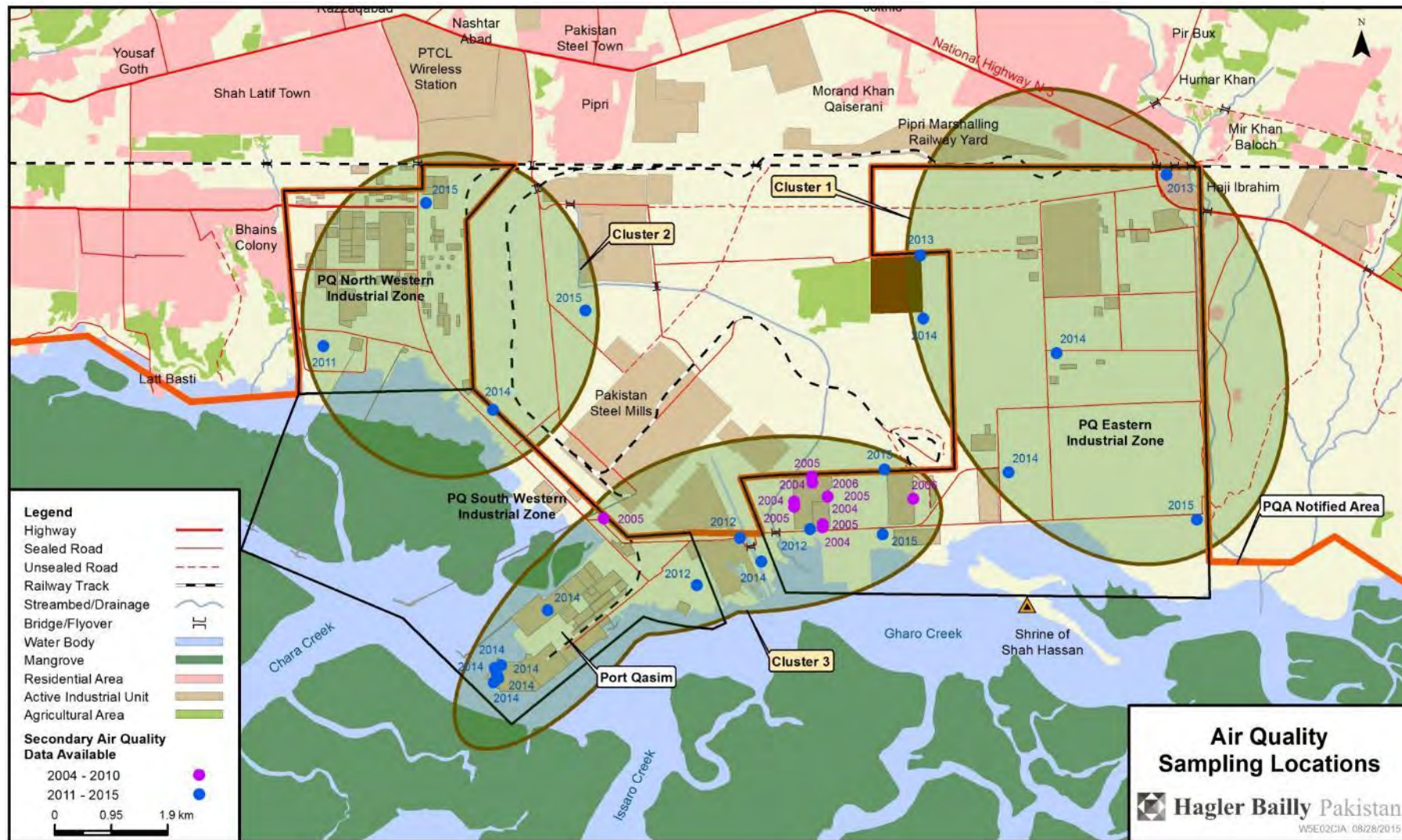
The duration weighted averaging ensures that longer sampling durations are given greater weightage in calculating the average.

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<sup>38</sup> The particulate matter is classified on the basis of particle size as follows: total suspended matter (TSP) contains particles of all sizes; coarse inhalable particulate matter containing particles of diameter 10 microns or less (PM<sub>10</sub>), and fine inhalable particulate matter containing particles of diameter 2.5 microns or less (PM<sub>2.5</sub>).



**Exhibit 4.18: Sampling Locations for Baseline Air Quality**



## Results and Discussion

1. The concentration of pollutants at all sampling locations are below the limits prescribed by national and international guidelines and standards including Sindh Environmental Quality Standards (SEQS) and International Finance Corporation (IFC), Environmental Health and Safety (EHS) Guidelines. Both these standards are provided in **Exhibit 4.19**.

**Exhibit 4.19: Ambient Air Quality Standards**

Pollutant	SEQS ( $\mu\text{g}/\text{m}^3$ )		IFC EHS Guidelines ( $\mu\text{g}/\text{m}^3$ )	
	Annual Average	24 hours	Annual	24 Hours
NO <sub>x</sub>	100 <sup>39</sup>	80	40	-
SO <sub>2</sub>	80	120	-	125
PM <sub>10</sub>	120	150	70	150
PM <sub>2.5</sub>	40	75	35	75

Note: “-” indicates that information is not available. +

2. The reported concentration of all pollutants along the coast (Cluster 3) is higher in 2004-2010 as compared to 2011-2015. The reason for the decrease in the amount of pollutant is not clear and needs further research. Probable causes include:
  - a. Bias (in averaging) due to a smaller amount of information available in the years from 2004-2010 compared to 2011-2015.
  - b. Reported decrease in the production of Pakistan Steel Mill (PSM). The production data of PSM is not available. PSM consumes imported coal annual consumption data for which is available and can be used as an indicator. The average consumption of coal between 2005-06 and 2009-10 (5 years) was 594,290 tonnes whereas the consumption for three subsequent years, the period for which data is available, was 322,707 tonnes. A corresponding reduction in emission is therefore expected. The situation has not improved this year as it has been reported<sup>40</sup> that the average production in the month of March 2015 and April 2015 stood at 41% and 35% of the production capacity, respectively.
3. The concentration of key pollutants including (NO<sub>x</sub>, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub>) along the sea coast (Cluster 3) is higher than the eastern and western industrial zones of PQA Area. This is because of the major port operational activities are taking place along this sampling site.

<sup>39</sup> IFC EHS Guidelines are for NO<sub>x</sub> expressed as NO<sub>2</sub>; whereas SEQS has separate standards for NO<sub>2</sub> and NO (40  $\mu\text{g}/\text{m}^3$  for each pollutant separately). The NO limit is converted to NO<sub>2</sub> limit by assuming that all NO oxidizes to NO<sub>2</sub> and hence a combined NO<sub>x</sub> limit is obtained ( $40 + 61.3 = 101.3 \mu\text{g}/\text{m}^3$ ). b. IFC EHS does not prescribe any annual limit for SO<sub>2</sub>.

<sup>40</sup> The News International, “Stricken Pakistan Steel Mills look to govt to ease financial crunch” May 14, 2015

4. The concentration of particulate matter is nearly same in all data sets. This high concentration of PM is common occurrence all over Pakistan and is attributed to dry conditions and natural wind-blown dust.

The above results are considered representative of the industrial zones. Some of the sampling points in Clusters 1 and 2 are likely to capture traffic emission, however, given the predominant wind direction, the sampling points in Cluster 3 are unlikely to receive emissions from Korangi, Landhi, or the N-5 traffic in any significant amount. This data can then be used to calibrate the baseline data that will be developed in the second part of the study through dispersion modeling.

As part of the impact assessment, all the existing sources of gaseous emission in PQA and vicinity were modelled. The simulation of the current emission largely confirmed the results of the analysis of the historic sampling data. However, the model also suggested that the concentration of NO<sub>x</sub> and SO<sub>2</sub> in the ambient air may already be exceeding the target limits (IFC ambient air quality guidelines in this case as it is more stringent than the SEQS for ambient air). The area in which the limits are exceeded is relatively small, which also explains why it has not been captured in any measurement.

## 4.6 Water Resources and Wastewater

This section provides a summary of the recent changes to freshwater in the region and in addition to a summary of wastewaters being discharged. This is followed by analysis of sampled seawater, freshwater and wastewater in the Study Area.

### 4.6.1 Surface Water Resources

The Study Area lies in the non-active and western extent of the Indus Delta that formed during the Holocene<sup>41</sup>. The delta is largely arid (see **Section 4.1**), with swampy areas in the immediate neighborhood of tidal channels and coastal plains that undergo tidal flooding. The deltaic coastline associated with Indus Delta is dissected by 17 major creeks and numerous minor creeks (see **Exhibit 4.20**). The major creeks of the Indus Delta within the Study area include the Phitti, Khuddi and Khai Creeks. Minor creeks, within the Study Area close to Port Qasim include the Korangi<sup>42</sup>, Gizri, Kadiro, Issaro, Gharo, Chann Waddo, Rakhal and Chara creeks (see **Exhibit 4.21**), among others.

Until recently the Indus River had a largely river-dominated estuary but due to increase in dams and reservoirs along the river, there is discharge to the Arabian Sea only during the summer (southwest) Monsoon; in the remaining nine to ten months there is effectively no estuary due to elimination of the river discharge.<sup>43</sup> Consequently, the Indus Delta has seen freshwater and sediment deprivation over the second half of the 20<sup>th</sup> Century (see **Exhibit 4.22**).

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<sup>41</sup> Inam *et al.* "The Geographic, Geological and Oceanographic Setting of River Indus' in 'Large Rivers: Geomorphology and Management', 2007.

<sup>42</sup> Some maps and literature refer to the extension of Gizri Creek that extends from the Malir River as Korangi Creek

<sup>43</sup> Schubel, J.R., "Estuarine circulation and sedimentation: an overview. Marine Geology and Oceanography of Arabian Sea and coastal Pakistan" Ed. B.U Haq and J.D Milliman Van Nostrand Reinhold Company Inc. New York, 1984 (pp113-136)



A part of Gharo River<sup>44</sup> that naturally drained into the Study Area from the Indus, has been inactive since at least 1837<sup>45</sup> (see **Exhibit 4.19**). The Gharo river currently drains the Makli hills in the north of the Study Area. In addition, the Baggaur River, the previous mouth of the Indus River, is now dry and only remnants of the old bed are visible in aerial imagery (see **Exhibit 4.19**). Variation in water and sediment discharge below Kotri Barrage are shown in **Exhibit 4.22**.

**Exhibit 4.20: Indus Delta**



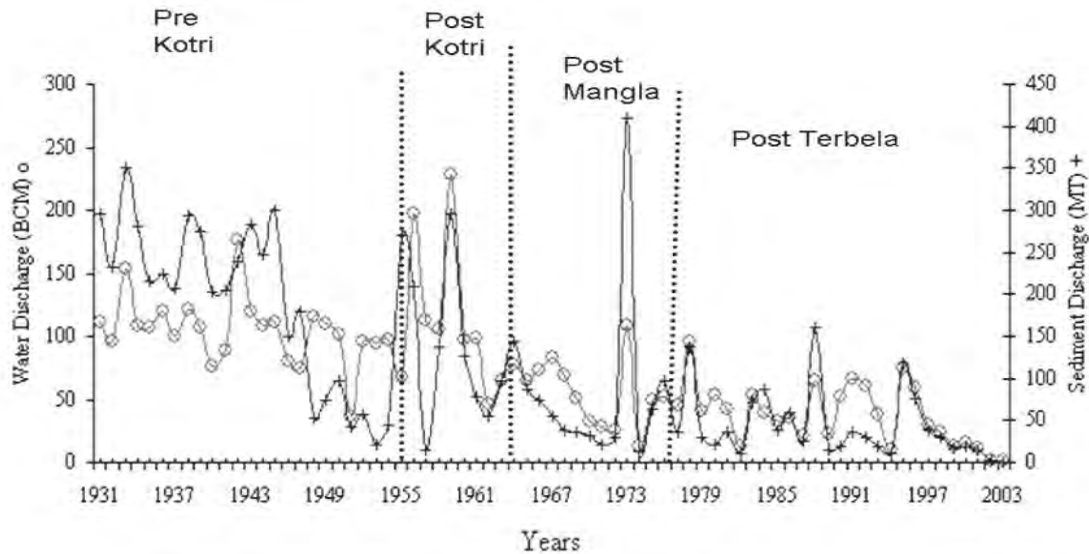
<sup>44</sup> Previously also known as Gharra River.

<sup>45</sup> Based on T. G Carless, "Sketch of Delta of Indus" indicating deserted bed of the Gharo Creek" 1837.

**Exhibit 4.21: Water Resources in the Study Area**



**Exhibit 4.22:** Variation in Water and Sediment Discharge below Kotri Barrage



Source: Inam et al. 'The Geographic, Geological and Oceanographic Setting of River Indus' in 'Large Rivers: Geomorphology and Management' (2007)

Embankments were constructed on Haleji and Keenjhar lakes in the 1940s and 1950s and freshwater was diverted from the Indus into these (see **Exhibit 4.21**) and then into the dry Gharo River. Photographs of water resources in the Study Area shown in **Exhibit 4.23**. Water is supplied to Karachi using conduits from the Gharo River (see **Exhibit 4.24**). All freshwater is diverted before it reaches the intertidal delta within the Study Area. Water from the Keenjhar Lake is also used for canal-fed irrigation within the eastern Study Area.

The main source of freshwater into the intertidal deltaic creeks of the Study Area is rain and associated runoff during the summer Monsoon (see **Section 4.4**). The rainwater drains the land in the north of the Study Area and joins the intertidal deltaic creeks (see **Exhibit 4.21**) along the Gharo River, Malir River, ephemeral drains such as Badal nullah, Ghaggar nullah, Lat nullah, and Mahyo nullah, as well as wastewater drains, particularly into Korangi Creek.



**Exhibit 4.23: Photographs of Water Resources in the Study Area**



*Badal Nullah, an ephemeral freshwater drain, flowing south across the PQA Eastern Industrial Zone*



*Badal Nullah with Pakistan Steel Mills in background*

**Exhibit 4.24: Karachi Water Supply Infrastructure Upstream of Study Area**



*Pumping Station along Gharo Creek*



*Water Supply Canal from Keenjhar Lake*



*Keenjhar Lake*

In addition to freshwater resources within the Study Area, there is exchange of seawater from the Arabian Sea among the mudflats due to tides, ocean currents and waves. The saline water within the Study Area are desalinated and utilized by some industries and power plants including the Korangi Thermal Power Station near Ibrahim Hyderi, the K-Electric power plants wedged between the Port Qasim Eastern and Southwestern

Industrial Zones, and Pakistan Steel Mills. Desalination of saline water will also be employed by the upcoming power plants in Port Qasim (see **Section 2**).

Groundwater resources in the region are limited. The aquifers close to the coastal belt are either dry or saline<sup>46,47</sup>. Since the groundwater is saline, the area is arid and there is no perennial freshwater river draining the Study Area, freshwater supply for the majority of villages and industrial uses are through piped municipal systems.

### **Seawater Salinities**

High evaporation rates result in a relatively high salt content of the seawater in the Arabian Sea. On average, the salinity in the Arabian Sea ranges between 35 and 37‰ (parts per thousand). An exceptional period is the short spell after rains during Summer Monsoon when the salinity drops to about 25-28‰ for a few days to a week.

The salinity in most of the intertidal creeks of the Indus Delta remains between 37 and 41‰ for most of the year. It drops to about 30‰ in certain creeks during the period of August to October, due to the rain. The influx of floodwater from the Indus River lowers salinity in the creeks adjacent to the river.

Additional information on salinity specifically within the Study Area is provided in **Section 4.6.3**.

### **Suspended Load**

The suspended matter in the creek areas within the Indus Delta has an annual range of 25 to 170 ppm. Higher values are observed during the summer Monsoon. The average suspended load during June and July is between 80 and 115 ppm. Higher values (115-170 ppm) have also been recorded at some places in the Ghara/Korangi Creek system. Lower suspended matter (25-50 ppm) is recorded during March and the September-November period. The suspended load in these creeks also exhibits variations with the degree of turbulence during a tidal cycle. During the flood season in the Indus River (September) the suspended load rises to about 4,000 ppm in Khobar Creek and to about 1,500 to 2,000 ppm in the adjacent creeks.

Additional data on suspended load specifically for the Study Area is provided in **Section 4.6.3**.

### **4.6.2 Wastewater**

The coastal belt is being used to dispose industrial wastewaters from industry within adjacent coastal areas and industries located in the Korangi Industrial Area, Landhi Industrial Trading Estate and the Port Qasim Industrial Area. There are also several open drains carrying untreated raw sewage discharge into Gizri, Korangi and Ghara creeks (see **Exhibit 4.25**).

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<sup>46</sup> HBP, 2007, Environmental Impact Assessment of Engro Asahi Polymer Chemical Ltd. Expansion Project

<sup>47</sup> HBP, 2013, Environmental Impact Assessment Coal Power Plant (CPP) Project Fauji Fertilizer Bin Qasim Complex

Wastewater enters the Gizri, Korangi, Kadiro and Gharo Creeks, within the Study Area, from:

- ▶ Industrial sources such as the Landi Industrial Area and Korangi Industrial Area that discharge wastewaters into Malir River at the western extent of the Study Area. Malir River drains into Gizri Creek and the wastewater ends up in Korangi Creek.
- ▶ Agricultural runoff and urban wastewater from areas along the northern periphery of the Study Area that drain into the Malir River and ultimately Gizri and Korangi Creeks.
- ▶ Multiple industrial units west of Port Qasim that drain directly into Korangi Creek. These include, in particular, animal fat melting facilities, fish processing facilities and the Korangi Thermal Power Station.
- ▶ Multiple sewage discharges (largely untreated) west of Port Qasim drain directly into Kadiro and Korangi Creeks including those from large settlements including Ibrahim Hyderi, Rehri Goth and Bhains Colony.
- ▶ Pakistan Steel Mills and Port Qasim Industrial (including K-Electric Power Plant) within the center of the Study Area draining into , Badal nullah and Kadiro or Gharo Creeks respectively.
- ▶ Agricultural and sewage from the Gharo area into Gharo Creek east of the Port Qasim.

Karachi generates approximately 200 million gallons per day of sewage and wastewaters from municipal and industrial sources. Estimates vary, however approximately 15% to 40% of untreated sewage from Karachi is estimated to flow into the Malir River or directly into Gizri and Korangi creeks within the Study Area. In terms of industrial sources, approximately, 77,000 m<sup>3</sup>/day of largely untreated effluent flowed from Korangi Industrial Area<sup>48</sup> into Malir River in 2005, and approximately 132,500 m<sup>3</sup>/day of effluent is expected to be flowing from the Landhi Industrial Trading Estate (LITE) into the Malir River<sup>49</sup>. As of 2003, the most of the discharge from the LITE was untreated.<sup>50</sup>

It is reported<sup>51</sup> that the pollution has significantly reduced the fishing potential in Gizri, Gharo and Korangi creeks and most fishermen no longer fish in these waters. Fishermen from both Rehri Goth and Ibrahim Hyderi have reported that they do fish at the eastern extent of Korangi Creek within the PQA Southwestern Zone, among the jetties.<sup>52</sup> The analysis in **Section 4.6.3** indicates that Malir River is polluted, as well as the area at the confluence of Malir River and Korangi Creek (at western extent of Korangi creek). In

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<sup>48</sup> Field measurements carried out for Hagler Bailly Pakistan, Social Impact Assessment for the Korangi Effluent Treatment Plant, 2005.

<sup>49</sup> Based on current water usage Landhi Industrial Trade Association reported on their website.

<sup>50</sup> Field measurements carried out for Hagler Bailly Pakistan, Social Impact Assessment for the Landhi Effluent Treatment Plant, 2003.

<sup>51</sup> During socioeconomic baseline surveys.

<sup>52</sup> Some fishing is carried out along the eastern extent of Korangi Creek in the vicinity of Port Qasim and the Pakistan International Bulk Terminal



addition to this, lower abundance of fish and lower diversity was found at sites closer to the coastline (see **Section 5.5.2**).

**Exhibit 4.25:** Wastewater Discharges into Creeks in the Study Area



*Discharge of Engine Oils at Rehri Goth Jetty*



*Solid Waste Disposal and Sewage Discharge*



*Solid Waste Disposal and Sewage Discharge at Ibrahim Hyderi*



*Solid Waste Disposal and Sewage Discharge at Bhains Colony*

#### **4.6.3 Water and Wastewater Quality Sampling and Analysis**

Seawater, freshwater and wastewater quality sampling and laboratory analysis was carried out to establish the baseline to meet the following key objectives:

- ▶ determine contamination levels
- ▶ determine level of mixing (lateral and vertical) within the intertidal zone

### **Current Water Quality Sampling**

A total of thirteen seawater, wastewater and freshwater quality samples were collected from June 4, 2015 to June 8, 2015. The sampling locations were chosen considering the marine ecosystem, port activities and wastewater inflows from the on-shore industry. For seawater, sampling across the profile was carried out, where water was collected from different depths, in addition to conductivity-temperature-depth profiling. A summary of sampling locations, including a description of the location is provided in **Exhibit 4.26**.

**Exhibit 4.26: Summary of Water Quality Sampling for Current Study**

<i>Sample ID</i>	<i>Coordinates</i>	<i>Type</i>	<i>Sampling Depths (m)</i>	<i>Location Description</i>
W1	24°45'49.6" N 67°07'24.4" E	Seawater	1	Korangi Creek
W2/EC5	24°43'45.9" N 67°21'13.2" E	Seawater	1 & 7	Near PQ main Jetty
W3/EC4	24°43'53.1" N 67°14'50.3" E	Seawater	1 & 8	Chann Wado Creek
W5	24°35'49.3" N 67°30'58.9" E	Freshwater	0.2	Upstream Regulator for Jam Sakro Outfall Drain
W7/EC7	24°37'51.8" N 67°17'9.0" E	Seawater	1	Reference site, near Khuddi Creek
W8/EC3	24°46'08.4" N 67°25'23.6" E	Seawater	0.2	Near Shah Hasan Shrine
W10/EC11	24°46'23.9" N 67°12'50.7" E	Seawater	1	Near Khprianwala Island
W13	24°44'29.8" N 67°35'39.4" E	Freshwater	0.2	Upstream Gharo Creek
WW1	24°49'20.7" N 67°05'45.8" E	Wastewater	0.2	Landi/Korangi industrial waste outfall drain
WW2	24°48'33.9" N 67°15'53.4" E	Wastewater	0.2	Near Bhains Colony
WW4	24°47'15.6" N 67°20'19.5" E	Wastewater	0.2	K-electric outfall drain

### **Previous Water Quality Sampling**

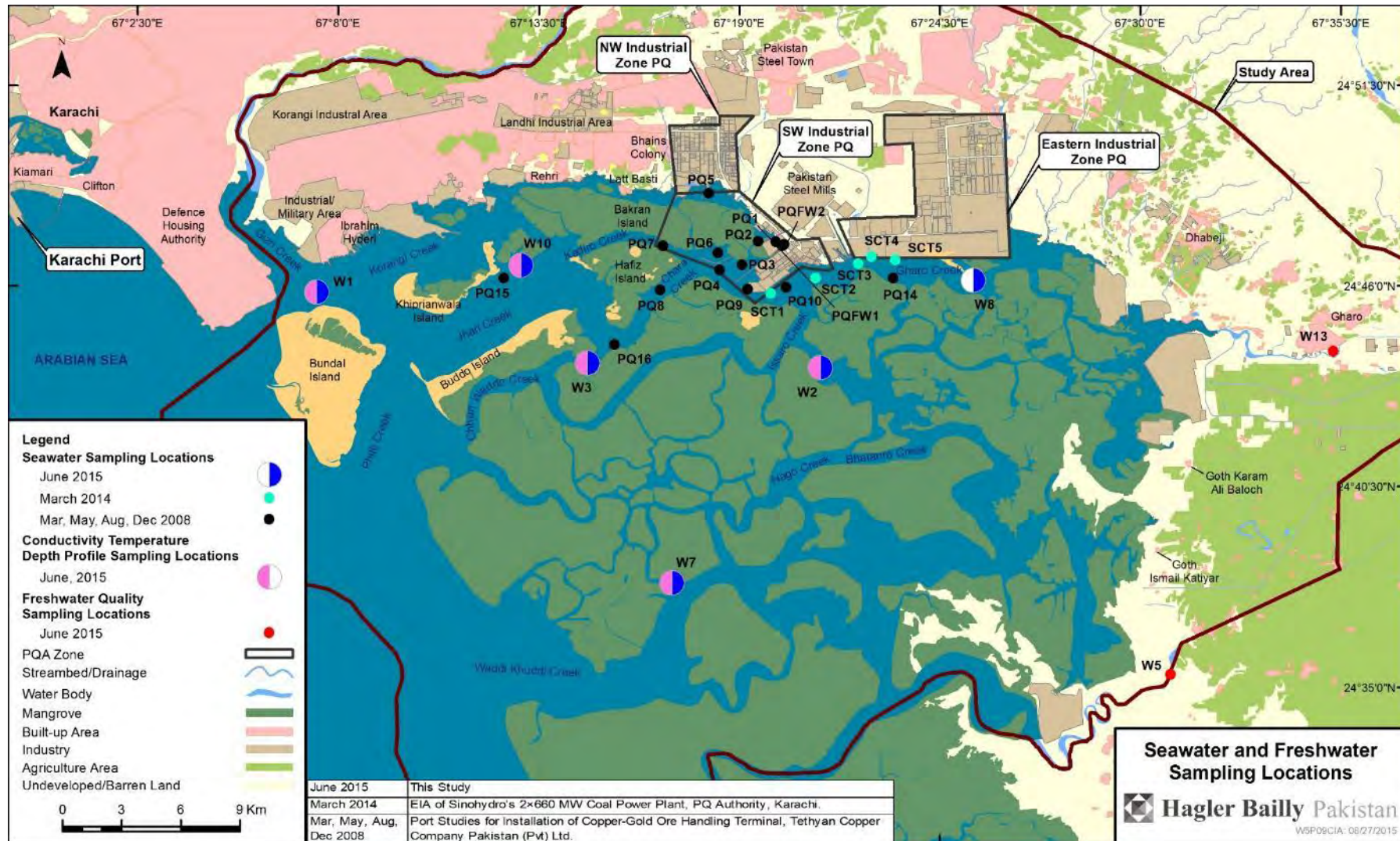
In addition to water quality sampling and analysis carried out for this Study, water quality sampling and analysis carried out for the following Projects has been utilized in the sections below:

- ▶ Hagler Bailly Pakistan, 2013, Environmental Impact Assessment of Coal-Fired Combined Steam and Power Project, Bin Qasim Fertilizer Complex (FBE)
- ▶ Hagler Bailly Pakistan, 2013, Environmental Impact Assessment of KESC's Bin Qasim Coal Conversion Project (KBR)
- ▶ Hagler Bailly Pakistan, 2014, Environmental Impact Assessment of Coal Jetty, Shipping Lane and Ash Disposal Site for Pakistan Port Qasim Electric Power Project 2×660 MW Coal Power Plant (SCT)
- ▶ Hagler Bailly Pakistan, 2008-2009, ESIA of Copper-Gold Ore Handling Terminal, Tethyan Copper Company Pakistan (Pvt.) Ltd (PSO)

The locations for current and previous sampling have been shown in **Exhibit 4.27** and **Exhibit 4.28**, photographs of sampling shown in **Exhibit 4.29**.

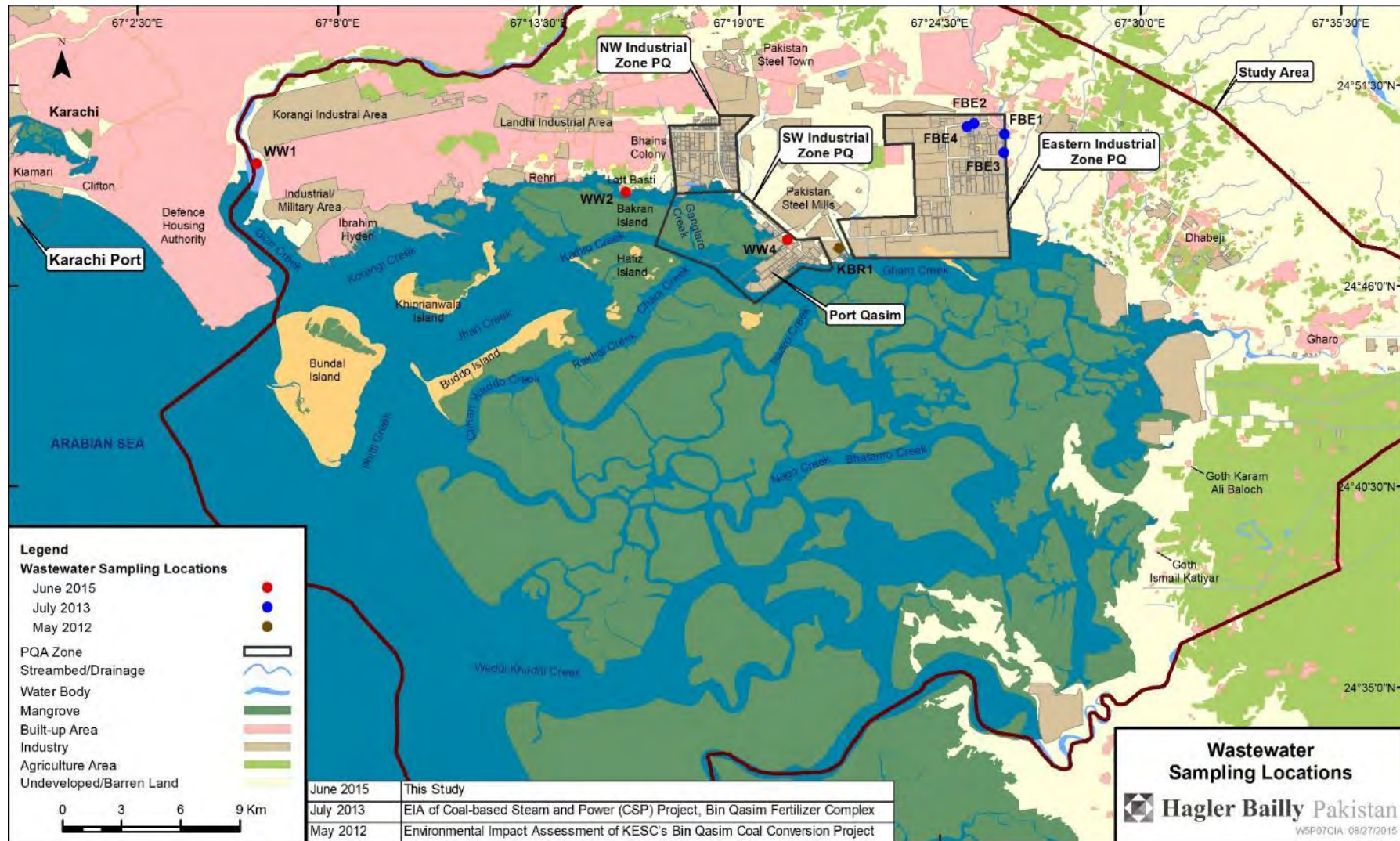


**Exhibit 4.27: Map of Seawater and Freshwater Sampling Locations**





**Exhibit 4.28: Map of Wastewater Sampling Locations**





**Exhibit 4.29: Photographs of Sampling**



**Photograph 01:** Ready for CTD Profile Measurement



**Photograph 02:** Seawater quality sampling in progress with the bladder pump



**Photograph 03:** Sample collection



**Photograph 04:** Sample collection



**Photograph 05:** Sample collection



**Photograph 06:** Field testing for pH, TDS, salinity, and temperature during sample collection

**Seawater Results and Analysis**

A summary of the sample analysis against Sindh Environmental Quality Standards (SEQS) for liquid effluent values is provided in **Exhibit 4.45**, while the detailed laboratory results are provided in **Appendix B.1**.

### Seawater Conductivity-Temperature-Depth Analysis

The conductivity-temperature -depth (CTD) profile of seawater at various sampling locations is presented in **Exhibit 4.30**. Graphical representations are shown in **Exhibit 4.31** and **Exhibit 4.32**.

The conductivity-temperature-depth data shows that there is little variation in conductivity and temperature along the profile at each site. While this indicates a well-mixed<sup>53</sup> system, the salinities which are all above 35 psu indicate this is primarily seawater. This is consistent with the discussion in **Section 4.6.1** where it is mentioned that only ephemeral freshwater streams drain the Study Area.

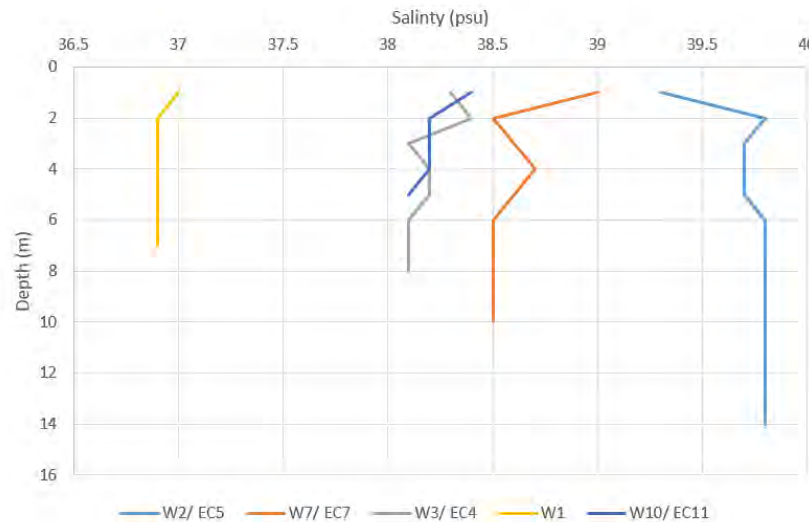
In addition to little variation in conductivity and temperature along the profile, there is very minor spatial variation at different sites. The absence of a spatial trend and trend along the profile, indicates that the estuary is tide-dominated i.e. the tide penetrates homogenously across the entire Study Area. A small difference in salinity is observed at W1; W1 has a lower average salinity than other sites, even though this site is closer to the open sea than others. The slightly lower average salinity at this site may be due to wastewater flows from Malir River into the W1 area. W1 temperatures were also lower, similar to the salinity, compared to other locations.

**Exhibit 4.30: Conductivity-Temperature-Depth Profile Data**

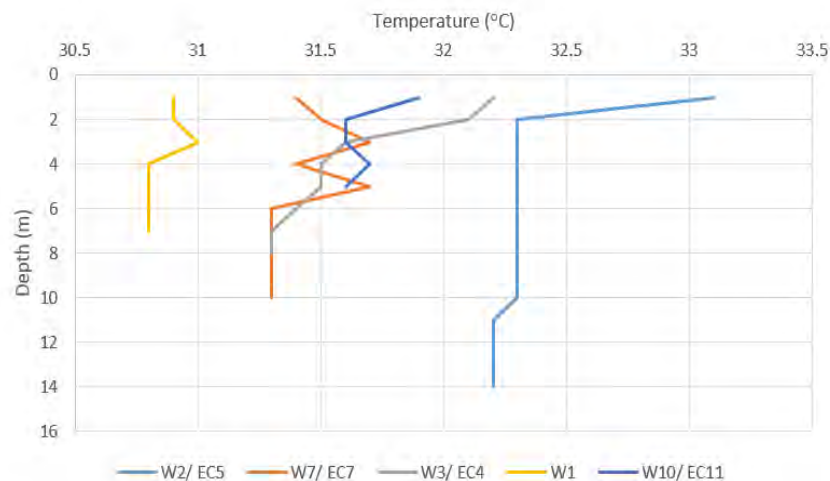
Depth (m)	W2/ EC5		W7/ EC7		W3/ EC4		W1		W10/ EC11	
	Salinity PSU	Temperature °C	Salinity PSU	Temperature °C	Salinity PSU	Temperature °C	Salinity PSU	Temperature °C	Salinity PSU	Temperature °C
1.0	<b>39.3</b>	33.1	<b>39.0</b>	31.4	<b>38.3</b>	32.2	<b>37.0</b>	30.9	<b>38.4</b>	31.9
2.0	<b>39.8</b>	32.3	<b>38.5</b>	31.5	<b>38.4</b>	32.1	<b>36.9</b>	30.9	<b>38.2</b>	31.6
3.0	<b>39.7</b>	32.3	<b>38.6</b>	31.7	<b>38.1</b>	31.6	<b>36.9</b>	31.0	<b>38.2</b>	31.6
4.0	<b>39.7</b>	32.3	<b>38.7</b>	31.4	<b>38.2</b>	31.5	<b>36.9</b>	30.8	<b>38.2</b>	31.7
5.0	<b>39.7</b>	32.3	<b>38.6</b>	31.7	<b>38.2</b>	31.5	<b>36.9</b>	30.8	<b>38.1</b>	31.6
6.0	<b>39.8</b>	32.3	<b>38.5</b>	31.3	<b>38.1</b>	31.4	<b>36.9</b>	30.8		
7.0	<b>39.8</b>	32.3	<b>38.5</b>	31.3	<b>38.1</b>	31.3	<b>36.9</b>	30.8		
8.0	<b>39.8</b>	32.3	<b>38.5</b>	31.3	<b>38.1</b>	31.3				
9.0	<b>39.8</b>	32.3	<b>38.5</b>	31.3						
10.0	<b>39.8</b>	32.3	<b>38.5</b>	31.3						
11.0	<b>39.8</b>	32.2								
12.0	<b>39.8</b>	32.2								
13.0	<b>39.8</b>	32.2								
14.0	<b>39.8</b>	32.2								
Average	<b>39.7</b>	32.3	<b>38.6</b>	31.4	<b>38.2</b>	31.6	<b>36.9</b>	30.9	<b>38.2</b>	31.7

<sup>53</sup> i.e. mixing of fresh and saline sea water

**Exhibit 4.31:** Salinity-Depth Profile of Seawater in the Study Area



**Exhibit 4.32:** Temperature-Depth Profile of Seawater in the Study Area



### Seawater Analysis

The SEQS do not specify any limits for seawater quality. Therefore comparison for seawater has been carried out against reference site W7 located about 20 km south of Port Qasim closer to the open sea. The comparative analysis and spatial trends are presented below.

The levels of arsenic show a spatial trend. Concentration of arsenic at a reference site located further away from Port Qasim was 1.9 micrograms per litre ( $\mu\text{g/L}$ ) compared to locations closer to the areas where industrial and municipal wastewater is discharged into the creeks where it ranged from 2.4 to 3.7  $\mu\text{g/L}$  (see **Exhibit 4.32**). Oil and grease, TPH and CN were not detected in any sample. No major differences were found in the analyzed samples for the pH, turbidity (except higher at W10/ EC11), alkalinity, nitrates

(except higher at W10/ EC11), nitrites, phosphorus, phosphate, sulfate, bromide, fluoride and chlorides.

HBP previously carried out water quality analysis for 108 samples at 16 locations in the vicinity of Port Qasim. The results for heavy metals within these samples have been summarized in **Exhibit 4.33** and compared to the results from the current study in **Exhibit 4.34**. No major differences are observed, other than for iron and zinc, which were higher in 2008.

The average concentration of arsenic, copper and zinc in the 2015 and 2008 sampling were all higher than the concentrations at the reference site of 2015. This corresponds to the higher concentration of the heavy metals found in the fish liver and tissue samples (see **Section 5.5.4**) compared to permissible limits and the Ketī Bandar reference site.

Additional seasonal seawater sampling is recommended. The seawater sampling as part of this Study was carried out during Summer Monsoon, when turbulence and mixing within the estuarine system is enhanced; and therefore there is greater dilution. In addition, the seawater sampling locations are not necessarily close to the drains. Given the relative difference between a large tidal prism within the Study Area and the volume of wastewater drains within the Study Area over a tidal period, the results showing low concentration of heavy metals within the seawater are expected. However, as mentioned previously, enhanced arsenic, copper and zinc are found in fish liver and tissue (see **Section 5.5.4**), showing that there is bioaccumulation of heavy metals due to the wastewater drains.

#### **Bacteriological Analysis**

Total coliforms were detected too numerous for count in the seawater samples. However, Faecal *E.coli* and Faecal Streptococci/ Enterococci were not seen in the analyzed seawater samples, some of which are located away from the wastewater drains. A

As mentioned in the preceding section, the dilution associated with turbulent mixing during Summer Monsoon is expected to be enhanced, and the relative difference between the volume of wastewater compared to the tidal prism is also high.

**Exhibit 4.33: Seawater Quality Results**

Parameter	Unit	LOR	W1-1	W1-1D (Duplicate Sample from ALS Malaysia)	EC5/ W2-1	EC5/ W2-7	EC4 / W3-1	EC4/ W3-8	EC7/ W7-1 (reference)	EC3/ W8	EC11/W10-1
<b>Physical and Organics</b>											
pH			7.80	7.60	7.76	7.79	7.85	7.90	7.95	8.17	7.60
Total Dissolved Solids	mg/L	10	37,888	33,300	42,968	43,424	41,460	42,624	42,080	47,116	32,500
Total Suspended Solids	mg/L	4	55.00	307.00	22.00	53.00	22.00	37.00	103.00	132.00	147.00
Salinity	ppt	1	24.50	39.50	26.80	27.10	27.10	27.80	27.40	29.90	32.50
Turbidity	NTU	0	20.40	560.00	32.00	37.00	28.00	42.00	48.00	52.00	215.00
Alkalinity, Total (as CaCO <sub>3</sub> )	mg/L	4	136.00	109.00	173.84	190.80	144.16	147.34	179.14	143.10	119.00
BOD <sub>5</sub> at 20°C	mg/L	1	NA	7.00	NA	NA	NA	NA	NA	NA	4.00
COD	mg/L	2	NA	21.00	NA	NA	NA	NA	NA	NA	14.00
Total Organic Carbon	mg/L	0.1	NA	0.80	NA	NA	NA	NA	NA	NA	0.20
Chlorophyll a	mg/L	0.0005	NA	0.003	NA	NA	NA	NA	NA	NA	0.004
Phenol	mg/L	0.02	NA	Below LOR	NA	NA	NA	NA	NA	NA	Below LOR
Oil and Grease	mg/L	5	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR
TPH (C6C9) fraction	µg/L	50	NA	Below LOR	NA	NA	NA	NA	NA	NA	Below LOR
TPH (C10C14) fraction	µg/L	50	NA	Below LOR	NA	NA	NA	NA	NA	NA	Below LOR
TPH (C15C28) fraction	µg/L	100	NA	Below LOR	NA	NA	NA	NA	NA	NA	Below LOR
TPH (C29C36) fraction	µg/L	50	NA	Below LOR	NA	NA	NA	NA	NA	NA	Below LOR
<b>Chemicals</b>											
<b>Nutrients</b>											
Nitrate	mg/L	0.1	0.28	0.26	0.29	0.24	0.23	0.24	0.25	0.27	0.10
Nitrite	mg/L	0.01	0.74	0.71	0.71	0.69	0.68	0.70	0.71	0.72	0.68



Parameter	Unit	LOR	W1-1	W1-1D (Duplicate Sample from ALS Malaysia)	EC5/ W2-1	EC5/ W2-7	EC4 / W3-1	EC4/ W3-8	EC7/ W7-1 (reference)	EC3/ W8	EC11/W10-1
Total Phosphorus	mg/L	0.01	0.15	0.21	0.17	0.19	0.17	0.17	<b>0.17</b>	0.19	0.18
Ortho-phosphate	mg/L	0.01	0.08	0.05	0.09	0.10	0.09	0.09	<b>0.09</b>	0.10	0.04
Ammonia	mg/L	0.5	Below LOR	16.20	Below LOR	Below LOR	Below LOR	Below LOR	<b>Below LOR</b>	Below LOR	8.04
Sulfate	mg/L	10	2,417.00	2,830.00	3,677.16	3,616.26	3,624.49	3,117.52	<b>2,725.78</b>	3,970.15	2,620.00
<b>Cyanide</b>											
Cyanide	mg/L	1	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	<b>Below LOR</b>	Below LOR	Below LOR
<b>Halides</b>											
Bromide	mg/L	0.001	59.20	68.40	43.72	46.33	62.84	65.93	<b>67.72</b>	63.40	66.00
Chloride	mg/L	5	22,156.25	18,400.00	21,447.25	23,042.50	23,485.65	22,776.62	<b>23,264.06</b>	24,859.31	17,640.00
Fluoride	mg/L	0.1	1.66	6.58	1.75	1.78	1.70	1.89	<b>1.53</b>	1.55	6.78
<b>Metals</b>											
Arsenic	µg/L	1	2.40	5.00	1.50	2.10	3.20	3.70	<b>1.90</b>	1.60	3
Boron	µg/L	1	1,681	5,580	2,611	3,080	5,327	4,897	<b>6,778</b>	6,109	5,240
Cadmium	µg/L	1	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	<b>Below LOR</b>	Below LOR	Below LOR
Calcium	µg/L	1	426,000	436,000	438,000	420,000	411,000	403,000	<b>392,000</b>	408,000	403,000
Magnesium	µg/L	1	1,285,000	1,360,000	1,464,000	1,339,000	1,154,000	1,206,000	<b>1,090,000</b>	1,144,000	1,280,000
Copper	µg/L	1	Below LOR	4.00	3.00	Below LOR	Below LOR	Below LOR	<b>2.00</b>	Below LOR	2.00
Iron	µg/L	1	4.00	370.00	13.0	17.00	22.00	19.00	<b>25.00</b>	1.10	152.0
Lead	µg/L	1	Below LOR	2.00	Below LOR	Below LOR	Below LOR	Below LOR	<b>Below LOR</b>	Below LOR	Below LOR
Nickel	µg/L	1	7.00	2.00	9.00	10.0	15.0	12.0	<b>19.0</b>	11.0	1.00
Potassium	µg/L	1	367,000	436,000	402,000	388,000	350,000	345,000	<b>329,000</b>	336,000	409,000
Sodium	µg/L	1	12,653,000	12,200,000	11,978,000	13,308,000	14,379,000	13,652,000	<b>13,987,000</b>	15,018,000	11,100,000
Strontium	µg/L	1	6,524	9,230	7,398	6,928	4,837	5,281	<b>7,800</b>	8,055	9,220

<i>Parameter</i>	<i>Unit</i>	<i>LOR</i>	<i>W1-1</i>	<i>W1-1D (Duplicate Sample from ALS Malaysia)</i>	<i>EC5/ W2-1</i>	<i>EC5/ W2-7</i>	<i>EC4 / W3-1</i>	<i>EC4/ W3-8</i>	<i>EC7/ W7-1 (reference)</i>	<i>EC3/ W8</i>	<i>EC11/W10-1</i>
Zinc	µg/L	1	8.00	Below LOR	14.00	12.00	7.00	9.00	<b>17.00</b>	23.00	Below LOR
<b>Biological</b>											
Total Colony Count	cfu/ml	500				855	530				
Total Coliforms	per 100 ml	0				Numerous	Numerous				
Fecal E.coli	per 100 ml	0				Below Detection	Below Detection				
Fecal Streptococci/Enterococci	per 100 ml	0				Below Detection	Below Detection				

In above table “–” means information is not available, x means the value is removed during QC (i.e. it is not plausible) and “NA” parameter not analyzed

**Notes:** “–” indicates that information is not available.

NA indicates that the parameter is not analyzed.

x indicates that the value is removed during QC (i.e. it is not plausible).

**Exhibit 4.34:** Comparison of Average Metals in Seawater Samples (2008 and 2015)

<i>Metal</i>	<i>Units</i>	<i>Number of Samples with concentration below LOR (out of 103) – 2008 sampling</i>	<i>Average value where concentration was above LOR - 2008 sampling</i>	<i>Average concentration - 2015 sampling</i>	<i>Reference Site - 2015 sampling</i>
Arsenic	µg/l	0	4.62	2.71	1.90
Cadmium	µg/l	59	0.45	Below LOR	Below LOR
Chromium	µg/l	68	3.11	NA	NA
Cobalt	µg/l	103	Below LOR	NA	NA
Copper	µg/l	0	5.14	2.75	2.00
Iron	µg/l	0	532.47	69.23	25.00
Lead	µg/l	41	33.58	2.00	Below LOR
Mercury	µg/l	94	0.10	NA	NA
Nickel	µg/l	8	2.77	9.56	19.0
Tin	µg/l	52	1.00	NA	NA
Zinc	µg/l	30	106.90	12.86	17.0

### ***Fresh and Wastewater Results and Analysis***

Both freshwater analyzed against the Sindh Environmental Quality Standards (SEQS) for drinking water, whereas wastewater has been analyzed against SEQS for liquid effluent discharge to sea. A summary of the sample analysis against Sindh Environmental Quality Standards (SEQS) is provided in **Exhibit 4.35** and **Exhibit 4.36**, while the detailed laboratory results are provided in **Appendix B.1**.

#### **Freshwater Analysis**

There are no major perennial sources of freshwater in the area (see **Section 4.6.1**). Water quality samples were taken from the agricultural areas in the north of the Study Area. Sampling was carried out here, largely to establish quality of flow into the Study Area from the Indus. However, the water at the sampling locations does not reach the Study Area as it is all utilized either in agriculture or for Karachi's water supply (see **Section 4.6.1**). A brief analysis has been carried out against the SEQS for drinking water.

The pH of freshwater at locations W13 and W5 was within the range 6.5-8.5 with the maximum pH observed as 8.25 at W5. The TDS concentration was higher at W13 than at W5 because of high salinity at W13 sampling location. The TDS concentration exceeded the SEQS for drinking water at both locations. Turbidity at sampling locations W13 and W5 was higher than the SEQS for drinking water, with the higher turbidity found in the freshwater sample taken from location W13. Total alkalinity (as CaCO<sub>3</sub>) was measured at the points W13 and W5 with maximum concentration observed as 188.68 mg/L at W13.

The concentration of total phosphorous, orthophosphate and ammonia were below level of reporting at W13 and W5. The concentration of nitrate, nitrite and sulfate was higher at W13 but was in compliance with the SEQS drinking water standards. The cyanide concentration at points W5 and W13 was below level of reporting.

The bromide and fluoride concentration was maximum at W13 whereas the maximum chloride concentration was observed at W5 and also exceeded the SEQS drinking water standards of 250 mg/L.

The heavy metals in freshwater that are of major concern on the basis of their toxicity even at lower concentration are arsenic, cadmium, lead and nickel. The concentration of arsenic was higher at W13 than W5 but was in compliance with the SEQS for drinking water. The cadmium and lead concentration at sampling locations W13 and W5 was in compliance with the SEQS for drinking water. The concentration of nickel was higher at W5 than W13 and both concentrations exceeded the SEQS for drinking water.

**Exhibit 4.35: Freshwater Quality Results**

Parameter	Unit	LOR	Freshwater		SEQS for Drinking Water <sup>54</sup>
			W5	W13	
<b>Physical and Organic</b>					
pH			8.25	8.04	6.5-8.5
Total Dissolved Solids	mg/L	10	1,190	2,848	1,000
Total Suspended Solids	mg/L	4	69.00	139.00	–
Salinity	ppt	1	1.01	1.62	–
Turbidity	NTU	0	54.00	62.00	5
Oil and Grease	mg/L	4	Below LOR	Below LOR	–
Total alkalinity as CaCO <sub>3</sub>	mg/L	5	151.58	188.68	–
<b>Chemical</b>					
<b>Nutrients</b>					
Nitrate	mg/L	0.1	0.10	0.12	≤50
Nitrite	mg/L	0.01	0.04	0.05	≤3
Total phosphorus	mg/L	0.01	Below LOR	Below LOR	–
Ortho phosphate	mg/L	0.01	Below LOR	Below LOR	–
Ammonia	mg/L	0.5	Below LOR	Below LOR	–
Sulfate	mg/L	10	210.00	453.47	–
<b>Cyanides</b>					
Cyanide	mg/L	1	Below LOR	Below LOR	≤0.05
<b>Halides</b>					
Bromide	mg/L	0.001	45.30	50.20	–
Chloride	mg/L	5	946.96	941.20	<250

<sup>54</sup> Same as National Environmental Quality Standards for Drinking Water 18<sup>th</sup> October 2010.

Parameter	Unit	LOR	Freshwater		SEQS for Drinking Water <sup>54</sup>
			W5	W13	
Fluoride	mg/L	0.1	0.47	0.68	≤1.5
<b>Metals</b>					
Arsenic	µg/l	1	6.00	17.00	≤50
Boron	µg/l	1	75.00	60.00	300
Cadmium	µg/l	1	Below LOR	Below LOR	10
Calcium	µg/l	1	142,790	164,660	–
Magnesium	µg/l	1	118,600	191,840	–
Copper	µg/l	1	19.00	25.00	2,000
Iron	µg/l	1	54.00	68.00	
Lead	µg/l	1	24.00	37.00	≤50
Nickel	µg/l	1	43.00	31.00	≤20
Potassium	µg/l	1	14,280	22,340	–
Sodium	µg/l	1	192,530	355,810	–
Strontium	µg/l	1	3,668	4,593	–
Zinc	µg/l	1	172.00	268.00	5,000

**Notes:** “–” indicates that information is not available.

NA indicates that the parameter is not analyzed.

Below LOR indicates that the specific parameter is not detected as the value is below level of reporting.

### Wastewater Analysis

The wastewater drains within the Study Area are described in **Section 4.6.2** and results of wastewater sampling carried out as part of this and previous studies are provided in **Exhibit 4.36**.

Based on the sampling and lab analysis, the pH of wastewater at all sampling locations was within the range 6-9 meeting SEQs and IFC General Environmental, Health and Safety Guideline indicative values for treated sewage discharges (IFC EHS guideline). The maximum pH was observed as 8.40 at WW1 (Malir River) and minimum at 7.2 at KBR1 (Bin Qasim Power Station drain).

The TDS were generally very high at WW1, WW2, WW4 and KBR1, and exceeded the SEQs limit of 3,500 mg/L at WW1, WW2 and KBR1. While the TDS were highest at WW4 (the K-electric drain), the limit of 3,500 mg/L above the concentration of seawater source applies to this. The TDS in effluents in all cases were below those of the average concentration of the seawater where these were discharged (see **Exhibit 4.33** and reference site W7).

The turbidity was high at the points WW1 (Malir River), WW2 (Bhains Colony drain) and WW4 (K-Electric drain), with the maximum value observed at WW2 (Bhains Colony drain). The associated total suspended solids (TSS) were also high at WW1, WW2 and



WW4. The SEQs for TSS are not met at WW2. The IFC EHS Guideline for TSS of 50 mg/L is not met at WW1 (Malir River) and WW4 (Bhains Colony). In a natural channel along the east of Port Qasim (FBE1, FBE2, FBE3 and FBE4), where there is some discharge of industrial wastewater, TSS and turbidity were within the SEQs. However, at FBE3, the TSS is not within the IFC EHS Guideline.

Total alkalinity (as  $\text{CaCO}_3$ ) was measured for samples collected at WW1 (Malir River), WW2 (Bhains colony) and WW4 (K-electric drain) with the maximum concentration observed at WW2 (Bhains Colony drain). The concentration of all the nutrients is maximum at WW2 with concentration of nitrate as 64.26 mg/l, nitrite as 8.74 mg/l, total phosphorous as 394.68 mg/l, orthophosphate as 174.25 mg/L and ammonia 1.89 mg/l, except for the sulfate which is highest at WW4. The total phosphorous at WW2 (Bhains colony) is higher compared to the IFC EHS Guideline of 2 mg/L.

The concentrations of nitrates and phosphates in the discharged wastewaters are higher than the ambient seawater nutrient concentrations (see for example nitrate in **Exhibit 4.33**). The lower concentration of ambient nitrates indicates good mixing or low wastewater flows in comparison to the tidal prism<sup>55</sup>.

Cyanide concentration at points WW1, WW2 and WW4 was below level of reporting. Cyanides are not analyzed at rest of the locations. The bromide and fluoride concentration is maximum at WW2 whereas the maximum chloride concentration is observed at WW4. Water quality at all locations west of Port Qasim exceed the SEQs limit for bromide and fluoride. At sampling locations east of Port Qasim, i.e. KBR1, FBE1, FBE2, FBE3 and FBE4 where sampling was conducted by HBP in 2012, the concentration of bromides and fluorides was either below level of reporting or below the SEQs.

The heavy metals that are of major concern on the basis of their toxicity even at lower concentration are arsenic, cadmium, lead and nickel. The concentration of lead and nickel was in compliance with the SEQs at locations where sampling was carried out for heavy metals (i.e. WW1, WW2, and WW4).

The concentration of arsenic and cadmium was highest at WW2 (Bhains Colony drain). At WW2 concentration of cadmium also exceeded the SEQs limit. The level of arsenic, cadmium, copper and zinc in WW1 (Malir River) and WW2 were significantly higher in the wastewater drains compared to freshwater and seawater in the Study Area (**Exhibit 4.33** and **Exhibit 4.35**). This is of consequence, as the arsenic, cadmium, copper and zinc levels in fish tissue and liver were also elevated (see **Section 5.5.4**).

Based on the analysis above, as well as the seawater analysis,. The concentration within Malir River is representative of other multiple sewage drains between Malir River and Bhains Colony.

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<sup>55</sup> The tidal prism is the volume of water in an estuary, of defined area, that gets exchanged with the ocean during each tidal cycle.

**Exhibit 4.36: Wastewater Quality Results**

Parameter	Unit	LOR	Wastewater								SEQS for Liquid Effluents <sup>56</sup>			IFC General EHS <sup>57</sup>
			WW1	WW2	WW4	KBR1 <sup>58</sup>	FBE1 <sup>59</sup>	FBE2	FBE3	FBE4	Into Inland Waters	Into Sewage Treatment	Into Sea	
Physical and Organics														
pH			8.40	7.82	7.70	7.20	8.27	8.04	8.25	7.95	6-9	6-9	6-9	6-9
Total Dissolved Solids	mg/L	10	4,554	5,279	41,790	18,500	2,074	1,863	1,916	986	3,500	3,500	3,500 <sup>60</sup>	
Total Suspended Solids	mg/L	4	55.00	584.00	29.00	44.00	9.75	18.50	50.50	29.75	200	400	200	50
Salinity	ppt	1	2.54	2.55	26.60	NA	NA	NA	NA	NA	–	–	–	
Turbidity	NTU	0	125.00	2,200.00	18.00	NA	NA	NA	NA	NA	–	–	–	
Alkalinity, Total (as CaCO <sub>3</sub> )	mg/L	4	916.90	2,081.00	175.96	NA	NA	NA	NA	NA	–	–	–	
Oil and Grease	mg/L	5	Below LOR	10.60	Below LOR	2.50	Below LOR	Below LOR	Below LOR	Below LOR	10	10	10	10
Chemical														
Nutrients														
Nitrate	mg/L	0.1	4.20	64.26	0.26	NA	NA	NA	NA	NA	–	–	–	
Nitrite	mg/L	0.01	0.07	8.74	0.70	NA	NA	NA	NA	NA	–	–	–	
Total Phosphorus	mg/L	0.01	0.98	394.68	0.16	NA	NA	NA	NA	NA	–	–	–	2
Ortho phosphate	mg/L	0.01	0.60	174.25	0.10	NA	1.50	2.01	2.80	3.00	–	–	–	
Ammonia	mg/L	0.5	0.61	1.89	Below LOR	NA	0.50	Below LOR	1.01	0.80	40	40	40	
Sulfate	mg/L	10	376.52	213.57	3,247.56	NA	1,038.21	918.06	915.18	271.18	600	1,000	–	
Cyanides														
Cyanide	mg/L	1	Below LOR	Below LOR	Below LOR	NA	NA	NA	NA	NA	1	1	1	

<sup>56</sup> Same as National Environmental Quality Standards for Municipal and Liquid Industrial revised December 1999.

<sup>57</sup> Table 1.3.1 in IFC, Environmental, Health and Safety (EHS) Guidelines on wastewater and ambient water quality.

<sup>58</sup> Hagler Bailly Pakistan, September 2013, EIA of Bin Qasim Coal Conversion Project, K-Energy (Pvt) Ltd., Karachi.

<sup>59</sup> Hagler Bailly Pakistan, February 2014, EIA of Coal Power Plant (CPP) Project, Fauji Fertilizer Bin Qasim Complex, Fauji Fertilizer Bin Qasim Ltd., Karachi.

<sup>60</sup> SEQs allows emission at 3,500 mg/L or at 3,500 mg/L above TDS of source.

Parameter	Unit	LOR	Wastewater								SEQS for Liquid Effluents <sup>56</sup>			IFC General EHS <sup>57</sup>
			WW1	WW2	WW4	KBR1 <sup>58</sup>	FBE1 <sup>59</sup>	FBE2	FBE3	FBE4	Into Inland Waters	Into Sewage Treatment	Into Sea	
<b>Halides</b>														
Bromide	mg/L	0.001	95.80	108.70	65.20	NA	NA	NA	NA	NA	–	–	–	
Chloride	mg/L	5	2,031.28	1,497.76	22,776.62	NA	308.41	269.42	318.16	284.49	1,000	1,000		
Fluoride	mg/L	0.1	0.22	16.26	1.65	NA	Below LOR	Below LOR	Below LOR	Below LOR	10	10	10	
<b>Metals</b>														
Arsenic	µg/l	1	322.00	589.00	13.00	NA	NA	NA	NA	NA	1,000	1,000	1,000	
Boron	µg/l	1	5,276	8,352	2,308	NA	NA	NA	NA	NA	6,000	6,000	6,000	
Cadmium	µg/l	1	19.00	120.00	Below LOR	NA	Below LOR	Below LOR	Below LOR	Below LOR	100	100	100	
Calcium	µg/l	1	184,240	215,260	505,000	NA	NA	NA	NA	NA	–	–	–	
Magnesium	µg/l	1	387,280	474,230	1425,000	NA	NA	NA	NA	NA	–	–	–	
Copper	µg/l	1	237.00	108.00	12.00	1.00	NA	NA	NA	NA	1,000	1,000	1,000	
Iron	µg/l	1	821.00	1,596.00	76.00	130.00	NA	NA	NA	NA	8,000	8,000	8,000	
Lead	µg/l	1	195.00	335.00	14.00	NA	NA	NA	NA	NA	500	500	500	
Nickel	µg/l	1	88.00	181.00	34.00	NA	NA	NA	NA	NA	1,000	1,000	1,000	
Potassium	µg/l	1	95,410	167,320	392,000	NA	NA	NA	NA	NA	–	–	–	
Sodium	µg/l	1	836,600	923,550	12,169,000	NA	NA	NA	NA	NA	–	–	–	
Strontium	µg/l	1	24,909	21,010	8,166	NA	NA	NA	NA	NA	–	–	–	
Zinc	µg/l	1	4,861	11,263	56	NA	NA	NA	NA	NA	5,000	5,000	5,000	

**Notes:** “–” indicates that information is not available.

NA indicates that the parameter is not analyzed.

Below LOR indicates that the specific parameter is not detected as the value is below level of reporting.

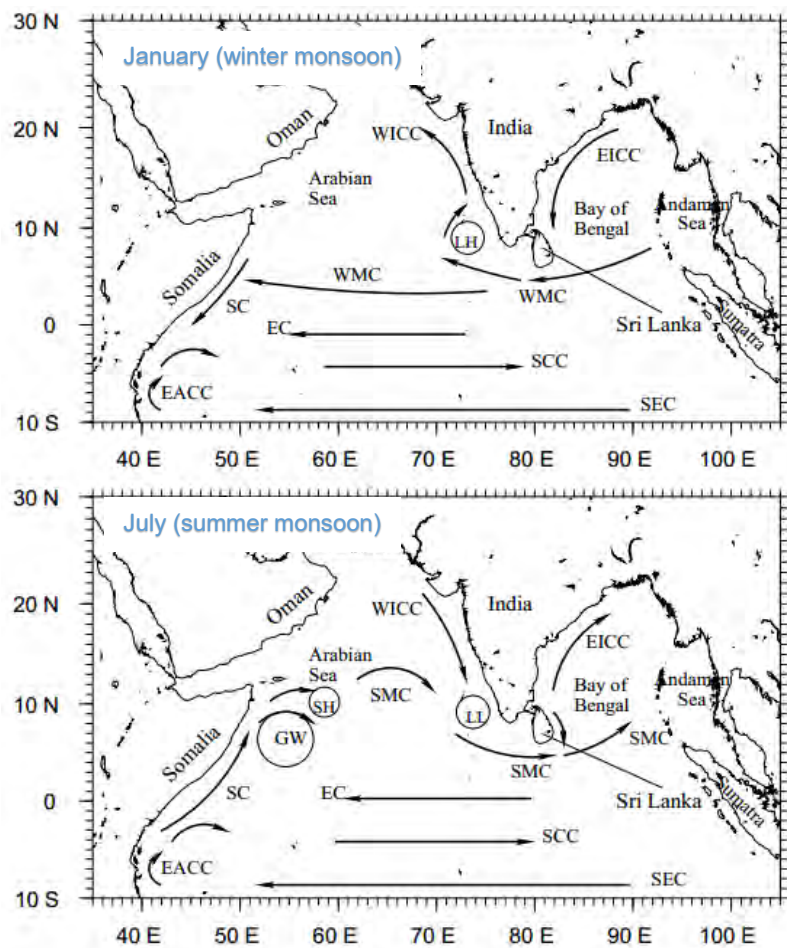
## 4.7 Estuarine and Ocean Dynamics

This section describes the ocean currents, tides, seawater temperatures, salinities, suspended load, wave, and wave induced currents in region. The majority information is based on field studies carried out for Hagler Bailly Pakistan by Marine Investigators, unless specified otherwise. **Section 4.7.5** (Erosion and Sedimentation) includes analysis specifically for the Study Area, while **Section 4.7.6** (Sediment Quality Sampling and Analysis) provides sediment quality and particle size distribution (PSD) data specifically for the Study Area.

### 4.7.1 Ocean Currents and Tides

Currents along the Indus Delta (based on measurements near Karachi) are bimodal. The current switches from south-westerly during the summer monsoon (May to September) to north-easterly during the winter monsoon (October to April) (see **Exhibit 4.37**). The tides in the area are semidiurnal, with tidal ranges in the area of about 2.7 m.

**Exhibit 4.37:** Schematic of Circulation in the Indian Ocean



Source: Shankar, D., P. N. Vinayachandran, A. S. Unnikrishnan, and S. R. Shetye. "The Monsoon Currents in the North Indian Ocean." *Progress in Oceanography* 52, no. 1 (2001): 63-120.

#### 4.7.2 Seawater Temperature

The sea surface temperature in the Study Area ranges from between 18°C to 32°C.

**Exhibit 4.38** shows the sea water temperature at various depths, seasons and locations in the Arabian Sea. The important features of the sea temperature variations are the following:

1. The sea water temperature in the Arabian Sea is strongly influenced by the monsoons.
2. The highest temperature occurs around May, shortly before the southwest monsoon sets in.
3. Temperature drops in mid-summer because at this time cold water from the deeper sea circulates near the coast.
4. When the southwest monsoon subsides in October, the influx of the cold deep-zone water also recedes. Coupled with a simultaneous decline of the air temperatures, the water surface temperature along the entire coast is relatively homogenous.
5. In the course of the winter cooling, a temperature drop sets in from south to north.
6. The water is coldest in February.

**Exhibit 4.38: Arabian Sea Temperature**

<i>Location</i>	<i>Depth</i>	<i>Season</i>	<i>Temperature (°C)</i>	
Deep Sea Northern Indian Ocean	Surface	Pre-monsoon (Feb-May)	Avg.	25.35
		SW Monsoon (Jun-Sep)	Avg.	26.18
		NE Monsoon (Oct-Jan)	Avg.	25.06
	100 m	Pre-monsoon (Feb-May)	Avg.	22.61
		SW Monsoon (Jun-Sep)	Avg.	21.13
		NE Monsoon (Oct-Jan)	Avg.	20.83
Off Mekran and Las Bela Coasts	Surface	Pre-Monsoon (May)	Avg.	~ 29
		Mid-summer	Avg.	~ 27
		Post SW Monsoon (October)	Range	26 to 27
		February	Range	< 22
Karachi Nearshore	Surface	Annual	Range	19 to 31
		Winter	Range	19 to 24
		Summer	Range	28 to 31
	5 m	Annual	Range	18 to 30



Location	Depth	Season	Temperature (°C)	
Karachi Offshore	Surface	Annual	Range	20 to 30
	5 m	Annual	Range	19 to 29
	10 m	Annual	Range	18 to 28
Inside the Indus Deltaic Creeks	Surface	Annual	Range	18 to 32
Seaward Side of the Creeks	Surface	Annual	Range	18 to 31
Indus Deltaic Coast Nearshore	Surface	Annual	Range	19 to 31
		Winter	Range	19 to 24
		Summer	Range	28 to 31

#### 4.7.3 Waves

The wave regime on the coast varies with seasons. During the winter season, when winds are around 5 m/s, the coastal waters are almost calm and the wave height is less than 1 m. During the southwest monsoons of the summer months, the winds are around 13 m/s and the waves on the coast are more than 3 m high and vary according to the nearshore depths and locations. In other months the waves are between 1.5 to 2.5 m.

*The Deep Seas Wave Climate:* Pakistan lies to the northern end of the Arabian Sea that extends southwards into the Indian Ocean for thousands of kilometers. The coast is exposed to waves from the south, southwest and west. The distances involved mean that the wave generation times, and consequently the wave periods may be very long.

During the severe weather in the summer due to the monsoons, the majority of the wind, and hence the waves come from the southwest. During the winter months, however, the weather conditions are very different, with the wind no longer coming predominantly from one direction. Therefore, in the winter both swell waves and locally wind generated waves influence the coast.

For the swell waves, voluntary observations of weather data by ships of passage are considered to give the most realistic offshore wave data. However, for the locally generated waves, wind data from nearby coastal stations are considered to be more accurate.

Deep sea wave data, for the southwest Monsoon months (May to September) applicable to Pakistan coast is given in **Exhibit 4.39**.

**Exhibit 4.39: Deep Sea Wave Frequency Distribution Statistics**

Resultant Wave Height (m)	Wave Period (Seconds) for Higher of Sea/Swell Height									
	0-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18	Total
0 to 0.5	2.6%	4.1%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	<b>7.4%</b>
0.6 to 1.0	1.1%	5.3%	1.8%	0.4%	0.1%	0.0%	0.0%	0.0%		<b>8.9%</b>
1.1 to 1.5	1.2%	6.7%	6.3%	2.2%	0.6%	0.1%	0.1%	0.0%	0.0%	<b>17.3%</b>
1.6 to 2.0	0.1%	3.8%	4.9%	2.9%	0.9%	0.2%	0.1%	0.0%	0.0%	<b>12.8%</b>

Resultant Wave Height (m)	Wave Period (Seconds) for Higher of Sea/Swell Height									
	0-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18	Total
2.1 to 2.5	0.0%	2.8%	5.0%	3.6%	1.4%	0.4%	0.1%	0.0%		<b>13.2%</b>
2.6 to 3.0		1.3%	3.4%	3.2%	1.5%	0.5%	0.1%	0.0%	0.0%	<b>10.0%</b>
3.1 to 4.0		1.1%	4.9%	6.1%	2.9%	1.0%	0.3%	0.1%	0.0%	<b>16.4%</b>
4.1 to 5.0		0.2%	1.8%	3.3%	1.9%	0.8%	0.2%	0.0%	0.0%	<b>8.3%</b>
5.1 to 6.0		0.0%	0.5%	1.4%	1.1%	0.4%	0.1%	0.0%	0.0%	<b>3.6%</b>
6.1 to 7.0			0.2%	0.5%	0.4%	0.2%	0.1%	0.0%	0.0%	<b>1.5%</b>
7.1 to 8.0			0.0%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	<b>0.5%</b>
8.1 to 9.0			0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	<b>0.1%</b>
9.1 to 10.0			0.0%	0.0%	0.0%	0.0%				<b>0.0%</b>
10.1 to 12.0				0.0%	0.0%		0.0%			<b>0.0%</b>
12.1 or more							0.0%			<b>0.0%</b>
<b>Total</b>	<b>5.1%</b>	<b>25.3%</b>	<b>29.4%</b>	<b>23.9%</b>	<b>11.0%</b>	<b>3.7%</b>	<b>1.3%</b>	<b>0.3%</b>	<b>0.1%</b>	<b>100.0%</b>

**Notes:**

1. Sea Area Coverage: 15-25 N, 60-70 E
2. Seasonal Coverage: May to September
3. Period of data: January 1949-October 1995
4. Blank indicates zero frequency whilst 0.0% indicates less than 0.05%
5. Total number of observations were 38,143

#### **4.7.4 Wave Induced Currents**

Apart from the currents generated by the orbital motion in waves, there are two important currents which influence the erosion and the movement of eroded material. These currents are described below.

The longshore current is the littoral current in the breaker zone which moves essentially parallel to the shore. The current is usually generated by waves breaking at an angle to the shoreline. The value of longshore current in the Indus Deltaic region is about 1.0 meter per second and at Gadani is 1.3 meter per second.

The rip currents are characterized by the under currents and eroding sand which swiftly move towards the open sea from the nearshore areas on the open sea beaches. The rip currents, therefore, pose a danger of drowning to the bathers and swimmers on the beaches in addition to the scouring effects on the artificial coastal structures built within the area of their influence. The rip currents have been observed in a few places along the coast of Karachi. The most probable places where the rip currents occur are in Hawkes Bay, Gadani Bay, Khalifa Bay, Phuari Bay and off the islands at the entrances of the creeks (e.g. Bundal Island).

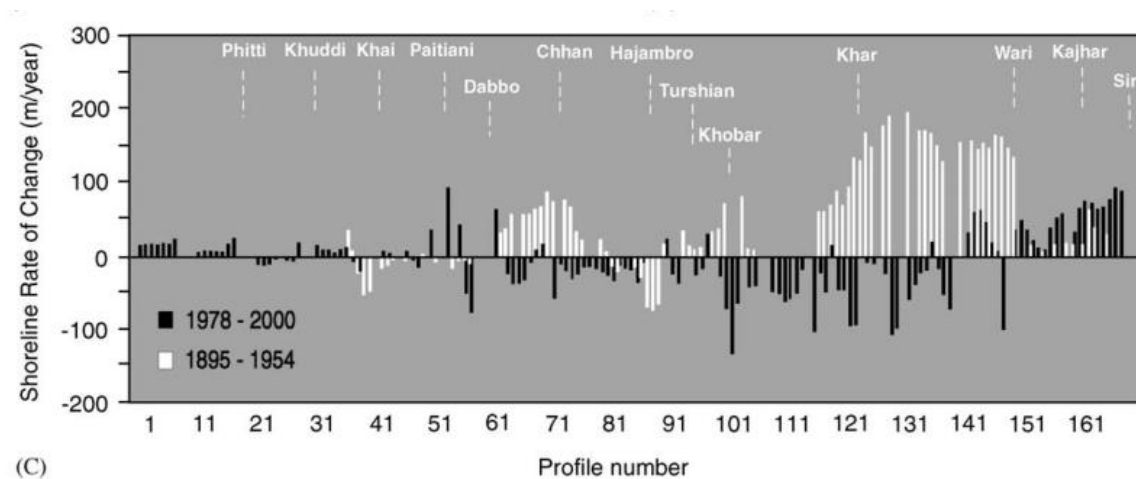
#### **4.7.5 Erosion and Sedimentation**

The abandoned channels of the Indus Delta have been reworked, through erosion and sedimentation, by tides into dendritic tidal creeks. The tidal creek network is most

extensive and mature east of the present Indus mouths (Khobar and Ghaghiar creeks). In comparison, the deltaic coast closer to Karachi is dense and a less mature channel network. The stronger wave influence along this part is suggested by occurrence of drumstick-shaped barrier islands typical of island systems significantly influenced by both waves and tides *e.g.* Khiprianwala Island<sup>61</sup>.

**Exhibit 4.40** provides a temporal comparison of shoreline change rates for the Indus Delta Coast. The shoreline changes indicate that extensive parts of the Indus Delta have become erosional after damming<sup>62</sup>. Nonetheless, the retreat rates between the Khobar creek and Karachi have had significantly lower rates, with the sector between Paitiani and Karachi prograding at an average rate of ~10 m/year. Specifically, within the Phitti, Khuddi creeks, within the Study Area, there has been a trend of progradation, likely associated with littoral drift.

**Exhibit 4.40: Shoreline Change Rates for Indus Delta Coast**



Source: Giosan et al. 'Recent morphodynamics of the Indus delta shore and shelf' (2006)

In comparison to the shoreline along Phitti, Khuddi and Khai creeks, the dynamics within the creeks of the Study area are different. In addition to influence by waves and tides on erosion and sedimentation along the coast, erosion related to Developments at Port Qasim and ship wake associated with Port Qasim has been reported by the PQA<sup>63</sup>. A comparison of mangrove extent along the banks of the current navigation channel and proposed extension (see **Section 2**) using aerial imagery from 2014 and 2004 indicates the following (see **Exhibit 4.41**):

<sup>61</sup> Inam *et al.* 'The Geographic, Geological and Oceanographic Setting of River Indus' in 'Large Rivers: Geomorphology and Management' (2007)

<sup>62</sup> Giosan et al. 'Recent morphodynamics of the Indus delta shore and shelf' (2006)

<sup>63</sup> Reported during discussions with the Director Dredging (Jawad Ud Din Ather)

- ▶ there is up to 100 m of erosion of mangroves along the banks of Kadiro Creek
- ▶ in section 1, along Kadiro Creek, the net erosion<sup>64</sup> per unit channel-length is 48.6 m<sup>2</sup>/m-channel<sup>65</sup>
- ▶ in section 2, in front of the main Port Qasim bulk terminals, the net erosion per unit channel-length is 15.0 m<sup>2</sup>/m-channel
- ▶ in section 3, where the extension is proposed, the net erosion per unit channel-length is 15.5 m<sup>2</sup>/m-channel

Lower net erosion is evident in section 2, where the channel is wider, and section 3 where there is a proposed extension compared to section 1. In comparison to section 2 and 3, the channel in section 1 (Kadiro Creek) is narrow. This indicates greater impact of ship wake, in particular, along section 1.

In addition to mangrove erosion along the banks, the amount of dredging material removed from the channel each year by Port Qasim is an indicator of net erosion and sedimentation within the channel<sup>66</sup>. This data could be used for further monitoring, as proxy for net erosion and sedimentation.

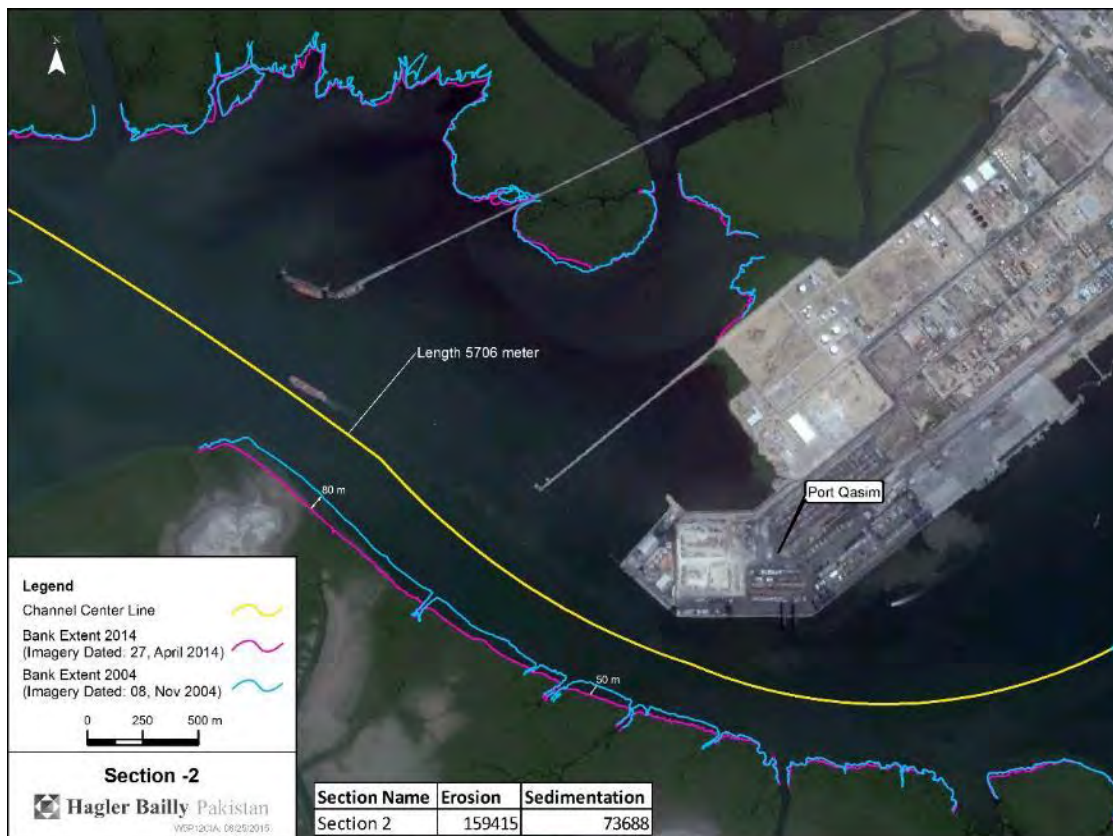
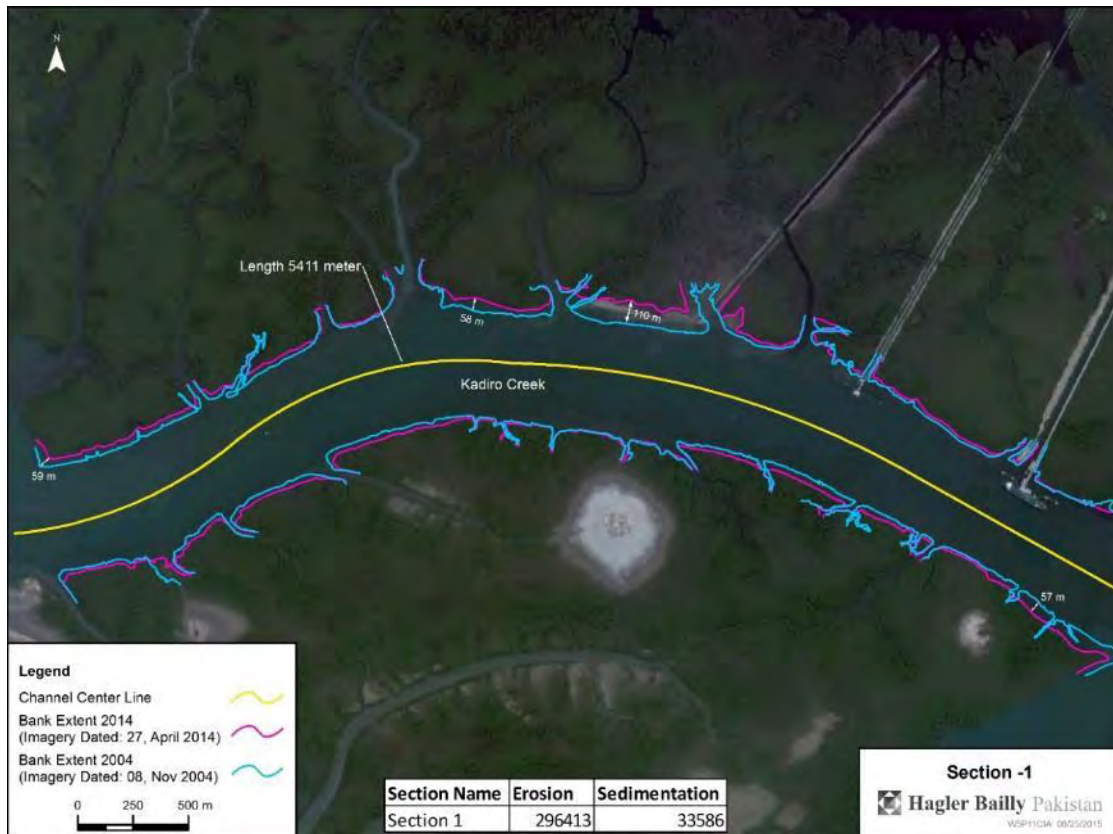
**Exhibit 4.41:** Erosion along the Current Navigation Channel and Anticipated Extension



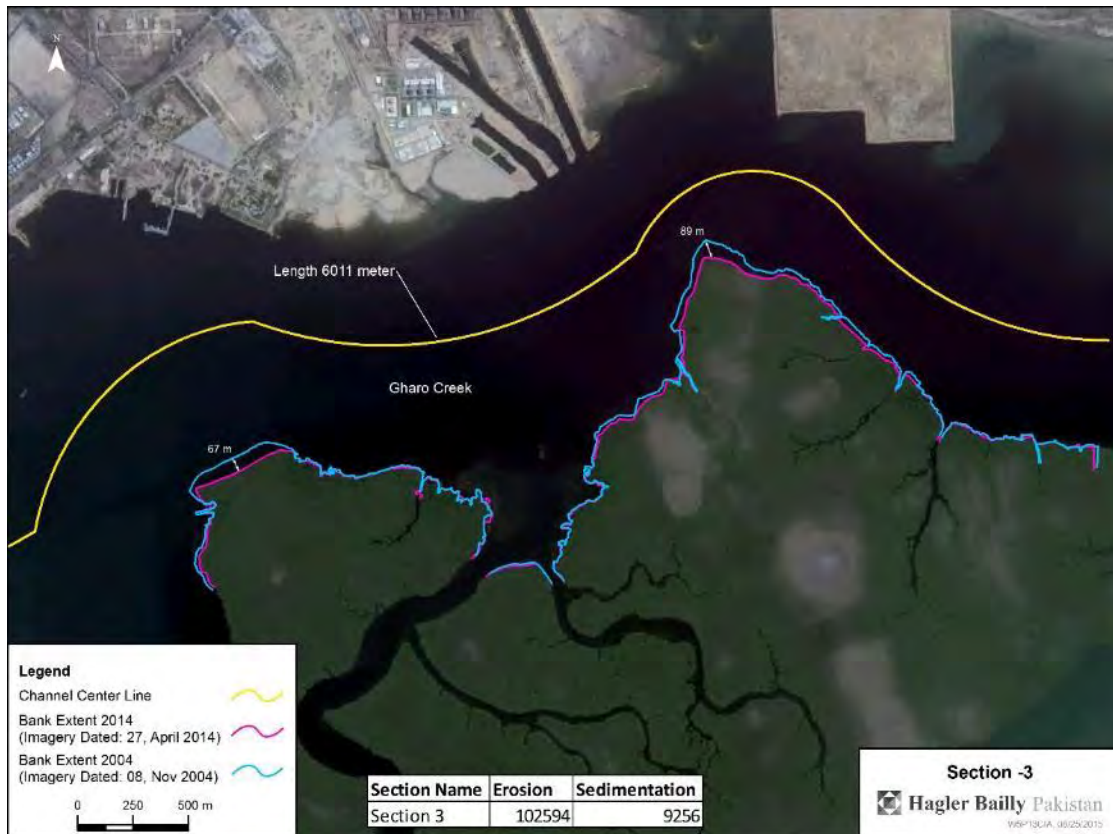
<sup>64</sup> Net Erosion (area) = Erosion (area) – Sedimentation (area)

<sup>65</sup> Recent design information provided by the Pakistan International Bulk Terminal indicates that some dredging has been carried out, along Section 1, which may erroneously increase the estimated net erosion. Nonetheless for the purposes of this Study, a 20% error is expected, particularly given the aerial imagery utilized.

<sup>66</sup> Where the dredged channel depth has remained the same.







#### 4.7.6 Sediment Quality Sampling and Analysis

Sediment was sampled from multiple locations from the Study Area for the purposes of the Study. The purposes of the sampling and analysis included:

- ▶ detecting major contamination of metals, cations and anions, hydrocarbons; and
- ▶ obtaining and assessing the particle size distribution, particularly to determine presence of clays within the channels.

#### **Current Sediment Quality Sampling and Locations**

A total of nine sediment quality samples were collected from June 4, 2015 to June 8, 2015. The sampling locations were chosen considering marine ecosystem, port activities and wastewater inflows from the on-shore industry. All samples were taken from the channel bed, as access to islands (with mangroves) was not possible given conditions due to the prevalence of the Summer Monsoon. The samples and its locations are listed in **Exhibit 4.43**.

**Exhibit 4.42: Sediment Sampling Locations**

<i>Sample ID</i>	<i>Coordinates</i>	<i>Sampling Depth (m)</i>	<i>Location Description</i>	<i>Sample Type</i>	<i>Analysis Type</i>
W1	24°45'49.6" N 67°07'24.4" E	5	Korangi Creek	Marine Sediment	PSD
W2/EC5	24°43'45.9" N 67°21'13.2" E	14	Near PQ Main Jetty	Marine Sediment	PSD
W3/ EC4	24°43'53.1" N 67°14'50.3" E	15	Chann Wado Creek	Marine Sediment	PSD
W4	24°43'57.75"N 67°14'40.28"E	0.2	Gharo Creek	Marine Sediment	PSD
W5	24°35'49.3" N 67°30'58.9" E	4	Upstream Regulator for Jam Sakro Outfall Drain	Freshwater Drain Sediment	PSD
W7/EC7	24°37'51.8" N 67°17'9.0" E	9	Near Khuddi Creek	Marine Sediment	SC & PSD
W8/EC3	24°46'08.4" N 67°25'23.6" E	0.5	Near Shah Hasan Shrine	Marine Sediment	SC & PSD
W13	24°44'29.8" N 67°35'39.4" E	0.2	Upstream Gharo Creek	Freshwater Drain Sediment	PSD
WW2	24°48'33.9" N 67°15'53.4" E	0.2	Bhains Colony Drain near Lat Basti Village	Wastewater Drain Dediment	SC & PSD

PSD: Particle Size Distribution

SC: Sediment Chemistry

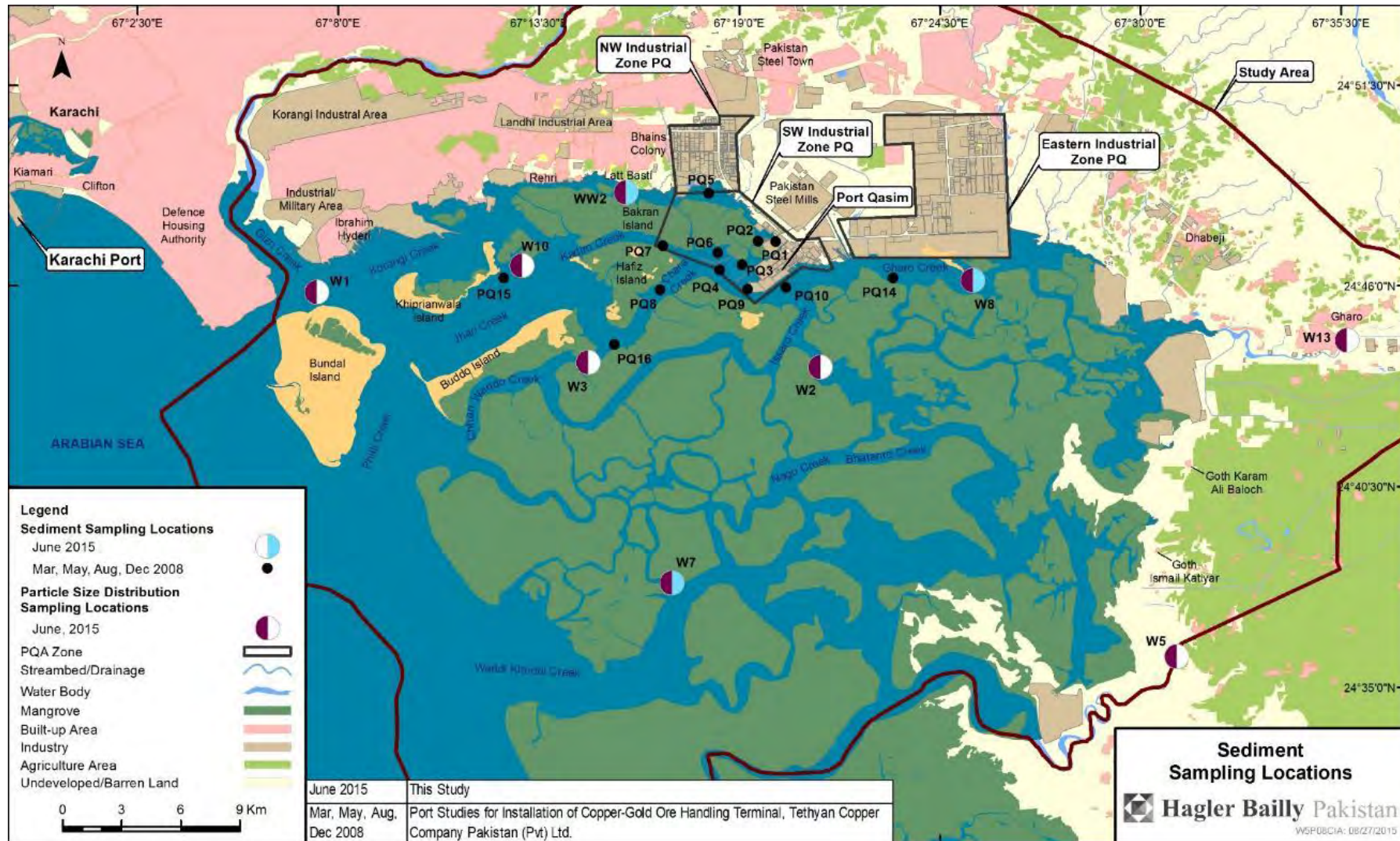
### ***Past Sediment Quality Surveys***

Past sediment surveys have been carried out for the following projects:

- Hagler Bailly Pakistan, Port Studies for Installation of Copper-Gold Ore Handling Terminal for Tethyan Copper Company, 2008

The locations for current and previous sampling have been indicated on a map in **Exhibit 4.43**. Photographs of the sampling are provided in **Exhibit 4.44**.

**Exhibit 4.43: Map of Sediment Sampling Locations**





**Exhibit 4.44: Photographs of the Sediment Sampling**



**Photograph 01:** Sample extraction from the Ponar grab sampler



**Photograph 02:** Sediment mixing before transfer to the glass container



**Photograph 03:** Sample separation for PSD analysis



**Photograph 04:** Sediment sample collection

***Sediment Quality Results and Analysis***

There are no national standards for screening of soil parameters. The approach used is to compare the concentration of various parameters with the three times the corresponding value of average crustal abundance (the target value) of metals that found in the Earth's crust and published international guidelines and standards.

A summary of the analysis against soil target values and standards is provided in **Exhibit 4.45** and sediment particle size distribution is provided in **Exhibit 4.46**, while the detailed laboratory results are provided in **Appendix A**.

Total metals were analyzed in three samples from the Study Area. The observations from the results are as follows:

- ▶ Manganese and Strontium were detected at concentrations higher than three times its average crustal abundance in all samples and exceeds the sediment quality guidelines, target values and standards.
- ▶ Values of all other analyzed metals were below the reported guidelines or target values.

Further discussion on relevant heavy metal contamination in fish is provided in **Section 5.5.4**.

**Exhibit 4.45: Sediment Metal Analysis**

Parameter	Units	Level of Reporting (LOR)	Soil Sample Results			Sediment Quality Guidelines, Target Values and Standards					
			W7/E C7	W8/E C3	WW2	3 x Crustal Abundance	UK ISQGs <sup>67</sup>	ASGWS S <sup>68</sup>	DTV <sup>69</sup>	CSQG <sup>70</sup>	SST <sup>71</sup>
Chromium	mg/kg	0.001	4.011	2.616	3.946	–	52.3	–	–	–	–
Cobalt	mg/kg	0.001	1.922	0.697	2.442	6.3	–	18	29	12	3.9
Iron	mg/kg	0.001	0.755	5.084	1.985	1,020	–	670	160	2000	–
Lead	mg/kg	0.001	1.787	0.693	1.452	26.1	30.2	120	–	–	–
Manganese	mg/kg	0.001	<b>90.244</b>	<b>43.923</b>	<b>75.193</b>	0.45	–	1.9	0.8	22	–
Molybdenum	mg/kg	0.001	2.080	0.822	1.293	204	–	300 <sup>a</sup> , 230	36	91	–
Nickel	mg/kg	0.001	1.114	0.981	2.025	30	–	120	85	600	400
Vanadium	mg/kg	0.001	0.564	0.374	0.938	0.201	–	0.29	–	50	23
Strontium	mg/kg	0.001	<b>12.56</b>	<b>21.392</b>	<b>19.272</b>	0.15	–	5.5	–	2.9	390
Titanium	mg/kg	0.001	0.979	1.850	1.682	270	–	340	35	50	1600
Zinc	mg/kg	0.001	34.999	17.707	30.253	420	124	160	100	87	300

In above table “–” means information is not available

### **Particle Size Distribution Results and Analysis**

The particle size distribution (PSD) was determined for nine soil samples through sieve analysis. The laboratory results of particle size distribution (PSD) are provided **Appendix A** and summarized in **Exhibit 4.46**. The PSD analysis of the quality control duplicate sample (W7D) shows a similar pattern of soil size distribution with the corresponding sample (W7).

The dominant fraction within the soils was found to be sand based on the results in all samples. The geology over intertidal deltaic land consists largely of Quaternary clays<sup>72</sup>. This indicates that any Quaternary clay eroded (see **Section 5.3.11** on erosion due to ship wake of mangrove areas within Port Qasim over the last 10 years) are flushed out of the

<sup>67</sup> UK ISQGs: The United Kingdom Interim Marine Sediment Quality Guidelines

<sup>68</sup> ASGWSS: Australian Soil, Ground Water and Sediment Standards (ASGWS) for use under Part XV.1 of the Environmental Protection Act, Table 6 (Generic Site Condition Standards for Shallow Soils in a Potable Ground Water Condition): Ministry of the Environment

<sup>69</sup> DTV: Dutch Target Values, 2000

<sup>70</sup> CSQG: Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health for Industrial Land Use

<sup>71</sup> SST: Soil Standards for Thailand

<sup>72</sup> Based on field observations, as well as indicated ‘deltaic and tidal deposits, tidal delta-marsh deposits’ in Geology Baseline (**Section 4.3**).



Study Area and that the dominant source of sediment in the intertidal are sands from the ocean<sup>73</sup>.

**Exhibit 4.46: PSD Analysis of Sediment Samples**

Soil Type	Sieve Size (mm)	% Passing through US Standard Sieve									
		W1	W2/EC 5	W3/EC4	W4	W5	W7/EC 7	W7/EC 7-D	W8/EC 3	W13	WW2
Sand	2.00	100	100	100	100	100	100	100	100	100	100
	1.41	100	100	100	100	100	100	100	100	99.2	100
	1.00	100	99.6	98.4	96.8	99.2	98.8	97.6	98.8	98.3	98.3
	0.71	95.9	94.9	94.3	92.1	96.7	95.5	93.2	91.1	94.2	96.4
	0.50	89.3	87.3	81.9	81.8	89.2	88.0	86.2	86.8	87.2	85.4
	0.35	79.7	82.7	72.1	64.9	82.2	80.2	70.2	45.0	76.7	78.5
	0.25	64.6	54.4	44.5	42.3	49.5	49.0	44.4	32.1	46.7	64.2
	0.13	39.0	30.0	23.0	3.8	25.4	29.5	20.4	2.6	26.4	20.0
Silt or Clay	0.06	16.7	11.7	9.5	1.3	11.3	8.1	4.6	1.3	10.0	9.3
	0.01	6.5	2.5	2.5	0	2.5	2.4	1.3	0	1.4	0

<sup>73</sup> This is consistent with discussion with Director for Dredging at Port Qasim.

## 5. Ecological Baseline

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This ecological baseline provides the following information on the biodiversity in the Study Area (see **Section 3** for the definition of the Study Area):

- ▶ coastal and marine biodiversity including mangroves, mud flat habitats, marine invertebrate species, coastal fish, marine turtles, and marine mammals;
- ▶ terrestrial biodiversity including vegetation, mammals, herpetofauna and birds; and
- ▶ key species of economic importance.
- ▶ critical habitats. These are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes.

A major ecological feature of this habitat is the mangrove ecosystem which provides the bulk of the ecosystem services to the local communities and to the industrial facilities. The mangroves have, therefore, been described in more detail in comparison to other ecological components.

As described in **Section 3** and illustrated in **Exhibit 3.1**, the Study Area consists of most of the Notified Port Qasim Authority Area (PQA Area) including the Northwestern Industrial Zone, Eastern Industrial Zone and the South West Zone, as well as important ecosystems in the vicinity such as marine, coastal and mangrove ecosystems that are affected by the facilities and installations in the PQA Area. Some industrial areas, located outside and not part of Notified PQA Area, such as Korangi Industrial Area, Landhi Industrial Area and Pakistan Steel Mills are also included in the Study Area. Industrial and municipal effluents originating from them affect the coastal and mangrove ecosystems. A part of the Notified PQA Area extending into sea beyond about 6 km from the mangrove areas was excluded from the Study Area as it is not likely to be influenced by developments at PQA or other industrial areas in vicinity.

### 5.1 Ecological Setting

Port Qasim is located on the northwestern fringe of the Indus Delta system. The Indus Delta is a unique example of a natural wetland in the Arabian coastal biogeographic region. It is the fifth largest delta of the world, formed by the river Indus and tidal creeks. The delta is considered unique, because it experiences the highest wave energy of any river in the world. The delta consists of creeks, estuaries, mud, sand, salt flats, mangrove habitat, marshes, sea bays and straits and rocky shores. It is a typical fan shaped delta, built up by the discharge of large quantities of silt and sediments washed down the Indus River from the Karakoram and Himalaya mountain ranges. The delta area is considered

as very important due to the presence of arid mangrove ecosystem which is the 7th largest mangrove forest in the world.<sup>74</sup>

Estimates for the area covered by mangroves in Indus Delta reported in the literature vary, depending on the time of the estimate and the techniques used for estimation. Based on a 2012 estimate, the area covered by mangroves in the Indus Delta is about 129,000 ha.<sup>75</sup> This is about 97% of the total mangrove area in Pakistan. Of this, approximately 31,316 ha<sup>76</sup> of mangroves are under the Port Qasim Authority, which is approximately a quarter<sup>77</sup> of the entire mangrove area in the country. Due to its large size, the delta is essential for maintaining the biodiversity in the region, including the arid mangrove habitat and its associated terrestrial and aquatic fauna. The estuarine creeks and mangrove area are the nursery ground for many species of fish and shrimps<sup>78</sup> and provide an important staging ground for migratory birds.

The World Wide Fund (WWF) has defined an eco-region as a 'relatively large unit of land or water containing a characteristic set of natural communities that share a large majority of their species, dynamics, and environmental conditions'.<sup>79</sup> There are two eco-regions in the Study Area, including The Indus Delta eco-region and the Northwestern Thorn Scrub forest eco-region (**Exhibit 5.1**). The Indus River Delta-Arabian Sea Mangroves represent a mangrove habitat of nearly mono-specific stands of *Avicennia marina* that is adapted to some of the most extreme temperatures and salinity conditions in the Indo-Pacific region. This habitat is considered endangered to critically-endangered.<sup>80</sup> **Section 5.8** includes a discussion on classification of mangrove habitats in the Study Area as Critical Habitat following IFC and ADB criteria.

## 5.2 Areas of International Importance and Protected Areas

### 5.2.1 Protected Areas Designated by Sindh Wildlife Department

A number of protected areas have been designated by the Sindh Wildlife Department in the Sindh province. These include national parks, game reserves and wildlife sanctuaries. The protected areas in the vicinity of the Study Area are shown on a map in **Exhibit 5.2**.

The Marho Kotri Wildlife Sanctuary covers an area of 162 hectares.<sup>81</sup> There is a discrepancy in various Government of Sindh publications on the exact boundaries of this Wildlife Sanctuary. However, it is located about 10 km away from the Study Area.

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<sup>74</sup> Indus for All Programme. WWF's Global 200 Eco-regions. Available at: [http://foreverindus.org/ie\\_protectedareas Ramsar.php](http://foreverindus.org/ie_protectedareas Ramsar.php), accessed June 2015

<sup>75</sup> Said A Damhoureyeh and Syed Ali Ghalib, "An Overview of the Status and Distribution of the Mangrove Forests and their Wildlife in Sindh". Canadian journal of pure and applied sciences, Vol. 8, No. 3, pp. 3051-3055, October 2014.

<sup>76</sup> See Section 4.2 for landuse within Study Area.

<sup>77</sup> Estimated based on 31,316 ha as a fraction of the total mangrove area in the country.

<sup>78</sup> Ibid

<sup>79</sup> Official website for World Wide Fund for Nature.: <https://www.worldwildlife.org/biomes>, accessed June 2015

<sup>80</sup> Ibid

<sup>81</sup> Indus Eco region Program, Official website, available at : [http://foreverindus.org/ie\\_protectedareas\\_wild\\_sanctuaries.php](http://foreverindus.org/ie_protectedareas_wild_sanctuaries.php), accessed June 2015

The Haleji Lake Wildlife Sanctuary is located at a distance of approximately 13km from the Study Area and covers an area of 1,704 hectares.<sup>82</sup> Haleji Lake is an artificial freshwater lake with fluctuating water levels, fringed by brackish seepage lagoons and supporting abundant aquatic vegetation. It's one of the most important breeding, staging and wintering areas for water birds in southern Pakistan, supporting between 50,000 and 100,000 birds annually, including Dalmatian Pelican (*Pelecanus crispus*), European Wigeon (*Mareca penelope*) and Black Coot (*Fulica americana*). Haleji Lake was declared a Wildlife Sanctuary in 1977 (Sindh Wildlife Protection Ordinance) in order to protect these bird species.<sup>83</sup>

Hudero Lake Wildlife Sanctuary is located at a distance of approximately 23 km from the Study Area and covers an area of 13,468 hectares. Hudero Lake is an important brackish water wetland of Sindh where variety of waterfowl prefers to take refuge. Common birds of this lake include storks, cranes, flocks of pelicans and occasional swans. Hudero Lake was declared as Wildlife sanctuary in 1977.<sup>84</sup>

The Keti Bandar North Wildlife Sanctuary is located at a distance of approximately 22 km from the Study Area and covers an area of 8,948 hectares. Migratory birds reported from this sanctuary include pelicans, egrets, herons, waders, raptors.<sup>85</sup>

### 5.2.2 Key Biodiversity Areas (KBAs)

Key Biodiversity Areas designated by IUCN (International Union for Conservation of Nature and Natural Resources)<sup>86</sup> are places of international importance for the conservation of biodiversity through their protected status and other governance mechanisms.

The Outer Indus Delta located adjacent to the Study Area (see **Exhibit 5.3**) has been designated a KBA as a result of significant populations of a globally threatened species, the Dalmatian Pelican *Pelecanus crispus* (VU) and significant congregations of water birds (**Exhibit 5.2**).

### 5.2.3 Ramsar Sites

Ramsar sites are wetlands of international importance designated under the Ramsar Convention.<sup>87</sup> Part of the Indus Delta has been designated as a Ramsar Site (see **Exhibit 5.2**). The Indus Delta Ramsar site overlaps with this KBA. It supports a large

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<sup>82</sup> Ibid

<sup>83</sup> Wildlife Sanctuaries in Pakistan. [http://pakistanpaedia.com/wildlife/wetlands/wild-life-sanctuaries-in\\_pakistan.html](http://pakistanpaedia.com/wildlife/wetlands/wild-life-sanctuaries-in_pakistan.html), accessed June 2015

<sup>84</sup> Indus Eco region Program, Official website, available at : [http://foreverindus.org/ie\\_protectedareas\\_wild\\_sanctuaries.php](http://foreverindus.org/ie_protectedareas_wild_sanctuaries.php), accessed June 2015

<sup>85</sup> Indus Ecoregion programme Official website. Available at: <http://foreverindus.org/pdf/sites/ketibunder.pdf>, accessed June 2015

<sup>86</sup> IUCN official website available at : [https://www.iucn.org/about/union/secretariat/offices/iucnmed/iucn\\_med\\_programme/species/key\\_biodiversity\\_areas/](https://www.iucn.org/about/union/secretariat/offices/iucnmed/iucn_med_programme/species/key_biodiversity_areas/), accessed June 2015

<sup>87</sup> Ramsar Convention, or Convention on the Wetlands of International Importance, Administered by the Ramsar Secretariat, Geneva, Switzerland. Available at: [http://ramsar.rgis.ch/cda/fr/ramsar-news-archives-2003-pakistan-designates-17884/main/ramsar/1-26-45-86%5E17884\\_4000\\_1\\_\\_](http://ramsar.rgis.ch/cda/fr/ramsar-news-archives-2003-pakistan-designates-17884/main/ramsar/1-26-45-86%5E17884_4000_1__), accessed June 2015

number of species of birds, fish and shrimps, dolphins, and reptiles. Other Ramsar sites in the vicinity of the Study Area include the Haleji Wildlife Sanctuary (13 km away) and Kinjhar Lake (36 km away).

The Indus Delta was notified as Ramsar Site in 2003. The northwestern boundary of the Ramsar site coincides with that of the Study Area, which lies just outside the boundary of the PQA Notified Area (see **Exhibit 3.2** in **Section 03**). Discussions with wildlife officials<sup>88</sup> reveal that the northwestern boundary of the Indus Delta Ramsar site was specifically set to maintain a short distance from the PQA Notified Area where port developments were expected. In terms of condition of mangrove habitat, it was quite apparent and clearly understood that the mangrove habitat and its ability to provide shelter and food for migratory birds actually improved moving into the Notified Area (see **Section 5.3.2**). The thinking amongst the wildlife managers at that time was that in view of its special status, alternate means of protecting and managing the mangrove habitats in the PQA Notified Area will be explored in future to maintain continuity of habitat in the Indus Delta.

#### **5.2.4 Important Bird Areas**

The Important Bird Areas (IBAs)<sup>89</sup> are designated by Birdlife International in different countries of the world and are key sites for conservation – small enough to be conserved in their entirety and often already part of a protected-area network. They do one (or more) of three things:

- ▶ Hold significant numbers of one or more globally threatened species
- ▶ Are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species
- ▶ Have exceptionally large numbers of migratory or congregatory species

The location of some of the IBAs identified in Sindh<sup>90</sup> are indicated on a map in **Exhibit 5.3**. The IBAs in the vicinity of the Study Area are the Outer Indus Delta that lies adjacent to the Study Area and Haleji Wildlife Sanctuary located about 13 km away from the Study Area.

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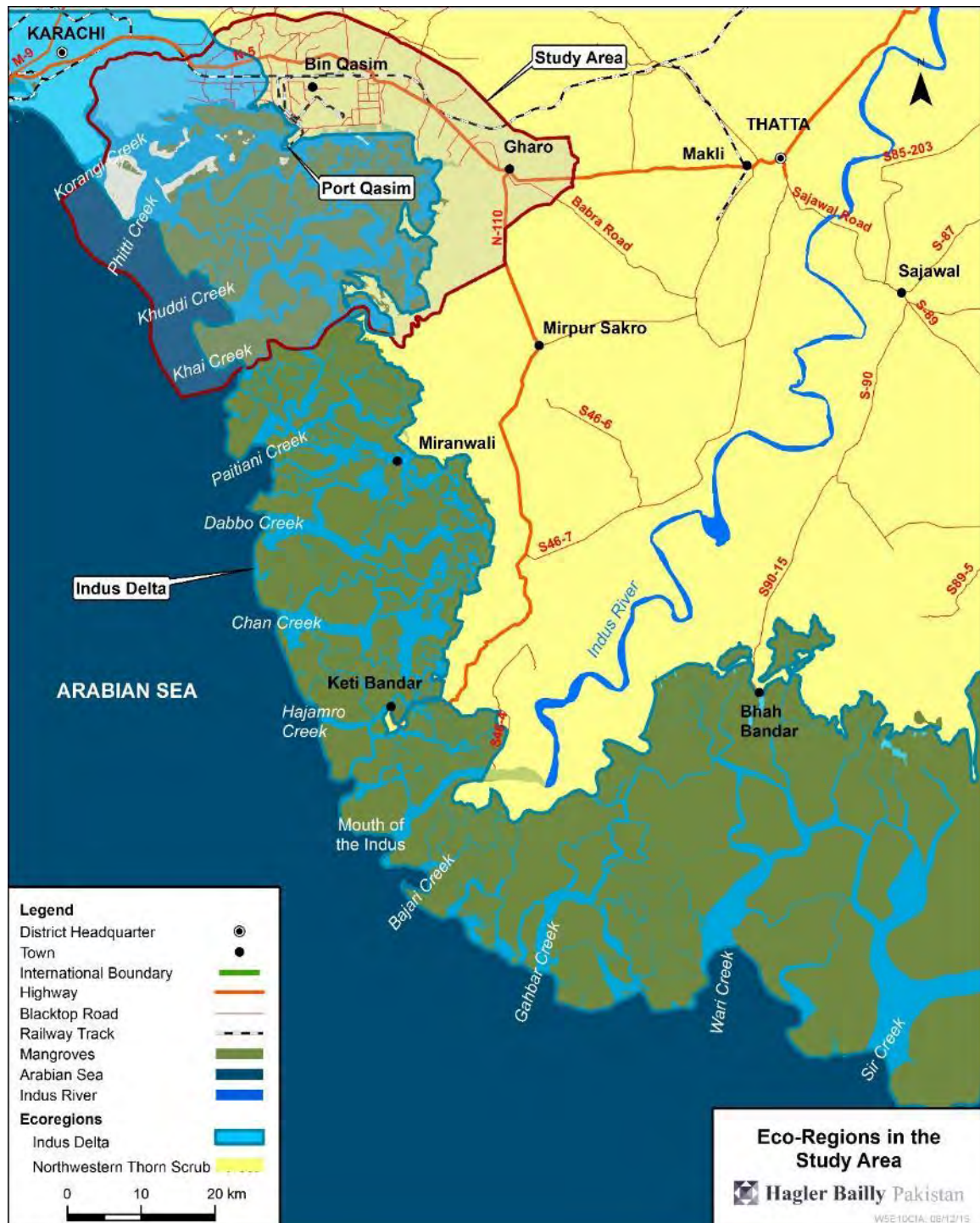
<sup>88</sup> Personal communication with Mr Munaf Qaimkhani, Deputy Inspector General of Forests, Ministry of Climate Change, November 2015. Mr Qaimkhani is on deputation from Sindh Wildlife Department, where he was closely involved in submission of the case for notification of Indus Delta as a Ramsar Site, preparation for which was done a few years prior to 2013 when the site was notified under the Ramsar Convention.

<sup>89</sup> Birdlife International official website. <http://www.birdlife.org/action/science/sites/index.html>. Downloaded 5 December 2012

<sup>90</sup> Birdlife International Official Website <http://www.birdlife.org/datazone/userfiles/file/IBAs/AsiaCntryPDFs/Pakistan.pdf>, accessed June 2015



**Exhibit 5.1: Ecoregions in the Study Area**



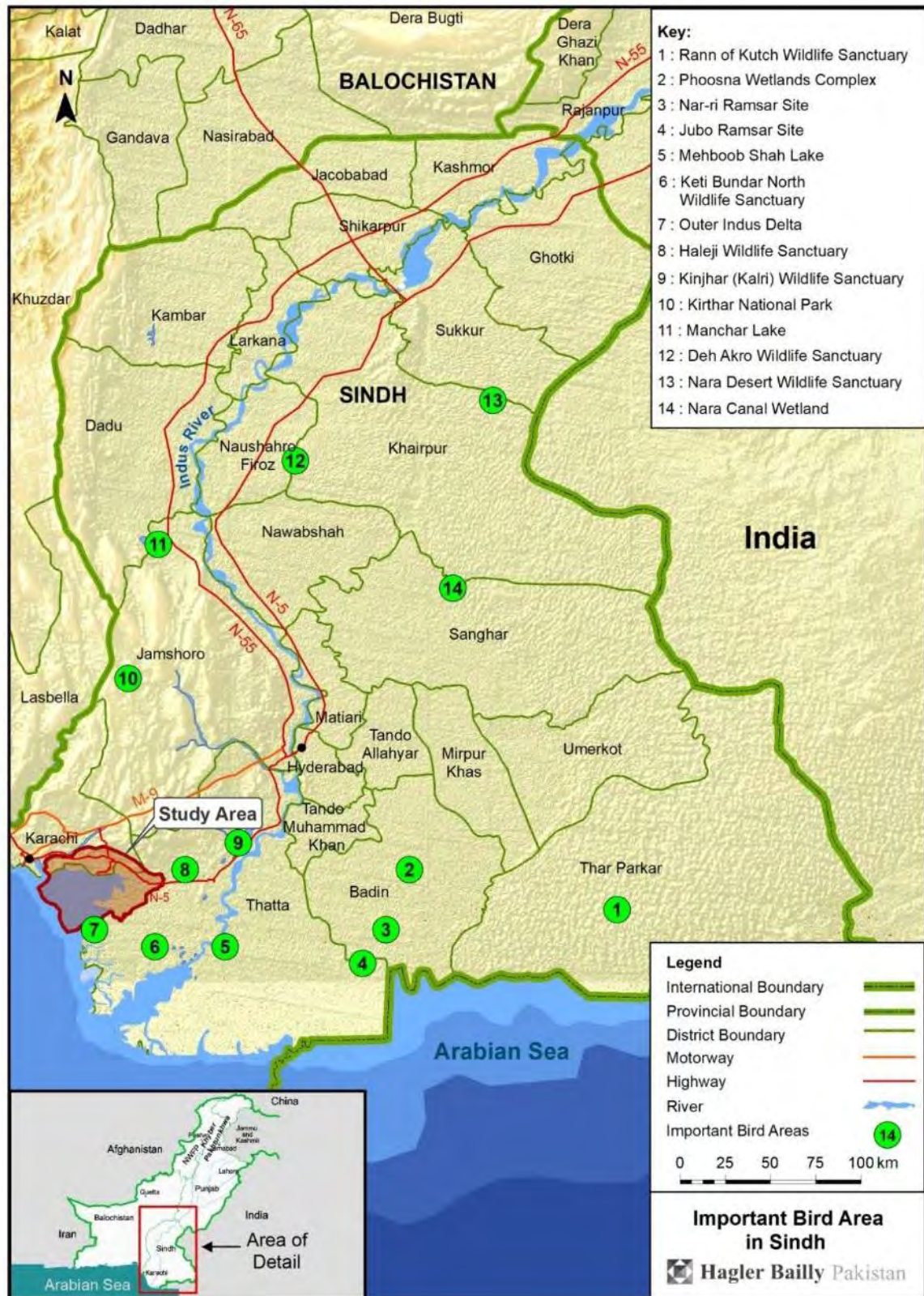
**Exhibit 5.2: Protected Areas in the Vicinity of Study Area**



**Note:** Boundary of Ramsar site at Indus Delta taken from official Ramsar website. Available at: <https://rsis.ramsar.org/RISapp/files/259/pictures/PK1284map.pdf>, accessed October 2015



**Exhibit 5.3: Important Bird Areas in Sindh**



## **5.3 Mangrove Habitat**

### **5.3.1 Importance of Mangroves**

Mangroves provide a habitat and breeding ground for a variety of marine life, particularly fish, shrimps and crabs, and are important for maintaining both the commercial and subsistence offshore fisheries. Mangroves also provide suitable habitats for migratory birds, meet fuel wood and fodder requirements of the local communities and support the livelihood of the coastal population in Sindh.<sup>91</sup> The following is extracted from Dr. Kanwal Nazim's PhD thesis titled 'Population Dynamics of Mangrove Forests from Coastal Areas of Sindh'.<sup>92</sup>

Mangroves provide one of the basic food chain resources for arboreal life and near shore marine life through their leaves, wood, roots and detritus materials. The mangrove vegetation provides a bulk source of organic matter (detritus) to decomposers. The detritus provides the base of the food chain. This primary productivity is a significant part of the food chain and supplies energy to aquatic and terrestrial habitats.

A variety of organisms use the mangroves as physical habitats and nursery grounds, including both vertebrates and invertebrates. Some, such as woodborers, fungi and bacteria are involved in recycling of the mangrove plant derived detritus. Out of all the micro-organisms, bacteria and fungi are known to play a vital role in nutrient cycling. Decomposition by these organisms' results in protein enriched fragments of the detritus.

The structural properties of mangroves are important, including trapping and stabilization of intertidal sediments, formation of organic soils, providing protection from wave and wind erosion, forming a structural complex of a multi-branched forest with a wide variety of habitats and providing a vegetative reef surface in sub-tidal and intertidal zones. The extensive root system of mangroves traps and filters plant matter which is why they are considered bio-chemical depositors.

Mangroves play an important role in nutrient cycling and nutrient mass balance of estuarine ecosystems. The mangrove forests provide a connecting link between the terrestrial and aquatic ecosystem. Most aquatic organisms depend on the nutrients released by the mangrove ecosystem, after decomposition. Furthermore, the fine anoxic sediments under the mangroves act as sinks for a variety of heavy (trace) metals, thereby, helping in reducing pollution.

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<sup>91</sup> Indus for All Program (IFAP). "Mangroves of Pakistan WWF- Pakistan", Karachi, pp16. 2008

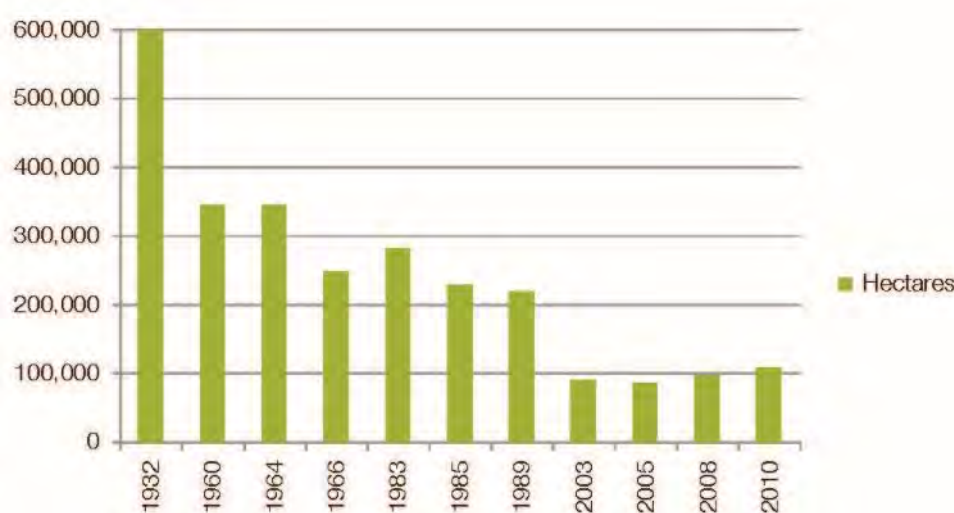
<sup>92</sup> Dr. Kanwal Nazim. Population Dynamics of Mangrove Forests from Coastal Areas of Sindh (PhD thesis, Federal University of Arts, Science and Technology, 2011)

### 5.3.2 Mangroves in the Indus Delta

The Indus Delta constitutes 97% of the mangroves in Pakistan<sup>93</sup> and part of it has been designated as a Ramsar Site (see **Section 5.2.3**). It supports the seventh largest mangrove forest system in the world.<sup>94</sup>

There are a number of estimates of mangrove cover by the Sindh Forest Department, Sindh Coastal Development Authority, the International Union for Conservation of Nature and Natural Resources (IUCN), and the World Wide Fund for Nature (WWF-Pakistan). Estimated mangrove cover has been provided in **Exhibit 5.4**.

**Exhibit 5.4: Mangrove Cover in Indus Delta**



Source: Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds) (2012). *Sharing Lessons on Mangrove Restoration*. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN

Historical records indicate that the distribution of mangroves in the Indus Delta has changed significantly over the past several hundred years as the river has shown a shifting pattern.<sup>95</sup> In more recent times, factors responsible for the changes in mangrove distribution include both the dynamic nature of the Indus Delta and impacts of human activities. In addition to this, natural events such as storms have also affected distribution.<sup>96</sup>

<sup>93</sup> Said A Damhoureyeh and Syed Ali Ghalib, "An Overview of the Status and Distribution of the Mangrove Forests and their Wildlife in Sindh". Canadian journal of pure and applied sciences, Vol. 8, No. 3, pp. 3051-3055, October 2014.

<sup>94</sup> World Wide Fund for Nature- Pakistan, official website available at [www.panda.org](http://www.panda.org) [http://www.panda.org/what\_we\_do/where\_we\_work/indus\_delta/?src=footer], accessed June 2015

<sup>95</sup> Snedaker, S.C. Mangrove: A summary of Knowledge with emphasis on Pakistan. In Marine Geology and Oceanography of Arabian Sea and coastal Pakistan Ed. B.U Haq and J.D Milliman Van Nostrand Reinhold Company Inc. NY. pp 255-262, 1984

<sup>96</sup> Chandra Giri, Jordan Long, Sawaid Abbas, R.Mani Murali, Faisal M. Qamer, Bruce Pengra, David Thau Distribution and dynamics of mangrove forests of South Asia. Journal of Environmental Management 148, pg 101-111, 2015



While the estimates for mangrove cover for different years vary among sources<sup>97</sup>, there is agreement that the dense mangrove cover in Pakistan has declined significantly due to multiple stresses since 1932<sup>98</sup> (see **Exhibit 5.4**). Recent trends since 2003, however, show a slight increase (see **Exhibit 5.4**). **Exhibit 5.5** shows that there is greater persistence and regeneration of mangroves in the northwestern part of the Indus Delta within the Study Area, compared to other parts of the Indus Delta. While the literature reviewed does not provide an explanation of this observation, possible reasons are fresher wastewater flowing into the creeks into the Study Area and nutrients brought in by wastewater along with flow of clays from the Malir catchment.

**Exhibit 5.6** shows the country-specific temporal variation of mangrove cover.<sup>99</sup> It can be seen from the values in **Exhibit 5.6** that mangrove cover in Pakistan has changed the most for each assessment year as compared to the other countries, with the exception of percentage change between 1990 and 2000 in which Vietnam has exceeded Pakistan. The rate of loss is more than 2% per year. Mangroves in Pakistan and Myanmar remain critically threatened.<sup>100</sup> The Philippines has also seen a large percentage change from 2000 to 2010. The perception amongst policy makers and developers in Pakistan of mangroves as wastelands has resulted in large areas of mangroves being cleared.<sup>101</sup> This historical perspective has contributed to severe mangrove degradation despite more recent changes in outlook and focus on their conservation.<sup>102</sup>

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<sup>97</sup> eg. the estimate in **Exhibit 5.6** does not correspond exactly with estimate in **Exhibit 5.4**.

<sup>98</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds) . Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

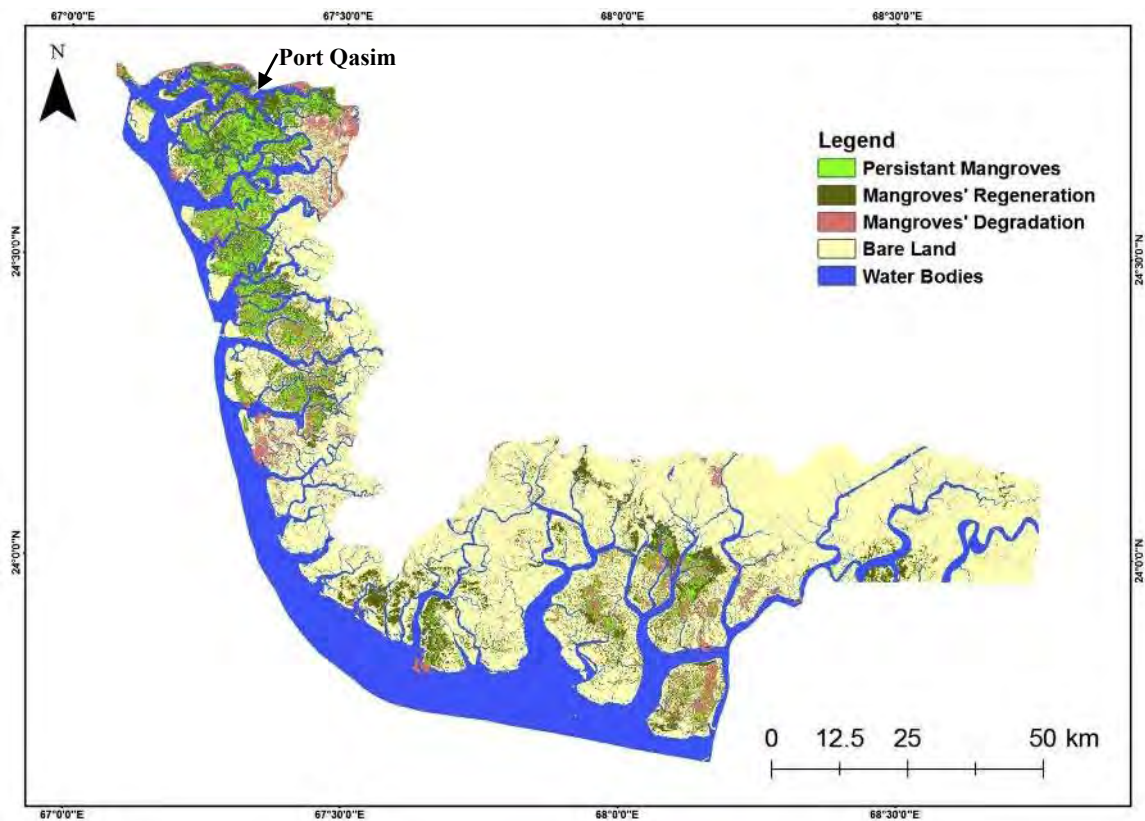
<sup>99</sup> Cumulative Impacts of Human Interventions and Climate Change on Mangrove Ecosystems of South and Southeast Asia: An Overview. Journal of Ecosystems Volume 2013, Article ID 379429, 15 pages.

<sup>100</sup> Ibid

<sup>101</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds). Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

<sup>102</sup> Ibid

**Exhibit 5.5:** Persistent Mangroves with forest loss and gain of Indus Delta  
from 1973 to 2010



Source: Cumulative Impacts of Human Interventions and Climate Change on Mangrove Ecosystems of South and Southeast Asia: An Overview. Journal of Ecosystems Volume 2013

**Exhibit 5.6:** Country-Specific Temporal Variation of Mangrove Cover

Country/ year	Mangrove Cover (km <sup>2</sup> )								
	1980	1990	%Change (1980–1990)	2000	%Change (1990–2000)	2005	Present	Assessment year	%Change (2000–latest)
<b>Pakistan</b>	<b>3,450</b>	<b>2,070</b>	<b>–40</b>	<b>1,580</b>	<b>–23.67</b>	<b>1,570</b>	<b>981<sup>a</sup></b>	<b>2010</b>	<b>–37.89</b>
India	5,067	4,670	–7.84	4,482	–4.03	4,480	4,639 <sup>b</sup>	2009	3.50
Bangladesh	4,280	4,600	7.48	4,760	3.48	4,760	4,810 <sup>c</sup>	2007	1.05
Myanmar	5,550	5,361	–3.41	5,167	–3.62	5,070	4379 <sup>d</sup>	2007	–15.24
Indonesia	42,000	35,000	–16.67	31,500	–10	29,000	32,440 <sup>e</sup>	2009	2.98
Malaysia	6,740	6,420	–4.75	5,895	–8.18	5,650	5,775 <sup>f</sup>	2007	–2.03
Vietnam	26,91	2,135	–20.68	1,575	–26.23	1,570	1,598 <sup>g</sup>	2008	1.43
Philippines	2,950	2,730	–7.46	2,500	–8.42	2,400	2,091 <sup>h</sup>	2007	–16.36
Thailand	2,800	2,502	–10.64	2,441	–2.44	2,400	2,296 <sup>i</sup>	2007	–5.94

Source: Cumulative Impacts of Human Interventions and Climate Change on Mangrove Ecosystems of South and Southeast Asia: An Overview. Journal of Ecosystems Volume 2013

### Species Composition and Salt Tolerance

In Pakistan, a total of eight species of mangroves existed in the coastal areas. However, only four species survive in the Indus Delta.<sup>103</sup> Three of these species (*Rhizophora mucronata*, *Aegiceras corniculatum*, *Ceriops tagal*) are at the verge of extinction, and only occur in localized patches. *Avicennia marina* is the dominant surviving species.<sup>104</sup>

*A. marina* is listed as Least Concern in the IUCN Red List.<sup>105</sup> It makes up about 99.9% of the mangrove forest cover along the coastline. This prevalence can be attributed to its high salt tolerance and ability to survive stressful conditions.<sup>106</sup> Studies indicate that mangroves thrive best at concentrations ranging from 3.5 psu<sup>107</sup> (practical salinity units) to 8.75 psu (10-25% seawater). However, best growth of Sunderban *A. marina* and Australian *Sonneratia alba* was reported at 17.5 psu (50% seawater).<sup>108</sup> *A. marina* behaves like a true halophyte, characterized by its enhanced growth under high salt conditions.<sup>109</sup> It is well adapted to a euryhaline environment.<sup>110</sup> However, *A. marina* has a physiological range of salt tolerance. Beyond that range its growth is also observed to be non-optimal as demonstrated by the various experiments attempting to establish its salt tolerance limit. In an experiment with propagules of *A. marina* taken from the Indus Delta, growth and physiological responses recorded at seedling and sapling stages showed a maximum growth at 17.5 psu (50% sea water) which declined with an increase in salinity beyond 17.5 psu. All other growth parameters followed more or less a similar pattern.<sup>111</sup> Greenhouse experiments with this species showed that growth of seedlings was significantly promoted by low salinity and optimum growth was obtained at 15.4 psu (practical salinity units) of NaCl. Higher salinities inhibited plant growth.<sup>112</sup> Another

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<sup>103</sup> Said A Damhoureyeh and Syed Ali Ghalib, "An Overview of the Status and Distribution of the Mangrove Forests and their Wildlife in Sindh". Canadian journal of pure and applied sciences, Vol. 8, No. 3, pp. 3051-3055, October 2014.

<sup>104</sup> Forest Department, Government of Sindh, <<http://sindhforests.gov.pk/>>, accessed on 26 May, 2015

<sup>105</sup> Duke, N., Kathiresan, K., Salmo III, S.G., Fernando, E.S., Peres, J.R., Sukardjo, S., Miyagi, T., Ellison, J., Koedam, N.E., Wang, Y., Primavera, J., JinEong, O., Wan-Hong Yong, J. & Ngoc Nam, V. 2010. *Avicennia marina*. The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 March 2015.

<sup>106</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds). Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

<sup>107</sup> The Practical Salinity Scale defines salinity in terms of the conductivity ratio of a sample to that of a solution of 32.4356 g of KCl at 15°C in a 1 kg solution. A sample of seawater at 15°C with a conductivity equal to this KCl solution has a salinity of exactly 35 practical salinity units (psu).

<sup>108</sup> Irfan Aziz and M. Ajmal Khan, Physiological Adaptations of *Avicennia Marina* to Seawater Concentrations in the Indus Delta, Pakistan. Pakistan Journal of Botany 32 (1): pages 151-169, 2000

<sup>109</sup> Ibid

<sup>110</sup> Philippa Drennan and N. W. Pammenter, Physiology of salt excretion in the mangrove *Avicennia Marina* (Forsk.) Vierh. New Phytologist, Volume 91, Issue 4, pages 597-606, 1982 [URL: <http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.1982.tb03338.x/abstract>]

<sup>111</sup> Irfan Aziz and M. Ajmal Khan, Physiological Adaptations of *Avicennia Marina* to Seawater Concentrations in the Indus Delta, Pakistan. Pakistan Journal of Botany 32 (1): pages 151-169, 2000

<sup>112</sup> Neha Tusharbhay Patel, Ajit Gupta, Amar Nath Pandey, Salinity tolerance of *Avicennia marina* (Forssk.) Vierh. from Gujarat coasts of India. Aquatic Botany, Volume 93, Issue 1, pages 9-16, 2010 [URL: <http://www.sciencedirect.com/science/article/pii/S0304377010000203>]

study found that over the range of 0 to 35 psu (0 to 100% sea water), an increase in the excretion rate maintains a constant leaf salt content.<sup>113</sup> The osmoregulator strategy of *A. marina* provides protection from sudden changes in salinity which is common in sub-tropical regions of the world.<sup>114</sup>

### **Factors Leading to Degradation and Regeneration of Mangroves**

The major destabilizing factor for mangroves in Pakistan has been identified as a reduction in fresh water flows which is expected to threaten their long term sustainability.<sup>115</sup> The Sindh Forest Department (SFD) has also identified shortage of fresh water and silt deposition from the River Indus as a key threat resulting in enhancement of the salinity of the Delta.<sup>116</sup> Until recently the Indus River had a largely river-dominated estuary (see **Section 4.6**) but due to increase in dams and reservoirs associated with agriculture and production of electricity, there is discharge to the Arabian Sea only during the summer southwest monsoon; in the remaining nine to ten months there is no estuary due to elimination of the river discharge.<sup>117</sup>

In a study carried out over the Indus Delta<sup>118</sup>, extensive degradation was observed in the upper tidal zone of the western end and the intertidal zone of the eastern part along the country's border line with India. The degradation in the upper tidal zone (region within which the Study Area is located) can be attributed to decreasing freshwater flows from the Indus River. As a consequence of this both the transport and uniform dispersal of suspended sediments over the mangrove area has been prevented. The surviving mangroves in the area are sparse and stunted.<sup>119</sup>

Factors apart from reduction in freshwater flows are also responsible for rapid mangrove degradation.<sup>120</sup> These include changes in environmental conditions in coastal areas such as hyper-salinity, decreased alluvial flow, pollution<sup>44</sup> including that from industrial and municipal areas<sup>121</sup>, dredging, soil erosion<sup>44</sup>, felling of mangroves<sup>44</sup>, encroachments of settlements around Karachi's mangroves, sea intrusion caused by sea level rise, dumping of waste, oil spills and leakages and the over-exploitation of mangroves for fuel, fodder

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<sup>113</sup> Philippa Drennan and N. W. Pammenter, Physiology of salt excretion in the mangrove *Avicennia Marina* (Forsk.) Vierh. New Phytologist, Volume 91, Issue 4, pages 597-606, 1982 [URL: <http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.1982.tb03338.x/abstract>]

<sup>114</sup> Irfan Aziz and M. Ajmal Khan, Physiological Adaptations of *Avicennia Marina* to Seawater Concentrations in the Indus Delta, Pakistan. Pakistan Journal of Botany 32 (1): pages 151-169, 2000

<sup>115</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds) . Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

<sup>116</sup> Riaz Ahmed Wagan, Management of Mangrove Forests by Sindh Forest Department (Presentation), 2015

<sup>117</sup> Schubel, J.R. Estuarine circulation and sedimentation: an overview. Marine Geology and Oceanography of Arabian Sea and coastal Pakistan Ed. B.U Haq and J.D Milliman Van Nostrand Reinhold Company Inc. NY. pp113-136, 1984

<sup>118</sup> Chandra Giri, Jordan Long, Sawaid Abbas, R.Mani Murali, Faisal M. Qamer, Bruce Pengra, David Thau Distribution and dynamics of mangrove forests of South Asia. Journal of Environmental Management 148, pg 101-111, 2015

<sup>119</sup> Ibid

<sup>120</sup> Qureshi, T. Mangroves of Pakistan: status and management. IUCN. Pakistan, 2005

<sup>121</sup> Riaz Ahmed Wagan, Management of Mangrove Forests by Sindh Forest Department (Presentation), 2015



and grazing by camels.<sup>122</sup> Tropical cyclones and tsunamis have also been highlighted as factors.<sup>123</sup>

Studies have shown vulnerability of Indus Delta to climate change as well. For example, Rasul *et al.*<sup>124</sup> have reported that the warming trend in the Himalaya-Karakoram-Hindukush region that feeds the Indus River System is almost double compared to other parts of Pakistan. This study attributed increased frequency of torrential rains, prolonged heat waves, frequent tropical cyclones, recurring flooding and persistent drought in the deltaic region to climate change. The authors have expressed concern that due to sea level rise, increased intrusion of sea water into the Indus deltaic region is expected which will affect the mangroves and the associated marine life.<sup>125</sup>

The contribution of various factors towards degradation has been qualitatively compared by Rajarshi DasGupta and Rajib Shaw (2013).<sup>126</sup> For the Indus Delta, amongst the anthropogenic factors, agricultural conversion and marine pollution were highlighted as the most severe causes of degradation followed by clear felling, wood and fodder and urbanization as moderate factors, with shrimp farming classified as a factor of no significance. Rise in sea level, high tide and tsunamis, cyclones and erosion of shoreline were considered not significant in comparison to other pressures.<sup>127</sup> As stated in the Physical Baseline (see **Sections 4.3** and **Section 4.4.1**) cyclones and tsunamis are not intense and frequent in the Study Area. However, the effects of erosion within the Study Area are noticeable in making areas unsuitable for mangrove growth. Persistent effects of wave activity, such as erosion, are likely to have affected areas such as Bundal and Buddo Islands. Like Khiprianwala Island, these areas are exposed to stronger wave influence (see **Section 4.7.5**), which is likely to be the reason for limited mangrove cover on these islands. An analysis of historical Google Earth<sup>TM</sup> satellite imagery shows that mangroves have not been present over large areas of these islands exposed to wave activity over a period of more than ten years (from 2004 to 2014). Google Earth<sup>TM</sup> satellite imagery also shows that mangrove cover is present on areas of these islands not exposed to stronger wave influence (located more eastward). As highlighted in **Section 5.3.1** and observed during the mangrove sampling exercise in September 2015 (see **Section 5.3.6**), mangroves constitute a habitat that is rich in biodiversity. Therefore, biodiversity associated with mangrove habitat is most likely to be absent from large parts of these islands and only present in the limited areas where there is healthy mangrove growth. However, the importance of areas with low mangrove cover for other species and organisms cannot be ruled out.

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<sup>122</sup> Ibid

<sup>123</sup> Chandra Giri, Jordan Long, Sawaid Abbas, R.Mani Murali, Faisal M. Qamer, Bruce Pengra, David Thau Distribution and dynamics of mangrove forests of South Asia. Journal of Environmental Management 148, pg 101-111, 2015

<sup>124</sup> Rasul, G, A. Mahmood, A. Sadiq, and S. I. Khan. Vulnerability of the Indus Delta to Climate Change in Pakistan. Pakistan Journal of Meteorology, Vol. 8, Issue 16, Jan 2012.

<sup>125</sup> Ibid

<sup>126</sup> Rajarshi DasGupta and Rajib Shaw Cumulative Impacts of Human Interventions and Climate Change on Mangrove Ecosystems of South and Southeast Asia: An Overview. Journal of Ecosystems Volume 2013, Article ID 379429, 15 pages, 2013

<sup>127</sup> Ibid

A well-studied area in the Indus Delta, known as Keti Bandar (see **Exhibit 5.2**), covers an area of 60,969 ha with the entire extent of it being mangrove forests, mudflats and creeks. During a study done on mangroves at this site, the Drivers-Pressure-State-Impact-Response (DPSIR) Framework of Analysis was applied. The study identified the following as the key points: <sup>128</sup>

**Drivers:**

- ▶ Unavailability of freshwater, increase in salinity levels and sea water intrusion
- ▶ Increased pollution
- ▶ Limited livelihood options and overdependence on fishing

**Pressure:**

- ▶ Overharvesting and overgrazing of mangroves

**State:**

- ▶ Reduction in mangroves species diversity
- ▶ Reduction in fish species diversity

**Impact:**

- ▶ Increased socio-economic stress on society
- ▶ Decreased adaptive capacity

**Response:**

- ▶ Re-plantation effort by the government departments and non-governmental agencies
- ▶ Integrated projects on social and environmental vulnerability assessment

More recently, a major cause of the decrease of mangroves in Keti Bandar area appears to be the drought between 1998 and 1999.<sup>129</sup> A relatively sustainable trend of mangroves from 2002 to 2011 was observed with an increase in area about 1,000 ha from 2010 to 2011 due to the post effects of the major flood of 2010.<sup>130</sup>

An emerging shift in perception about the mangroves over the past two decades has resulted in more attention towards their conservation. The integrated development and management of the mangrove ecosystem has been supported by government, international NGOs, local NGOs and small grassroots organizations.<sup>131</sup> Since 1985 about 80,000 ha of mangroves along the Sindh and Balochistan coasts have been replanted or

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<sup>128</sup> Kashif Majeed Salik, Md. Mobassarul Hassan, Shamen Prabhath Vidanage, Dr.Victor Hugo Rivera-Monroy, Impact of Climate Change on Mangroves Ecosystem in South Asia, FINAL REPORT for APN PROJECT, 2012

<sup>129</sup> Ibid

<sup>130</sup> Ibid

<sup>131</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds). Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

rehabilitated with the Indus Delta being a focus of this restoration.<sup>132</sup> These activities have helped stabilize the mangrove population.<sup>133</sup>

The recent regeneration of mangroves in the Indus Delta has mostly been observed in the intertidal zone resulting in increased mangrove cover.<sup>134</sup> This has largely been attributed to conservation efforts particularly by the IUCN aimed at both replantation and engagement with local communities as well as the selection of the salt tolerant species *A. marina* and *R. mucronata*.<sup>135</sup>

The SFD has stated that over the past 25 years it has planted 50,032 ha of mangrove forests with a focus on three species including *A. marina*, *R. mucronata* and *Cerrostagal*. They have also stated that a number of initiatives are currently underway including the planting of 5,000 ha of mangroves in the areas under the PQA and the Board of Revenue and the planting of 8,000 ha in Ketu Bandar and Shah Bandar areas with assistance from the Asian Development Bank.<sup>136</sup> **Exhibit 5.7** shows plantation by the SFD.

**Exhibit 5.7: Photographs of Plantations by the SFD**



Source: Riaz Ahmed Wagan (2015), Management of Mangrove Forests by Sindh Forest Department (Presentation)

Further initiatives to restore up to 100,000 ha of mangrove forests have been taken in 2012 involving the SFD and the IUCN. These efforts have drawn significant media attention and recognition.<sup>137</sup> However, it is unclear to what extent these initiatives have been successful. There are conflicting opinions from anecdotal evidence; during the

<sup>132</sup> Ibid

<sup>133</sup> Ibid.

<sup>134</sup> Chandra Giri, Jordan Long, Sawaid Abbas, R.Mani Murali, Faisal M. Qamer, Bruce Pengra, David Thau Distribution and dynamics of mangrove forests of South Asia. Journal of Environmental Management 148, pg 101-111, 2015

<sup>135</sup> Ibid.

<sup>136</sup> Riaz Ahmed Wagan, Management of Mangrove Forests by Sindh Forest Department (Presentation), 2015

<sup>137</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds). Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

mangrove sampling exercise carried out in September 2015 the locals stated that plantations had not been successful. Furthermore, aerial imagery analysis presented in **Section 5.3.10** shows that a plantation identified within the Study Area has not been successful in establishing into mature mangroves over a period of about ten years. The SFD has also engaged local communities to protect newly planted mangroves by providing economic incentives. These initiatives are aimed at helping with mangrove protection and conflict resolution with communities that partly depend on mangroves for meeting their fuel and fodder requirements. These initiatives also offer the opportunity for claiming carbon credits for the coastal communities.<sup>138</sup>

Other factors which could be contributing to localized mangrove regeneration in the Indus Delta are changes in local morphology driven by changes in stream flows and an increase in atmospheric carbon dioxide concentration.<sup>139</sup>

There is a high value of mangroves species richness at Sandspit (see **Exhibit 5.35**) located about 40 km west of Port Qasim outside the Indus Delta; while it is lowest at Port Qasim. Mangroves at Sandspit are being managed by the Sindh Forest Department with support from the WWF-P and are designated as Wetlands of International Importance (although this is not a Ramsar Site) and so considered less disturbed by human activity. At Port Qasim, in contrast, there is more disturbance from human activity.<sup>140</sup>

### **5.3.3 Conservation Status and Legal Protection**

Mangrove plantations enjoy a special legal status under the Forest Act of 1927. 344,870 ha of mangroves area was transferred to the Sindh Forest Department (SFD) in the year 1958 and declared “Protected Forest” under the Forest Act 1927. In 1973, part of area under the jurisdiction of the SFD was transferred to the PQA for development of Port Qasim. The Port Qasim Act 1973 allows PQA to plan and develop the ‘port area’. However, one source maintains that the mangroves under the jurisdiction of the PQA continue to, legally, be “Protected Forests”.<sup>141</sup> For all practical purposes, the right of PQA to develop the area under its jurisdiction and to clear mangroves for port development is recognized. The environmental regulator, SEPA, has not questioned this right in the EIAs for port developments submitted to it for review. The lack of legal clarity on protected status of mangroves notwithstanding, clearing of mangroves is recognized as an impact by SEPA and the developers adopt the strategy of minimizing the clearing and supporting mangrove plantations elsewhere as an offset.

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<sup>138</sup> Riaz Ahmed Wagan, Management of Mangrove Forests by Sindh Forest Department (Presentation), 2015

<sup>139</sup> Chandra Giri, Jordan Long, Sawaid Abbas, R. Mani Murali, Faisal M. Qamer, Bruce Pengra, David Thau Distribution and dynamics of mangrove forests of South Asia. Journal of Environmental Management 148, pg 101-111, 2015

<sup>140</sup> Dr. Kanwal Nazim. Population Dynamics of Mangrove Forests from Coastal Areas of Sindh (PhD thesis, Federeal University of Arts, Science and Technology, 2011

<sup>141</sup> International Union for Conservation of Nature (IUCN) Pakistan. Mangroves of Pakistan—Status and Management. IUCN, 2005.

#### 5.3.4 Approach to Characterization of Mangroves in the Study Area

Mangroves in the Study Area are the northwestern most extension of the Indus Delta mangrove system. The current course of the Indus River is more than 60 km to the southeast of the Port Qasim Area and there are no major sources of freshwater in the Study Area (see **Section 4.6**). The dependence of the mangroves in the Study Area on these sources of water including the Indus River is not fully understood.

The major creeks in the Study Area include the Phitti, Khuddi Creek and Khai Creek (**Exhibit 5.1**). A number of smaller creeks are located between the major creeks. Similar to the Indus Delta as a whole, *A. marina* is the dominant species of the mangroves in the Study Area.

The following studies were conducted to establish the baseline conditions of the mangroves in the Study Area and to understand the trends in changes in their condition over time:

1. Spatial and Temporal Analysis Using Google Earth™ Images
2. Assessment of Mangroves through Field Sampling

**Appendix C.1** includes the studies conducted to characterize the baseline condition of mangroves and trends.

Sites within the Study Area selected for assessment and analysis were common to both of the studies (**Exhibit 5.8**). These sites were selected to assess the spatial variations in mangrove habitat, and cover the extent of habitat from North to South (M1, M5, M6, M7) moving from mainland and Port Qasim towards the open sea, and from West to East moving from Port Qasim towards the Indus Delta (M1, M2, M3, M4).

The health of mangroves in the Study Area was categorized drawing on detailed categorization schemes for the **Exhibit 5.8** study of mangroves for the monitoring, mapping, management and rehabilitation of mangroves<sup>142</sup>, and simplified approaches to categorization adopted for high level assessments.<sup>143</sup> A simplified categorization scheme adopted for this study is described in **Exhibit 5.9**. Photographs of mangroves that illustrate the categorization are presented in **Exhibit 5.10** to **Exhibit 5.13**.

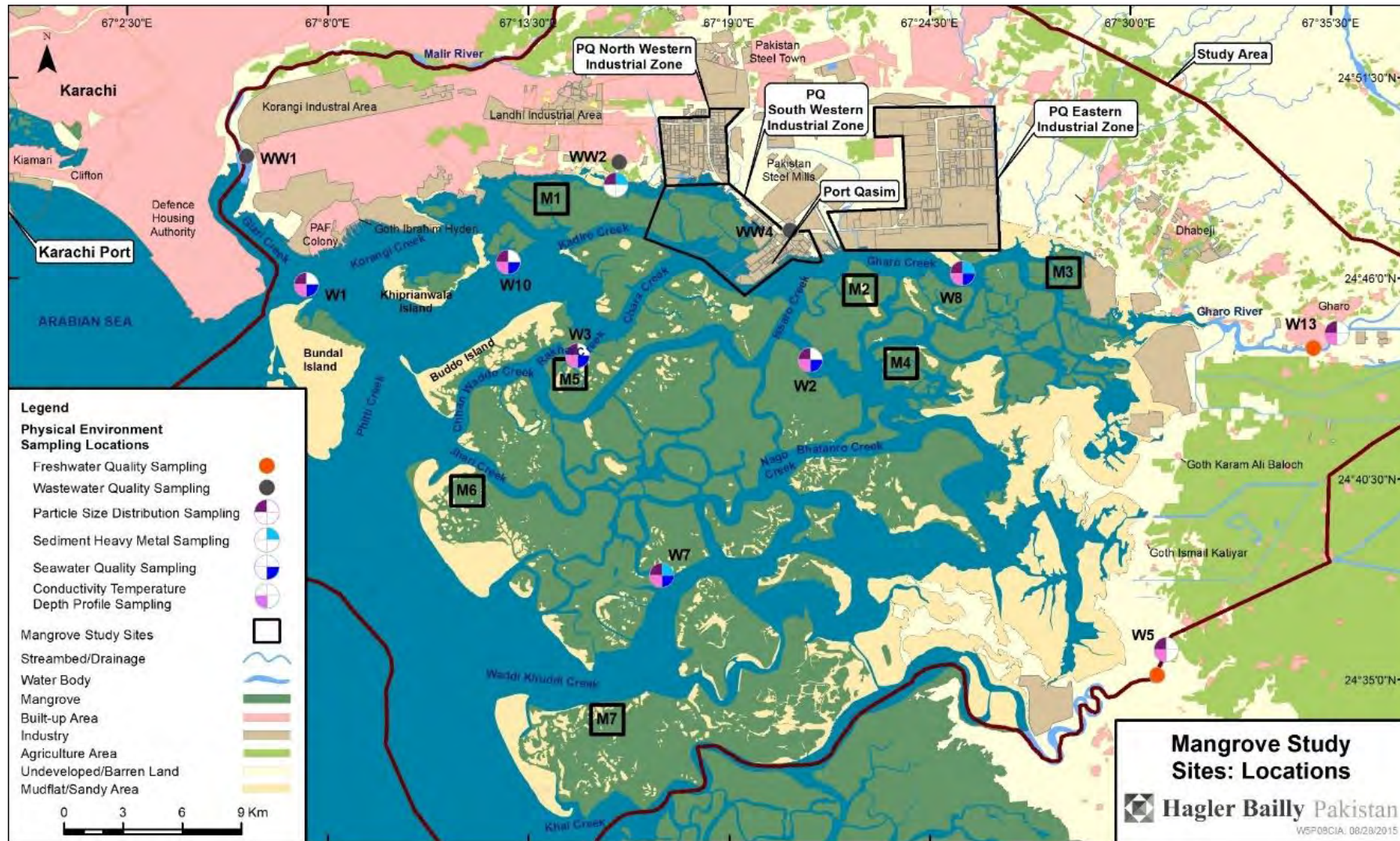
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<sup>142</sup> Department of Employment, Economic Development and Innovation, Data collection protocol for mapping and monitoring mangrove communities in Queensland, 2011

<sup>143</sup> Local management and rehabilitation of mangroves: present and future, Prof Colin Field, University of Technology, Sydney, Australia



**Exhibit 5.8: Mangrove Categorization Site Locations**



### **Exhibit 5.9: Categorization of Mangrove Health**

<i>Category</i>	<i>Definition</i>
Healthy Mangroves	Excellent condition with trees in good health, very tall and large trees, canopy very compact, leaves not yellowing, daily tidal flushing and drainage
Unhealthy Mangroves	Generally reasonable health but sparse canopy, leaves not yellowing, trees moderate height, young and/or stunted growth, possibly due to low nutrients and high salinity, moderate or no extensive epicormic <sup>1</sup> growth, daily tidal flushing and drainage
Mangroves with Die Back	Very bad condition, leaves yellowing or dead, degrading main trunk, canopy very open, lots of broken branches and trees falling, suffering from lack of tidal flushing due to raised ground, extensive epicormic growth <sup>144</sup>

### **Exhibit 5.10: Healthy Mangroves in the Study Area**



Source: Mangrove Sampling Exercise carried out by HBP in the Study Area in September 2015

<sup>144</sup> Epicormic growth means a shoot or branch growing from a previously dormant bud on the trunk or a limb of a tree . Epicormic buds are dormant vegetative buds embedded beneath the bark that have a regenerative function after crown destruction, for example by fire (EUCLID, Centre for Plant Biodiversity Research, Contributors: AV Slee, MIH Brooker, SM Duffy, JG West)



**Exhibit 5.11: Healthy Mangroves - Well Established Community of  
*Avicennia marina* in the Vicinity of Phitti Creek**



Source: Hagler Bailly Pakistan (HBP), March 2009, Environmental and Social Impact Assessment (ESIA), Marine Ecology Study of Port Qasim, Tethyan Copper Company Pakistan (Pvt.) Ltd.

**Exhibit 5.12: Unhealthy Mangroves -Mangroves along a Bank within the  
Port Qasim Area**



Source: Survey carried out by HBP staff in June 2015 for the current study

**Exhibit 5.13: Mangrove Dieback**



Source: Mangrove Sampling Exercise carried out by HBP in the Study Area in September 2015

**5.3.5 Assessment of Mangroves in Study Area Based on Analysis of Google Earth™ Images**

The mangrove categorization scheme (**Exhibit 5.9**) was applied to Google Earth™ images of specific Study Sites (M1 to M7) shown in **Exhibit 5.8**. These images are available in **Appendix C.1.2**. Each selected Study Site was a square of 1.5 km by 1.5 km (2.25 km<sup>2</sup>). Locations were selected for:

- ▶ coverage of the Study Area (sites in the North and South as well as East and West); and
- ▶ locations proximal and distal from anthropogenic activities and disturbance along the shore. Anthropogenic activities include release of effluents from industrial activity and human settlements which contribute to pollution in the area.

Study Sites M1, M2 and M3 are located close to areas with greater anthropogenic activities, and sites M6 and M7 are located relatively further away, while sites M4 and M5 are located between these sites. M3, M4 and M2 are further from the ocean than M7, M6, M5 and M1.

Sampling sites for the physical environment baseline<sup>145</sup> are also shown in **Exhibit 5.8** to enable observation and to make associations, where possible, between the condition of mangroves and that of the physical environment.

A relatively large area (2.25 km<sup>2</sup>) was selected to ensure that the analysis is representative of the location and not affected by localized variations. Relatively clear and recent Google images for each Study Site were utilized. All images used were from the last quarter of 2014.

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<sup>145</sup> Water quality, wastewater quality, sediment quality and sediment particle size distribution (PSD).

### **Spatial Variations**

The demarcated images together with percentage areas, for each category are provided in **Exhibit 5.14** and **Exhibit 5.15**. A complete series of images for Spatial Variations, together with their satellite images are included in **Appendix C.1.2**, along with tabulated results for all Study Sites. A review of the images indicates the following patterns:

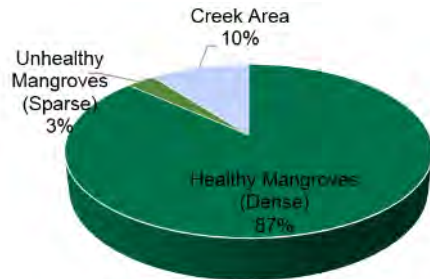
1. The percentage area covered by Healthy Mangroves is highest at M1 (87%), and M3 (79%), which are closest to anthropogenic activities along the coast and to Port Qasim. Study Site M2 closer to the coast and to Port Qasim, however, is an exception and shows a lower proportion of Healthy Mangroves at 35%. M6 is the only Study Site distal to anthropogenic activities (described above) along the coast that has a relatively higher proportion of Healthy Mangroves (46%), but not comparable to Study Sites M1 and M3.
2. There is a higher proportion of Unhealthy Mangroves at sites M2, M4, M5, M6 and M7, (49% to 83%). With the exception of M2, all these Study Sites are distal from Port Qasim and from anthropogenic activity along the coast.
3. Mangrove Dieback is absent from all Study Sites. Mangrove dieback was only observed in thin strips mainly along some shorelines (see **Appendix C.1.4.2 Exhibit C.43**).
4. The percentage of areas with No Mangrove cover is higher for the Study Site further away from Port Qasim, M5. Nonetheless, for site M2 which is proximal to Port Qasim, the area of no mangrove cover is similar to these sites.
5. Within each Study Site the presence of Healthy Mangroves are largely along the banks of the creeks, whereas mangroves inland and away from the banks are typically Unhealthy Mangroves.



**Exhibit 5.14: Study Sites Closest to Port Qasim Industrial Activity**

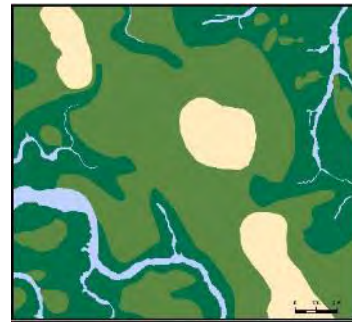
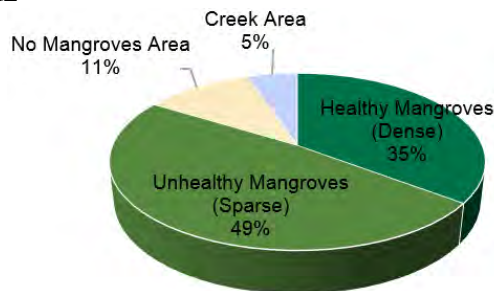


**M1**



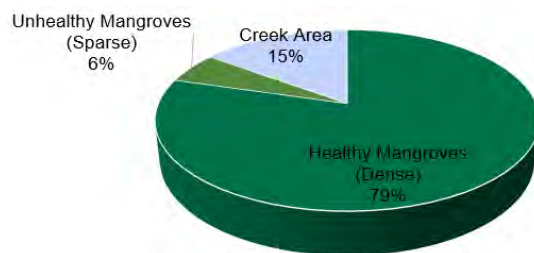
Study Site M1 is located closest to the Port Qasim Industrial area relative to other Study Sites (Exhibit 5.8). It is also close to the wastewater outfall at WW2 (Exhibit 5.8). From the demarcated image it can be seen that healthy mangroves (dense) cover most of the area (87%). Unhealthy mangroves (sparse) are only found at relatively smaller patches (3%) near some of the creeks, while the other two categories are absent.

**M2**



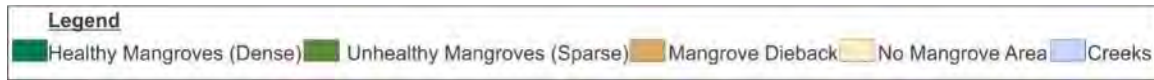
Study Site M2 is located relatively close to the Port Qasim Industrial area compared to other Study Sites (Exhibit 5.8). From the demarcated image it can be seen that healthy mangroves (dense) are mostly around the creek shorelines. Inwards from the shoreline unhealthy mangroves (sparse) can be observed. Moving further inwards towards the center no mangrove areas can be observed. Out of Study Sites M1, M2 and M3, this Study Site is least exposed to effluent release.

**M3**

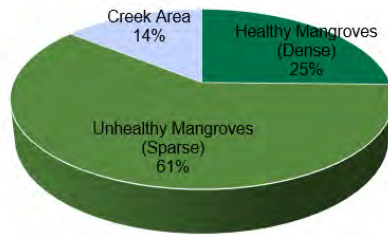


Study Site M3 is located relatively closer to the industrial area as well as to other anthropogenic activities (Exhibit 5.8). The demarcated image shows that there is an abundance of healthy mangroves (dense) with relatively smaller patches of unhealthy mangroves (sparse).

**Exhibit 5.15: Study Sites Further from Port Qasim Industrial Activity**

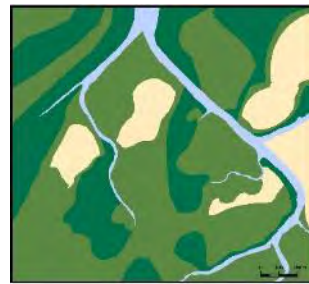
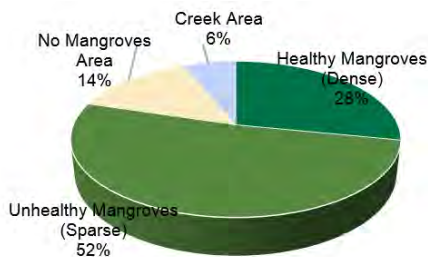


**M4**



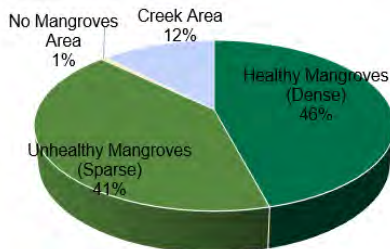
Study Site M4 is located relatively close to the industrial area but further away compared to Study Sites M1, M2 and M3 (Exhibit 5.8). The demarcated image shows that healthy mangroves (dense) are located mostly closer to the creek shorelines. The demarcated image also shows that not all the shorelines are covered with healthy mangroves; in certain portions of the shoreline unhealthy mangroves (sparse) can be observed.

**M5**



Study Site M5 is located relatively close to the open sea compared Study Site M4, both of which are approximately equidistant from the Port Qasim Industrial Area (Exhibit 5.8). The demarcated image shows a trend of healthy mangroves (dense) present along the creek shorelines. This demarcated image also shows that not all the shorelines are covered with healthy mangroves; in certain portions unhealthy mangroves (sparse) and even no mangrove areas can be observed along it. The no mangrove areas are located mostly inland.

**M6**



Study Site M6 is located closest to the open ocean relative to the other Study Sites. Furthermore, with the exception of Study Site M7, it is located furthest from the Port Qasim Industrial Area. The demarcated image shows that, as in previous study locations, healthy mangroves (dense) are located mainly along the creek shorelines. As in other study locations some portions of the shorelines are covered by unhealthy mangroves (sparse). There is also a patche of no mangrove areas visible including at the seaward side of the study location.

**M7**



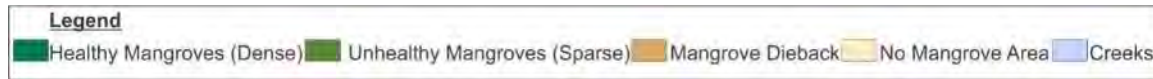
Study Site M7 is located furthest from the Port Qasim Industrial area relative to the other study locations (Exhibit 5.8). From the demarcated image it can be seen that unhealthy mangroves (sparse) makes up most of the area (83%). Healthy mangrove (dense) cover is very limited, being visible only around some of the creek shorelines with limited inland expansion.

### **Temporal Analysis and Variation**

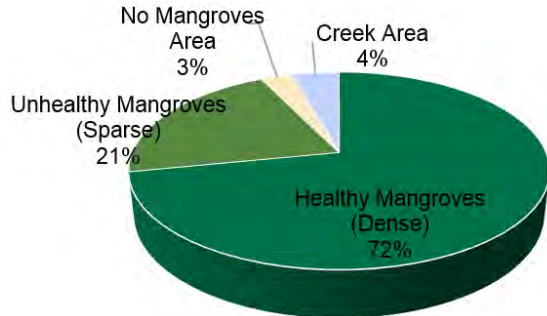
**Exhibit 5.16** to **Exhibit 5.18** show a time series analysis using Google Earth™ images for Study Sites M1, M2 and M7 for the years 2004, 2011 and 2014. An exception was Study Site M1 for which a December 2010 image was used instead of 2011 as an image of reasonable quality for 2011 was not available. A complete series of images for Temporal Variations, together with their satellite images are shown in **Appendix C.1.2.2**, along with tabulated results. These specific Study Sites were selected to understand the relationship of change in mangrove cover over time with the distance of the Study Site from the port and points of discharge on municipal and industrial effluents.

In the case of Study Site M1, this site is located closest to the Landhi Industrial Area inside Port Qasim relative to all other Study Sites. The mangroves at this Study Site receive effluent from the waste water and they are relatively protected from the impact of wave activity which affects mangroves located closer to the open sea and in other areas more exposed to wave activity. Study Site M2 was selected because mangroves at this site are located opposite an area where development of port terminals started during 2009. The objective was to observe change in mangrove health (based on cover) over a period of time when development took place close to the mangroves. Study Site M7 was selected because it is the furthest from industrial and other anthropogenic activities. Furthermore, it is more exposed to hydrologic impacts of the open sea relative to Study Sites M1 and M2.

### Exhibit 5.16: Time Series Analysis of Mangrove Study Site M1

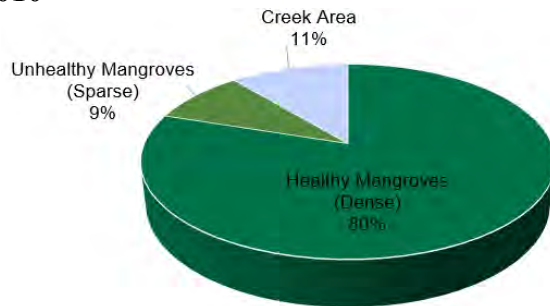


**2004**



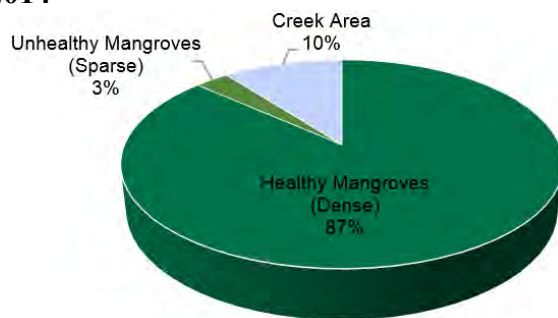
The image shows Study Site M1 towards the end of the year 2004. From the demarcated image it can be observed that there were relatively small patches of no mangrove areas as well as clearly visible areas with unhealthy mangroves (sparse). The image shows that healthy mangroves (dense) are located more inland as well, away from this major creek, but on along the shorelines of other creeks.

**2010**



The image shows Study Site M1 towards the end of the year 2010. From the demarcated image it can be observed that there is an increase in the area covered by healthy mangroves (dense), which can now be seen where unhealthy mangroves (sparse) were visible in 2004. This is noticeable across the entire area of the Study Site M1.

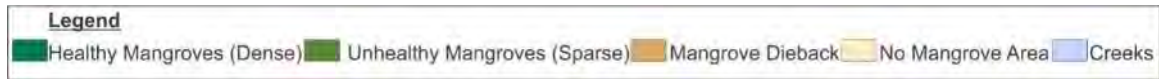
**2014**



The image shows Study Site M1 towards the end of the year 2014. From the demarcated image it can be seen that healthy mangrove (dense) cover makes up most of the area. Most of the area covered by unhealthy mangroves (sparse) visible in 2011 is replaced by healthy mangroves (dense) in 2014.



### Exhibit 5.17: Time Series Analysis of Mangrove Study Site M2

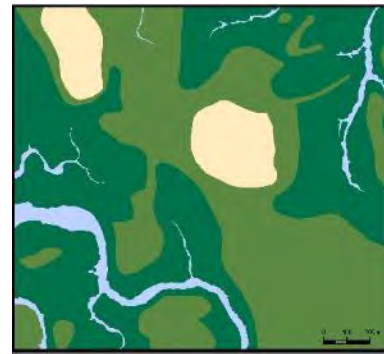
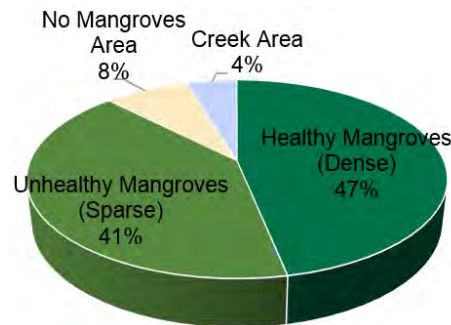


**2004**



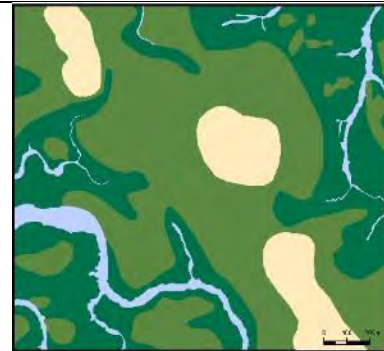
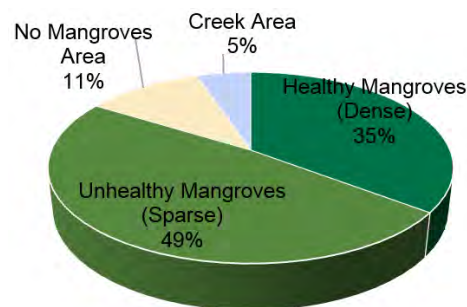
The image shows the Study Site M2 towards the end of the year 2004. From the demarcated image it can be observed that healthy mangroves (dense) are located mainly around the creek shorelines but with some spreading away from them. Most of the area inland is covered with unhealthy mangroves (sparse). A single patch of no mangrove areas is visible.

**2011**



The image shows the Study Site M2 towards the middle of the year 2011. From the demarcated image it can be observed that there is an increase in healthy mangrove (dense) cover from 2004, replacing unhealthy mangrove (sparse) area. However, there is an increase in no mangrove area.

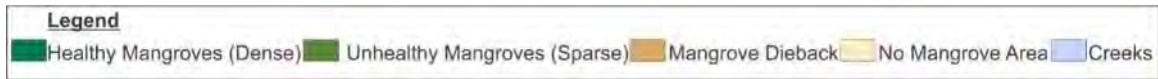
**2014**



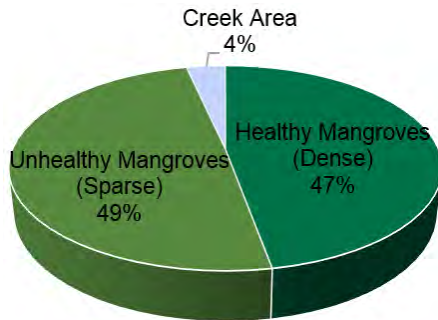
The image shows Study Site M2 towards the end of the year 2014. From the demarcated image it can be observed that there is a decrease in healthy mangrove (dense) area compared to 2011. By 2014 these are located mainly around the creek shorelines. Furthermore, there is an increase in no mangrove area, now visible across the Study Site.



### Exhibit 5.18: Time Series Analysis of Mangrove Study Site M7

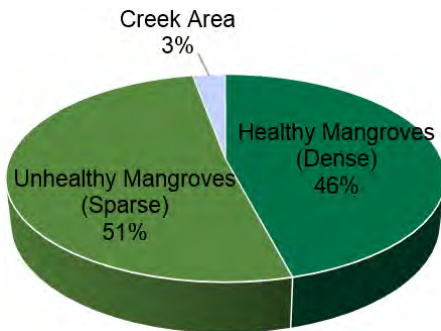


**2004**



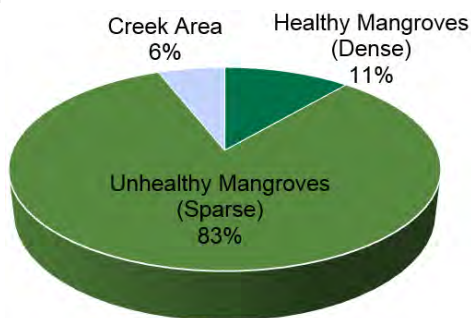
The image shows Study Site M7 towards the end of the year 2004. From the demarcated image it can be observed that there is generally an abundance of healthy mangroves (dense) towards one side with increasing unhealthy (sparse) mangrove area moving away from it. The trend of healthy mangroves (dense) located along the shorelines of can be observed in some areas.

**2011**



The image shows Study Site M7 towards the end of the year 2011. From the demarcated image it can be observed that there is little change in the appearance of the area by 2011 compared to 2004. Furthermore, the spatial arrangement of the two categories of mangroves appears to be very similar to that in 2004.

**2014**



The image shows Study Site M7 towards the end of the year 2014. From the demarcated image it can be observed that a large portion of the area covered by healthy mangroves (dense) in 2004 and 2011 has been replaced by unhealthy mangroves (sparse). There is a much lower area of healthy mangroves (dense) visible in 2014 relative to that present in 2004 and 2011.

Based on the temporal variations observed in types of areas the following can be concluded:

1. There is an increase in Healthy Mangrove areas and a decrease in Unhealthy Mangrove areas between 2004 and 2014 at the Study Site M1.
2. Similar to site M1, there is an increase in Healthy Mangrove area and a decrease in Unhealthy Mangrove area at M2. The No Mangrove area increased at this site, due to dumping of dredged materials. The site is also relatively close to the coastline but does not receive as much wastewater from inland.
3. There is a decrease in Healthy Mangrove area and an increase in Unhealthy Mangrove area at the Study Site M7 which is most distal from Port Qasim and the coastline.

### **Conclusions on Spatial and Temporal Variations**

Based on the spatial analysis carried out (see **Section 5.3.5**) it is concluded that:

1. Within each Study Site the Healthy Mangroves are largely present along the banks of the creeks, whereas mangroves inland and further away from the banks tend to be Unhealthy Mangroves.
2. Mangroves along the coast, closer to Port Qasim and to the areas that receive municipal and industrial effluents are healthier, possibly due to presence of fresh wastewater, fertilization by nutrients (see **Section 4.1.3**) and better protection.
3. Proportion of Unhealthy Mangroves is higher at Study Sites distal from Port Qasim. This could possibly be due to lower delivery of nutrients (see **Section 4.1.3**), a decline in both fresh water flows and sediment from the Indus Delta, and lower level of protection from fodder and fuel wood extraction.
4. The temporal analysis indicates that the mangroves show an improvement over time in proximity to the Port Qasim and points where municipal and industrial effluents are discharged into the sea. This trend reverses moving away from the coast towards the open sea.

Further studies will be required to understand the exceptions in patterns observed which could be attributable to anthropogenic as well as physical factors.

### **5.3.6 Assessment of Mangroves Based on Sampling Conducted in September 2015**

Sampling was conducted in September 2015 to investigate the condition of the mangroves in the Study Sites when the weather conditions were favorable and mangroves were safely accessible. A 'Mangrove Sampling Plan' developed for this purpose is included in **Appendix C.1.3**. Comparative analysis was carried out between Study Sites using data collected during the mangrove sampling exercise (see **Appendix C.1.4**). Results for the following parameters are summarized in **Exhibit 5.19**, and illustrated in **Exhibit 5.20**:

- ▶ Mean Adult Tree Density
- ▶ Mean Adult Tree Height
- ▶ Mean Adult Tree Girth
- ▶ % Canopy Cover
- ▶ Mean Seedling Density
- ▶ Crab Hole Density

A review of results provided in **Exhibit 5.20** indicates the following:

- ▶ Tree density was found to be highest along the coastline possibly due to higher concentration of nutrients mainly resulting from industrial and municipal waste discharge.
- ▶ Observations of tree dimensions indicate that most mature trees are located at Study Site M5, the Study Site located closest to the proposed shipping channel.
- ▶ Trees harvesting was observed to be highest at Study Site M5, the location along the proposed shipping channel.
- ▶ The similarity in percentage canopy cover between all Study Sites indicates that most of the mudflat area within the Study Area is covered by mangroves, either non-stunted or stunted.
- ▶ The highest number for mean crab hole density at Study Site M1 could have an association with the increased levels of nutrients and effluent from nearby anthropogenic activity along the coastline. Considering the fact that adult tree density is highest at Study Site M1, those mangroves and the habitat conditions created by the effluent release may be providing very favorable conditions for crab populations at that Study Site.

In addition to this, observations for seedlings (**Exhibit 5.19** and **Appendix C.1.4, Exhibit C.67**) reveal that they grow in dense patches. This indicates that there are patches of mangrove habitat (mudflat areas) which are suitable for persistence of seedlings and that the entire mangrove habitat is not. Another important observation regarding seedlings was that, even in areas where canopy cover was not provided by large mangrove trees over large areas, the seedlings were observed to be concentrated under the canopies of adult mangrove trees. This was most noticeable at sampling locations near Study Site M1 (see **Appendix C.1.4.1**).

The mangrove sampling exercise established that the mangroves in the Study Area support a crab population regardless of their proximity to Port Qasim and to coastal anthropogenic activity. It is noteworthy that the highest mean number of crab hole density was observed at Study Site M1, the location closest to Port Qasim and effluent release from the coastline. As mangrove crabs are a keystone species<sup>146</sup> their abundance observed across the habitat highlights that the mangroves are providing a very important

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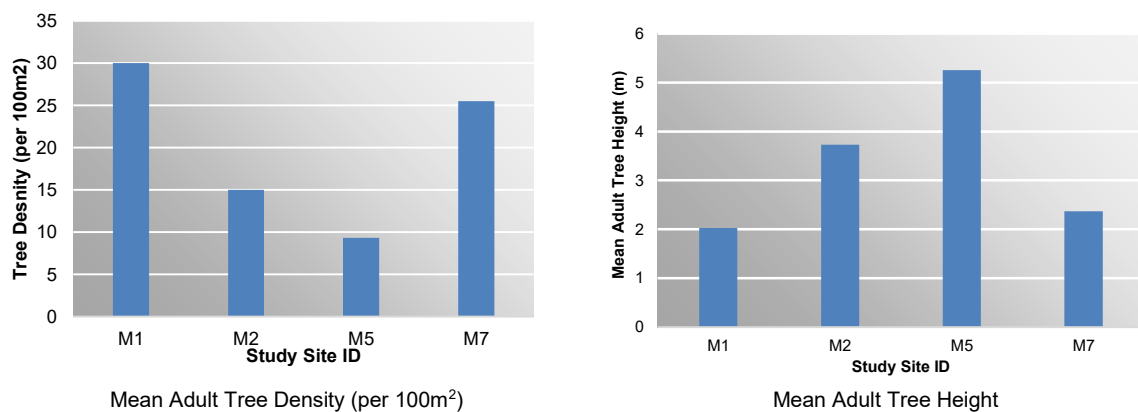
<sup>146</sup> Thomas J. Smith, Kevin G. Boto, Stewart D. Frusher, Raymond L. Giddins. Keystone Species and Mangrove Forest Dynamics: the Influence of Burrowing by Crabs on Soil Nutrient Status and Forest Productivity. *Estuarine, Coastal and Shelf Science*, Vol 33, Issue 5, pp 419-432, November 1991

habitat for an organism that is exerting a major influence on ecosystem level parameters.<sup>147</sup> Consequently large scale clearing of mangroves can have a damaging effect on the ecosystem by altering its ecosystem level parameters such as soil ammonium and sulphide levels, as well as on forest productivity and reproductive output.<sup>148</sup>

**Exhibit 5.19:** Characteristics of Mangroves Based on Data Collected  
Sampling Exercise, September 2015

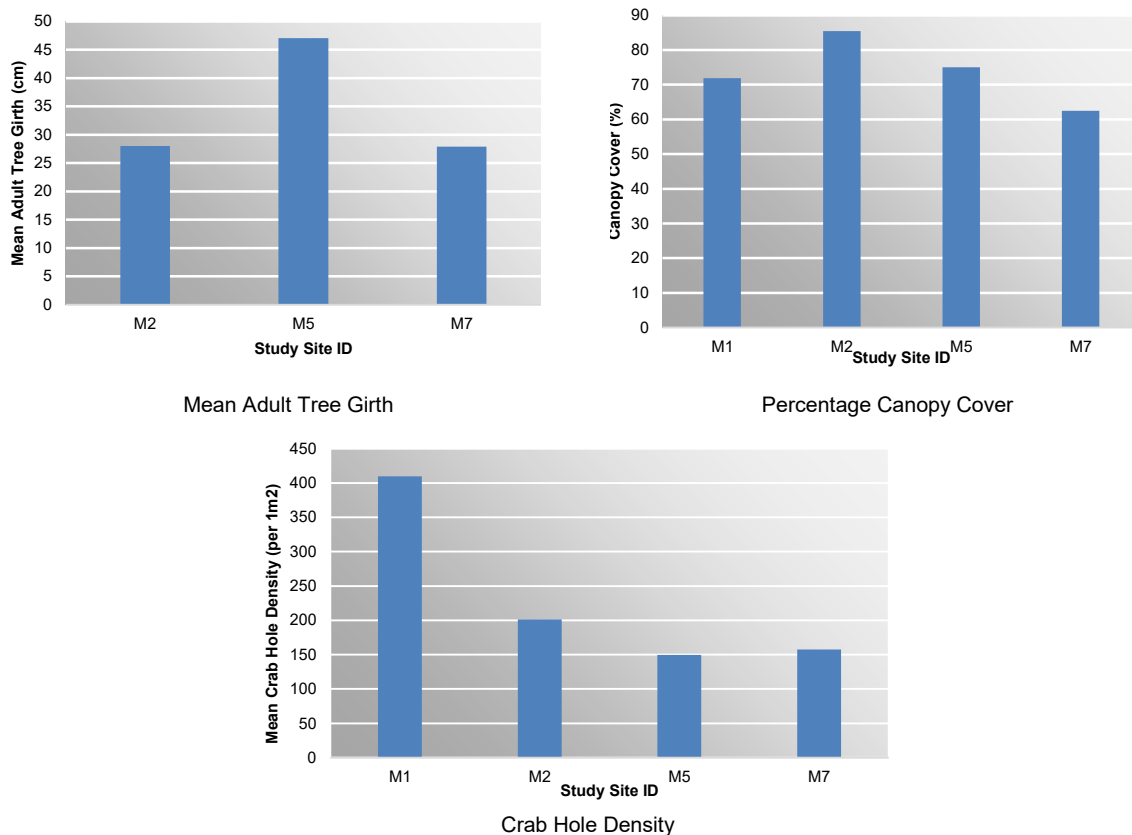
Parameters	Study Site ID			
	M1	M2	M5	M7
Proximity and General Quadrat Information	Very close to anthropogenic effluent. Typical soil conditions sludge like	Close to anthropogenic activity but not to effluent release	Along proposed shipping channel, away from effluent release	Furthest from Port Qasim relative to other Study Sites
Mean Adult Tree Density (per 100m <sup>2</sup> )	30	15	9	26
Mean Tree Height (m)	2.0	3.7	5.3	2.4
Mean Tree Girth (cm)	N/A	28.0	47.1	27.9
% Canopy Cover	71.9	85.4	75.0	62.5
Mean Seedling Density (per 100m <sup>2</sup> )	5,500	4	4,507	6
Mean Crab Hole Density (per 1m <sup>2</sup> )	410	201	150	157

**Exhibit 5.20:** Graphical Comparison of Mangrove Characteristics based on  
Data Collected in September 2015



<sup>147</sup> Ibid

<sup>148</sup> Ibid



### Insect Attack and Diseases

A number of insects and fungi were observed within the mangrove habitat (see **Appendix C.1.4**). These were classified into harmful and beneficial insects with respect to mangrove health, with the help of a plant pathology expert. In addition to this various signs of damage to the mangrove trees were observed which included gummosis and canker. The conclusions from research conducted on these insects, fungi and signs of damage along with their possible implications are presented in this section.

#### Harmful Insect Pests

Amongst the harmful insects those observed included:

**Borers:** Borers have been known to kill over 50% of *Rhizophora mangle* canopy in experimental plots across tidal elevation gradients.<sup>149</sup> Wood-feeding insects (including wood borers) attack live trees which can create widespread disturbances in forests.<sup>150</sup> Woodborers are known to reduce timber quality.<sup>151</sup>

<sup>149</sup> Feller, I. C. The role of herbivory by wood-boring insects in mangrove ecosystems in Belize. – Oikos 97: 167–176, 2002

<sup>150</sup> Ibid

<sup>151</sup> Ibid



**Leaf Gall Midges:** Eight species of gall-formers have been described for mangroves (all on *Avicennia* spp.), seven of which are formed by flies of the midge family Cecidomyiidae (Diptera).<sup>152</sup>

**Weevil:** A study on mangroves has found that *A. marina* may be the dominant host of the petiole-feeding weevil as it is commonly found on this species but not on other mangrove species.<sup>153</sup>

**Leaf Miner Insect:** Damage due to leaf miners has been reported in mangrove swamps in Papua and New Guinea.<sup>154155</sup>

#### Fungi

**Fungi:** In one of the earliest studies on the ecology of mangrove fungi Kohlmeyer (1969)<sup>156</sup> encountered three common species of marine fungi in the mangrove habitat, namely *Lulworthia* spp. (20% of all collections), *Leptosphaeria australiensis* (15%) and *Phoma* sp. (10%).

#### Other Signs of Damage

**Gummosis:** This disease has been investigated in cultivated plants. It has been found to be difficult to control and peach orchards, for example, that are water stressed or poorly managed are at a greater risk for severe disease damage.<sup>157</sup> Gummosis has a worldwide distribution and is responsible for 10% to 30% of losses in citrus cultured around the world.<sup>158</sup> No information on Gummosis specific to mangroves could be found.

#### Beneficial Insects

Insects beneficial for the mangrove plants were also observed. These included:

**Spiders:** Spiders are abundant in the mangroves, however, their presence has been poorly documented.<sup>159</sup> This rich diversity of spiders is also indicative of the overall biodiversity of this urban forest since spiders are considered to be useful indicators of the species richness and health of terrestrial ecosystems<sup>160</sup>

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<sup>152</sup> Damien Wayne Burrow. The Role of Insect Leaf Herbivory On the Mangroves *Avicennia Marina* and *Rhizophora Stylosa* (PhD Thesis) Zoology and Tropical Ecology within the School of Tropical Biology, James Cook University, 2003

<sup>153</sup> Ibid

<sup>154</sup> Johnstone, I.M. Consumption of leaves by herbivores in mixed mangrove stands. *Biotropica* 13:252-259, 1981

<sup>155</sup> Farnsworth, E.J. & Ellison, A. Patterns of herbivory in Belizean mangrove swamps. *Biotropica* 23:555-567, 1991

<sup>156</sup> V.V. Sarma and Kevin D. Hyde. A review on frequently occurring fungi in mangroves. *Fungal Diversity* 8: 1-34 (2001)

<sup>157</sup> Pusey, P. L. "Influence of water stress on susceptibility of nonwounded peach bark to *Botryosphaeria dothidea*." *Plant Disease* 73: 1000–1003, 1989

<sup>158</sup> Timmer, L.W., S.M. Garnsey and J.M. Graham. Compendium of citrus diseases. APS Press, St. Paul. Minnesota. USA, 2000

<sup>159</sup> Koh. J. K. H., Spiders of the family Araneidae in Singapore Mangroves. *Raffles Bulletin of Zoology* 39(1): 169-182, (1991)

<sup>160</sup> Noss R. F. Indicators for monitoring biodiversity: A hierarchical approach. - *Conservation Biology*, 4: 355 p, 1999

**Ants:** Ants are social insects that occur in virtually all types of habitats and whose colonies may occupy a multitude of nest sites, ranging from terrestrial to arboreal nests.<sup>161</sup> In the tropics a great number of ant species forage intensively in plant foliage.<sup>162</sup> This highlights a diversity of species within the mangroves.

#### Observations of Ecological Balance between Plant Pests and Predators of Plant Pests

**Mealy Bugs and Mealy Bug Destroyers:** Information was found on the pink hibiscus mealy bug, *Maconellicoccus hirsutus*, which is a serious pest of many plants in tropical and subtropical regions, including Africa, Southeast Asia, and northern Australia.<sup>163</sup> The beetle, *Cryptolaemus montrouzieri*, was also observed, which is a Mealybug Destroyer.<sup>164</sup> This finding suggests the existence of an ecological balance between organisms preying on plants and organisms providing protection to plants by feeding on plant pests.

It is noteworthy that some of the harmful insects observed have the potential to cause damage to relatively large areas of mangrove forests. An example is that of borers. Furthermore, the presence of a balance of plant pests and predators of plant pests along with spiders and ants highlights that the mangroves in the Study Area harbor rich community in terms of biodiversity.

#### 5.3.7 Observations of Dumping of Dredged Material from Google Earth™ Imagery

The Google Earth™ images in **Exhibit 5.21** from 2011 to 2015 show the dumping of dredged material by PQA within the Port Qasim Notified Area where healthy mangroves had been observed in images taken prior to the dumping (visible in images dated January 2011 and April 2011). Images from January 2011 to June 2015 show that dumping of dredged material resulted in the destruction of a significantly large area that was once covered by Healthy Mangroves. Shortly after the disposal of the dredged material a relatively large area around the site appears clear of mangroves. A close-up is shown in **Exhibit 5.22**.

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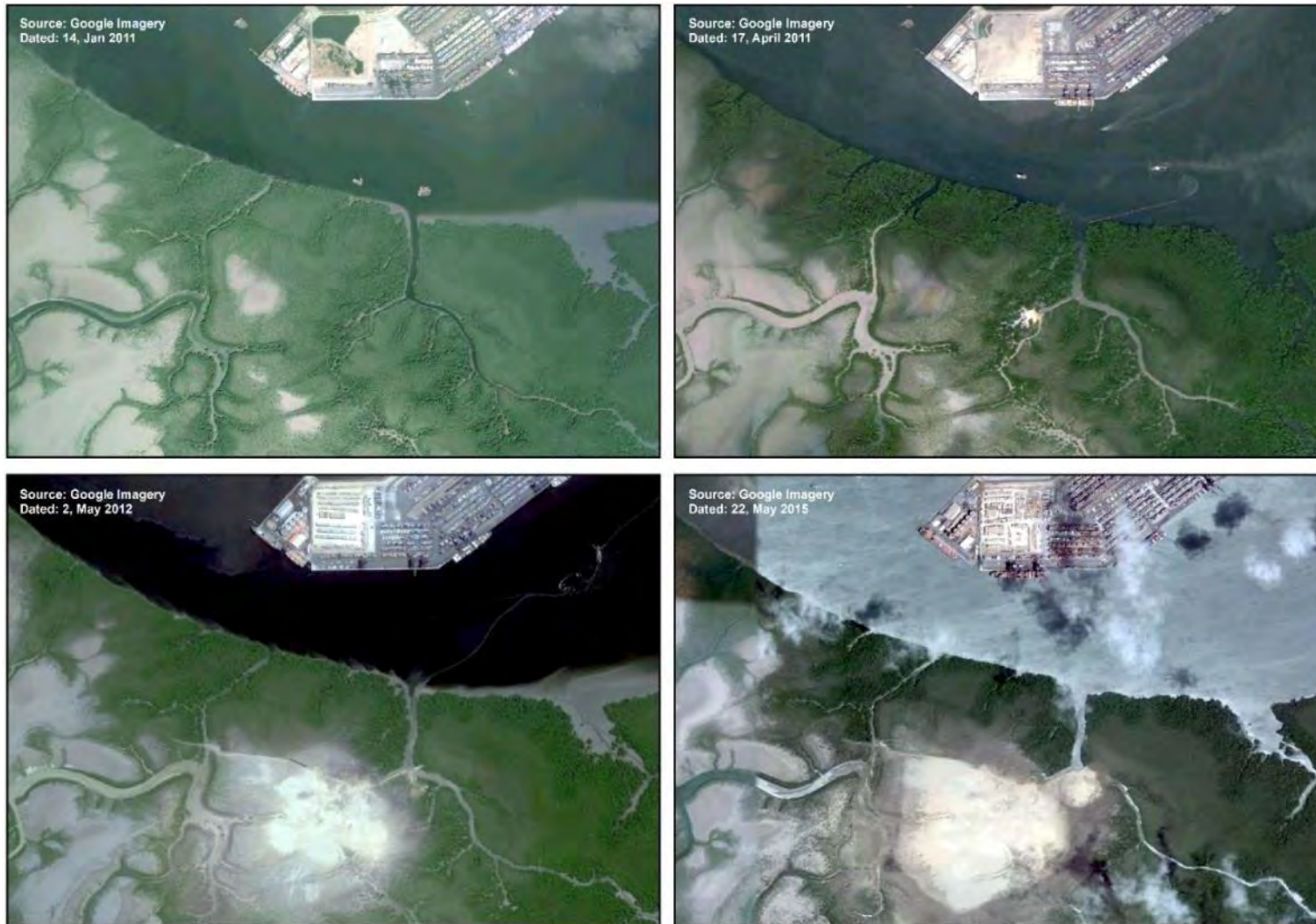
<sup>161</sup> Hölldobler B & Wilson EO The Ants. The Belknap Press of Harvard University Press, Cambridge, MA, 1990.

<sup>162</sup> Carroll CR & Janzen DH. Ecology of foraging by ants. Annual Review of Ecology and Systematic 4: 231–257, 1973

<sup>163</sup> Information extracted from <http://entnemdept.ufl.edu/creatures/orn/mealybug/mealybug.htm>, accessed on 19th October 2015

<sup>164</sup> Information extracted from <http://www.biocontrol.entomology.cornell.edu/predators/Cryptolaemus.php>, accessed on 19th October 2015

**Exhibit 5.21:** Time Series Analysis for Confirmed Dumping Site in Port Qasim



**Exhibit 5.22:** Close up of Dumping Activity – Image from 17 April 2011



### **5.3.8 Dumping of Material Adjacent to Jetties of Major Terminals in the Area**

Dumping can also be observed along the jetties in the PQA where dredged materials were dumped when the jetties were constructed by the developers. See **Exhibit 5.23**.



**Exhibit 5.23: Dredged Material Dumped Along Jetties**



### **5.3.9 Potential Dumping Sites**

The dumping site for dredged material (shown in **Exhibit 5.21**) has a distinctive appearance. The Study Area was investigated for the presence of sites with similar appearances. Locations where these are visible are shown in **Exhibit 5.24** marked as possible dumping sites.



**Exhibit 5.24: Possible Dumping Sites**



Creek erosion has also been observed to be a factor contributing to the degradation of mangroves in the Study Area. In a Marine Ecology Study of Port Qasim, conducted as part of an ESIA in 2009,<sup>165</sup> well established mangrove plantations (mature trees 4-6) were observed to be under stress due to eroding sediments in the Phitti Creek (southern bank).

The excessive erosion may be due to strong waves and current during ebb and flood tides and also due to the bow waves generated as a result of moving vessels in the creek.

**Section 4.2.5** provides and analysis on the erosion along the banks of the Port Qasim navigation channel.

### **5.3.10 Mangrove Plantations**

Plantation of mangroves has also been carried out by organizations such as the IUCN and the SFD.<sup>166167</sup> Plantation efforts are also visible from Google Earth™ Satellite imagery as shown in **Exhibit 5.25**. **Exhibit 5.25** is an image of a site within Study Site M5 showing where plantations have been carried out. This image shows plantation visible in 2004 and 2015.

The locals, especially those visited near Study Site M2 during the mangrove sampling exercise carried out in September 2015, stated that plantations have been carried out at sites within the Study Area. However, according to them these planted mangroves have not matured and plantation efforts have remained unsuccessful (see **Appendix C.1.4.2**).

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<sup>165</sup> Hagler Bailly Pakistan (HBP), March 2009, Environmental and Social Impact Assessment (ESIA), Marine Ecology Study of Port Qasim

<sup>166</sup> Macintosh, D.J., Mahindapala, R., Markopoulos, M. (eds). Sharing Lessons on Mangrove Restoration. Bangkok, Thailand: Mangroves for the Future and Gland, Switzerland: IUCN, 2012

<sup>167</sup> Riaz Ahmed Wagan, Management of Mangrove Forests by Sindh Forest Department (Presentation), 2015

**Exhibit 5.25:** Mangrove Plantation Site Identified in Google Earth™ (Study Site M5)



The change over time from 2004 to 2015 also shows that not all plantations have been successful. At the site shown in (**Exhibit 5.25**) the plantations did not establish into mature trees over a period of about eleven years.

### **5.3.11 Mangrove Removal and Land Reclamation**

Landsat imagery from 1976, Google Earth™ imagery from 2004 and 2014 was analyzed along the shorefront where land reclamation and clearing, or mangrove removal had been carried out by Developments at Port Qasim. The areas where mangroves have been removed, as well as areas which have been cleared or reclaimed along the shorefront are shown in **Exhibit 5.26**. Analysis of erosion and loss of mangroves along the banks of part of the current navigation channel and anticipated extension is provided in **Section 4.7.5**. The analysis estimates that 44 ha (44,000 m<sup>2</sup>) of mangrove areas have been lost to erosion since 2004. This is in addition to the clearing and removal that has been carried out since 1976 and presented in **Exhibit 5.27**.

To gauge the extent of removal of mangroves and land reclamation/clearing, the following ratios have been calculated:

- ▶ Ratio of area reclaimed or cleared and area of Port Qasim Southwestern Zone<sup>168</sup>: 29%
- ▶ Ratio of mangroves removed and area of Port Qasim Southwestern Zone<sup>169</sup>: 18%

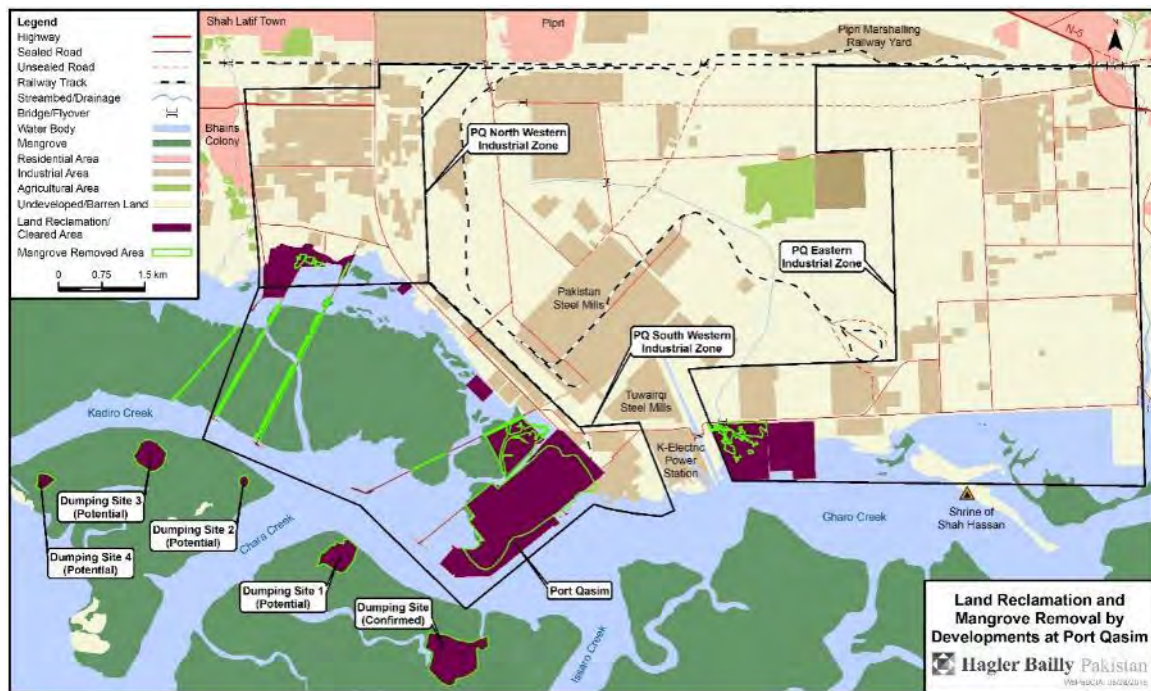
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<sup>168</sup> Note that the ratio is provided as a guide to gauge the amount of removal and reclamation and mangroves removed includes areas outside the Southwestern Zone. The ratio does not present the percent of mangrove removal or land reclamation within the Southwestern Zone.

<sup>169</sup> Ibid



**Exhibit 5.26: Mangroves Cleared and Reclaimed/Cleared Land**



**Exhibit 5.27: Area of Mangroves Cleared and Land Reclaimed or Cleared**

Location	Land Cleared or Reclaimed along Shorefront		Mangroves Removed	
	m <sup>2</sup>	ha	m <sup>2</sup>	ha
Port Zone in South Western Zone				
Wheat/Fertilizer Terminal-1 (FAP Terminal)	66,827	6.68	2,262,233	226.22
Container Terminal-1 (QICT 1)	310,490	31.05		
Container Terminal-2 (QICT 2)	262,917	26.29		
Marginal Wharf	244,083	24.41		
Engro Vopak (land)	392,088	39.21		
Others in Port Zone	1,754,448	175.44		
Jetties and Terminals				
Engro Vopak (jetty)	13,255	1.33		0
SSGC Jetty	44,403	4.44	158,226	15.82
FOTCO Oil Jetty	15,871	1.59	68,868	6.89
Pakistan International Bulk Terminal (PIBT)	288,028	28.8	37,654	3.77
Iron Ore and Coal Berth	48,575	4.86	20,535	2.05
Engro Elengy (land)	507,850	50.79	472,601	47.26
TransAsia Refinery	732,883	73.29	0	0



Location	Land Cleared or Reclaimed along Shorefront		Mangroves Removed	
	m <sup>2</sup>	ha	m <sup>2</sup>	ha
<b>Port Zone in South Western Zone</b>				
Port Qasim Electric Power Company	822,144	82.21	212,257	21.23
Other Areas (near PIBT and FOTCO area)	529,896	52.99	45,746	4.57
<b>Dumping Locations</b>				
Dumping Site (Confirmed)	639,418	63.94	639,418	63.94
Dumping Site 1 (Potential)	249,033	24.9	249,033	24.9
Dumping Site 2 (Potential)	28,721	2.87	28,721	2.87
Dumping Site 3 (Potential)	220,289	22.03	220,289	22.03
Dumping Site 4 (Potential)	61,936	6.19	61,936	6.19
<b>Total</b>	<b>7,233,155</b>	<b>723.32</b>	<b>4,477,517</b>	<b>447.75</b>

### 5.3.12 Mangrove Harvesting

Information on harvesting of mangroves has been collected as part of surveys carried out for the socio-economic baseline (see **Section 6.14**). Based on responses from individuals in the local communities no specific locations could be identified as those frequented for cutting of mangroves. Therefore, no association could be established between harvesting and no mangrove areas or mangrove with dieback areas. Information for areas where mangroves have undergone harvesting was obtained from ground observations carried out by HBP staff in September 2015. Mangrove harvesting was observed at three out of the four Study Sites visited (M1, M5 and M7). Mangroves were observed to be harvested for timber and fodder use. The level of timber harvest observed at each sampling location was estimated to range from medium to low (see **Appendix C.1.4.5**).

### 5.3.13 Recommendations for Further Study

Analysis conducted in this study can be improved using higher resolution satellite images with spectral bands. This analysis can be carried out over a wider area within the Study Area (potentially the entire Study Area), and the entire extent of the mangrove area can be categorized and percentage areas for each category can be calculated. Furthermore, additional locations for special studies can be isolated and analyzed.

The mangrove sampling exercise carried out during September 2015 identified two distinct types of mangroves within the Unhealthy Mangroves category in terms of growth and appearance, shown in **Exhibit 5.28**. These included stunted mangroves at the Study Site most distal from industrial and municipal effluent release, stunted mangroves at the Study Site closest to industrial and municipal effluent release and non-stunted mangroves (see **Appendix C.1.4**). It is recommended that further study be carried out on both types of stunted mangroves to establish the causes for their limited growth.

**Exhibit 5.28: The Three Different Types of Mangroves Observed Based on Health and Growth**



Stunted Mangroves at the Study Site most distal from effluent release



Stunted Mangroves at the Study Site closest to effluent release



Normal sized Mangroves (Large Trees)

## **5.4 Coastal Invertebrate Fauna**

Coastal areas and the intertidal region is a complex area where the division between land and sea is unclear. Coastal intertidal areas have a diverse range of communities including sandy shores, mudflats, and mangrove forests.

The Study Area and the associated creeks have faunal communities which are characteristic of mud flats. The substrate has very fine sediments (mud, clay and silt) and the faunal communities present are dominated by faunal assemblages representing soft sediments. The sediment substrates are generally found to be high in organic content and with black mud just below the substrate. The mudflats adjoining the mangroves are high in salt and hydrogen sulphide ( $H_2S$ ) and low in oxygen.<sup>170</sup> At low tide, when a large part of muddy bottom is exposed, crabs, mudskippers and birds are seen in large numbers picking up their food which includes worms and different animals left behind by the receding tide<sup>171</sup>.

<sup>170</sup> Akhter, N Sustainable Fisheries The Pakistan National Conservation Strategy, Government of Pakistan Environment and Urban Affairs Division in collaboration with IUCN – The World Conservation Union, 1995

<sup>171</sup> Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research.

#### 5.4.1 Surface and Burrowing Forms

Coastal intertidal areas have a diverse range of communities that inhabit muddy/clay shores. The surface and burrowing marine invertebrates play an important role in mixing the organically enriched bottom sediments and are the key linkages in transferring the energy from lower trophic level to the next higher trophic level in the food chain. The marine invertebrate communities reported from the Study Area are characteristic of fine sediments from muddy to clayey. Dominant communities reported include Fiddler Crab *Uca sp.*, Mud Skippers *Boleophthalmus spp* and *Telescopium spp* assemblages, bivalve mollusks, Pinnotherid crabs and *Cerithium sp* Barnacles (**Exhibit 5.29**).

Brachyuran crabs form a major component of the crabs present in the mangroves in Sindh coastal areas.<sup>172</sup> They have been found to occur virtually throughout the intertidal zone with abundance from mean low tide level to mean high water level of spring tide. The mangroves have species that fall into the families Grapsidae, Ocypodiadae, Xanthidae and Portunidae. Among Xanthids, one of the most conspicuous family of crabs on the tropical shore, only a few representatives of Xanthids have penetrated the mangroves. Swimming crabs, *Scylla senata* (family Portunidae), can be seen darting for safety under the root cover of mangroves, or the holes of the trunks of mangroves.<sup>173</sup>

**Exhibit 5.29:** Marine Invertebrate Species Observed in Intertidal Mud Flats in Study Area near Port Qasim in October 2014 and June 2015



Pinnotherid crabs



*Uca Spp*

<sup>172</sup> IUCN "Mangroves of Pakistan: status and management" IUCN, 2005

<sup>173</sup> Ibid





Gastropod Mollusk *Cerithium* spp



Bivalve *Cardium* spp



*Telescopium* spp



Barnacles



Oyster spats



*Bivalves* Spp



Gastropods in Mangrove nematophores



Gastropods and bivalves.



Mud Skippers *Boleophthalmus spp\**



Fiddler Crab *Uca spp\**

- \* Source: Hagler Bailly Pakistan (HBP), October 2014, Environmental Impact Assessment of Coal Jetty, Shipping Lane and Ash Disposal Site for Pakistan Port Qasim Electric Power Project 2×660 MW Coal Power Plant, Port Qasim Electric Power Company Private Limited (PQEPC), Karachi.

#### 5.4.2 Marine Benthic Invertebrates (MBI)

The marine benthic invertebrate community includes the microbes: detritus feeders, small and large herbivores, and small and large carnivores. In the mangrove ecosystem, the benthic community of the adjacent shallow water is a subject of interest. Here, the microbes decompose the plant litter into organic detritus - a fundamental commodity for the transfer of energy from lower to higher trophic level. The marine invertebrates play an important role in mixing the organically enriched bottom sediments and are the key linkages in transferring the energy from lower trophic level to the next higher trophic level in the food chain.

The Marine Benthic Invertebrates consist of benthic macro (between 1 mm and 5 mm in size) and meiofauna (from  $>64\ \mu$  to 1.0 mm in size). The benthic macro and meiofauna are organisms that inhabit the interstitial spaces, in between sand grains. The vertical distribution of benthic fauna is restricted to the Redox Potential Depth (RPD) layer that ranges in mud flats from 10-20 cm depth in compact sediment types. Below the RPD layer is the anoxic region. Organic matter and anoxic bacteria produce hydrogen sulphide in the sediments.

During a sampling of MBI carried out in June 2015, sediment samples were collected using a grab operated from a vessel as shown in **Exhibit 5.30**.



**Exhibit 5.30:** Sampling Platform, Fiberglass Boat and Benthic Sediment Samples Collected Using a Grab for MBI Analysis PQA



Benthic Sediment Sampling techniques used for collection of bottom sediments to evaluate MBI.

The MBI sediment samples were analyzed using a binocular microscope in the biological lab at Karachi University. Benthic macro and meiofauna was enumerated, and specimens identified using standard taxonomic identification sheets. Statistical software was employed to calculate diversity and mode of distribution of the MBI. Some of the MBI showed an aggregate distribution behavior (polychaete worms, nematodes, harpactoid copepods and ostracodes) while others showed a random mode of distribution (Sabellid worm, Sea-anemone, Cirripedia bivalves etc.). The descriptive statistics of the Marine Benthic Invertebrates (MBI) observed during the sampling period are given in **Exhibit 5.31**.

**Exhibit 5.31:** Marine Benthic Invertebrates (MBI) Descriptive Statistics

Sampling Station	Mean Individuals	Variance	Standard Deviation	Standard Error	Total Individuals	Total Species	Min	Max	Mean Confidence Interval
EC 1	1.636	9.1	3.017	0.643	36	9	0	10	3.803
EC 2	6.955	898.712	29.979	6.392	153	6	0	141	375.548
EC 3	0.818	3.584	1.893	0.404	18	5	0	8	1.498
EC 4	7.636	997.766	31.587	6.734	168	14	0	149	416.94

<i>Sampling Station</i>	<i>Mean Individuals</i>	<i>Variance</i>	<i>Standard Deviation</i>	<i>Standard Error</i>	<i>Total Individuals</i>	<i>Total Species</i>	<i>Min</i>	<i>Max</i>	<i>Mean Confidence Interval</i>
EC 5	2.045	31.569	5.619	1.198	45	8	0	25	13.192
EC 7	3.727	178.398	13.357	2.848	82	10	0	63	74.548
EC 11	1.818	58.442	7.645	1.63	40	5	0	36	24.421

MBI were most abundant (total individuals = 168) at sampling station EC 4 and EC 7 (total individuals = 82 per 10 cm<sup>2</sup>). The sampling locations are shown in **Exhibit 5.35**.

The MBI taxa distribution (aggregate or random) was calculated for each of the taxa identified from the sampling stations is given in **Exhibit 5.32**.

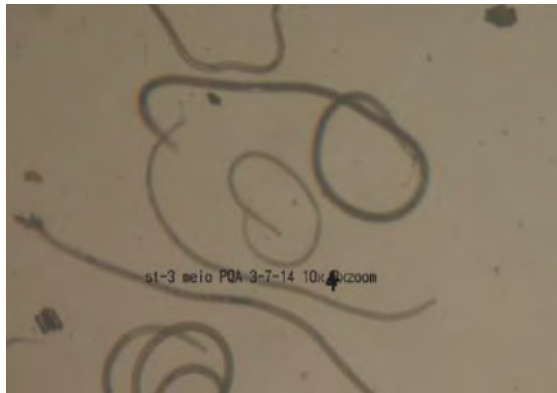
**Exhibit 5.32: MBI Taxa Distribution. Baseline Information**

<i>Taxa</i>	<i>Variance</i>	<i>Mean</i>	<i>d.f.</i>	<i>Distribution</i>
Oligochaets	1.9524	1.5714	6	Random
Polychaetes	11.1429	3.8571	6	Aggregated
Gastropod Shells	0.2381	0.2857	6	Random
Nematode	3765.9048	60.2857	6	Aggregated
Harpacticoid Copepods	11.2857	1.4286	6	Aggregated
Cyclopoids	0.2857	0.4286	6	Random
Spicula	0.1429	0.1429	6	Random
Asphidosiphora	0.1429	0.1429	6	Random
Foraminiforans	13.5714	1.7143	6	Aggregated
Bivalve	0.1429	0.1429	6	Random
Halacaroidea	0.1429	0.1429	6	Random
Sarcomastigophora	0.1429	0.1429	6	Random
Ostracoda	0.5714	0.2857	6	Random
Gastropoda larva	3.2857	1.5714	6	Random
Bivalvia Larva	13.1429	2.1429	6	Aggregated
Oligochaets	0.619	0.4286	6	Random
Polychaets	0.2857	0.5714	6	Random
Gastropod Shells	2	1	6	Random
Bivalvia shells	0.1429	0.1429	6	Random
Siphonophores	0.1429	0.1429	6	Random
Turbellaria	0.1429	0.1429	6	Random

MBI organisms (like those shown in **Exhibit 5.33**) are a good indicator of ecological disturbances. MBI's have a relatively short regeneration time (6-8 weeks). The habitats of benthic MBI are interstitial (live between sand grain spaces). MBI's either adapt to a disturbed ecological condition and multiply (one species with a higher biomass) or perish (impacting on biological diversity of MBI). Some MBI's are also opportunist species (Nematode/polychaete worms) as they are the first organisms to recolonize the bottom substrate. Nematode worms were by far the most numerous organisms in the MBI samples collected from the PQA area. The distribution pattern shows an aggregate behavior. Copepod, polychaete worms, and bivalve shell also show an aggregate behavior. This is probably due to their mode of reproduction in the benthic environment.

The aggregate or random distribution is due to the mode of reproduction and bottom currents that may also be responsible for their distribution behavior. The MBIs are restricted to the top 10-15 cm of the mud flats. They have a relatively short regeneration time (about 3-4 week) and are quick to re-colonize. The MBI are good indicators of physical disturbance to bottom sediments or pollution related studies (see **Section 4.2.6**).

#### **Exhibit 5.33: MBI Organism**



*Nematode spp*



*Harpactoid copepod*



*Cirripedia spp*



*Sabellid worm*



Ostrocod



Polychaete worm

Source: Benthic Fauna microphotographs from Hagler Bailly Pakistan (HBP), October 2014, Environmental Impact Assessment of Coal Jetty, Shipping Lane and Ash Disposal Site for Pakistan Port Qasim Electric Power Project 2×660 MW Coal Power Plant, Port Qasim Electric Power Company Private Limited (PQEPC), Karachi.

#### 5.4.3 Shanon Weiner Diversity Index for Measuring the Health of the Ecosystem

The Shannon Weiner diversity index is a tool for measuring the health of the ecosystem. The data generated using the Shannon Weiner diversity index is given **Exhibit 5.34**.

Sampling Stations EC 4 (1.146) and EC 7 (1.0) show a relatively higher MBI biodiversity ( $H_{\max}$ ) followed by EC 1 (0.954) and EC 5 (0.903). All the locations showing higher MBI biodiversity are located away from the main land where impacts of pollution originating from industrial and residential areas inland are likely to be low.

The species show a relatively even distribution as indicated by  $J'$  at Sampling Station EC 1 (0.841), EC 3 (0.898), and relatively uneven distribution at Sampling Station EC 2 (0.207), EC 4 (0.239), and at EC 11 (0.288). The normal range for evenness ( $J'$ ) is from 0.1 to 1.0. Clear and definite spatial patterns in distribution of evenness do not appear to emerge from the collected data.

The  $J'$  values for Sampling Stations EC1 and EC3 are highest. These two sampling stations are located closest to anthropogenic activities releasing effluents into coastal waters (**Exhibit 5.35**). Similarly EC2 is also located closest to these activities, however, the  $J'$  at this sampling location is relatively lower (the lowest as shown in **Exhibit 5.35**).

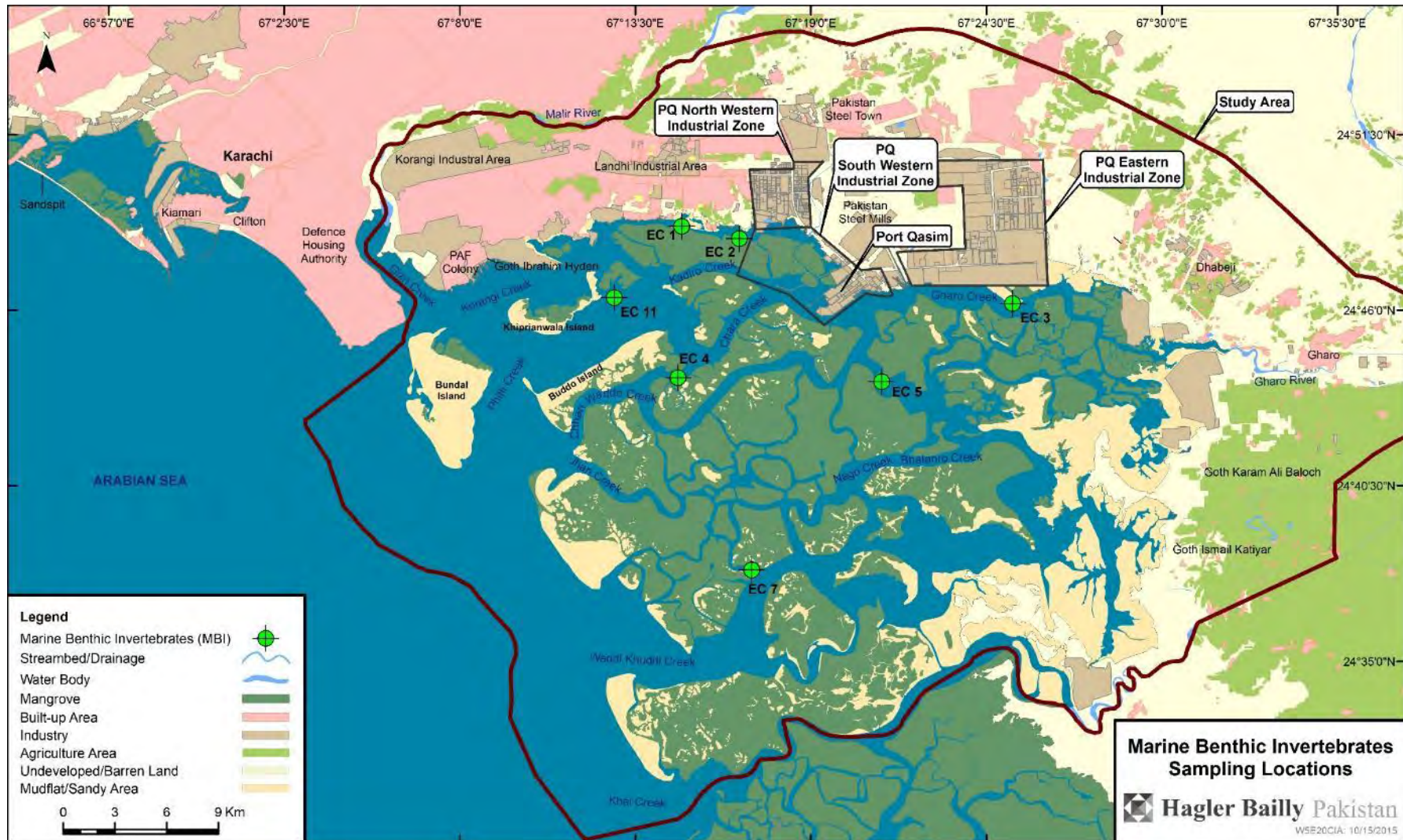
While a clear link between sediment heavy metal (**Section 4.2.6**) and MBIs cannot be established, overall the Port Qasim Area creeks are a disturbed area, and therefore both species diversity and species richness are relatively low.

**Exhibit 5.34:** Shanon Weiner Diversity Index

Index	EC 1	EC 2	EC 3	EC 4	EC 5	EC 7	EC 11
Shannon $H'$ Log Base 10.	0.802	0.161	0.628	0.274	0.577	0.418	0.201
Shannon $H_{\max}$ Log Base 10	0.954	0.778	0.699	1.146	0.903	1.0	0.699
Shannon $J'$	0.841	0.207	0.898	0.239	0.639	0.418	0.288



**Exhibit 5.35: Marine Benthic Sampling Locations**





#### 5.4.4 Effect of Nutrient Concentration

The nutrients including phosphate, nitrate, nitrite and ammonia play vital role in the food chain of marine ecosystem in primary production of coastal and oceanic waters. They support the growth of phytoplankton which serve as the food for zooplankton as well as larval stages and juveniles of fish and crustaceans and also serve as food for filter feeders.

The average nutrient concentration (National Institute of Oceanography archives) generally increases from Kiamari coast towards Gizri Creek (**Exhibit 5.35**), suggesting that the coastal waters opposite Defence Housing Authority (DHA) beaches are very productive which is also influenced by Gizri Creek and Korangi Creek waters harboring mangrove forest which itself is one of the highly productive marine ecosystems. Nutrients in the Gharo Creek do not appear to be limiting to primary productivity in the channels. If there is any limitation, it is due to turbidity and thus to a highly restricted photic zone. This indicates that limitations in productivity observed at these locations are most likely due to turbidity rather than lack of nutrients.

The Karachi Harbour, Gizri Creek, Gharo Creek and Korangi Creek receive large quantities of nutrients as part of the sewage effluent and garbage that is disposed of in these creeks (see **Section 4.1.2** and **4.1.3**). Higher concentrations of nutrients result in overproduction and exhaustion of dissolved oxygen in the seawater. This leads to anoxic conditions and eutrophication. Anoxic conditions prevail in about 40% of the bottom areas of Karachi Harbour and about 60% of the Gizri Creek areas.<sup>174</sup> Eutrophication is conspicuous in the middle and lower parts of Gizri Creek. Nutrient enrichment is dominant and associated with the municipal wastewater flows in Korangi and Gizri Creeks (see wastewater analysis in **Exhibit 4.16** in **Section 4.1.3**).

As discussed in **Section 5.5.4**, all the locations showing higher MBI biodiversity are located away from the main land where impacts of pollution originating from industrial and residential areas inland are likely to low. The exception is sampling point EC1 which is close to the main land and to the points of discharge of effluents into the creeks.

Sampling point EC 11 which is likely to have been disturbed by dredging shows a relatively lower diversity ( $H_{max}$ ) at 0.699. However, based on the results of sampling it is not possible to conclusively establish any relationship of MBI biodiversity with dredging activities, as with other factors such as turbidity and pollution.

#### 5.4.5 Conservation Status

Based on information available in previous ESIA's and secondary literature, none of the marine invertebrates species reported from the Study Area are threatened according to the IUCN Red List of Threatened Species.<sup>175</sup> Moreover, their distribution is not limited to any specific site or habitat type and are widespread.

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<sup>174</sup> ESIA of LNG Terminal, Jetty & Extraction Facility - Pakistan Gasport Limited (Not dated)

<sup>175</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 May 2015

## 5.5 Coastal Marine Fishery

### 5.5.1 Fish Diversity in Indus Delta

A very high diversity of fish species (approximately 200) have been recorded from the Indus Delta region.<sup>176</sup> There are four types of fish groups in Korangi and the adjoining creeks areas; these are permanent dwellers, partial residents, tidal fish, and seasonal visitors in the mangrove habitat. Ahmed (1997)<sup>177</sup> reported 98 species of fish from mangrove swamps of Korangi-Phitti creek system and backwaters of Sandspit (located at a distance of 42 km west of Port Qasim). Out of these 98 species, 46 species were fingerling or young stages while 52 species were either sub-adult or adult. Common larvae of fishes described for Korangi Creek (located at a distance of 16 km west of Port Qasim) and adjoining creeks in Indus Delta belong to the families Mugilidae, Gerreidae, Clupeidae, Nemipteridae, Gobiidae, Sciaenidae, Engraulidae, Sillaginidae and Lutjanidae.<sup>178</sup> Some juvenile sharks have been reported from Issaro Creek.<sup>179</sup>

Based on the information submitted by the Sindh Wildlife Department for notification of the Ramsar Site adjacent to the Study Area, certain shark species, stingray species and guitarfish species are reported at the Indus Delta Ramsar Site.<sup>180</sup> These include species that are of conservation importance according to the IUCN Red List of Threatened Species.<sup>181</sup> The species include *Carcharhinus melanopterus* Blacktip Reef Shark (Near Threatened), *Glyphis gangeticus* Ganges Shark (Critically Endangered) and *Sphyrna lewini* Scalloped Hammerhead (Endangered). None of these species are endemic to the Indus Delta. Based on the predicted geographic range information from the FishBase website<sup>182</sup>, the range of the Blacktip Reef Shark does extend into the Indus Delta Ramsar Site and along the western and southern periphery of the Study Area but not into the Study Area. Therefore, there is low probability that they are present in the Study Area. Similarly, the Ganges Shark has a low probability of being found in the Indus Delta Ramsar Site and, therefore, in the Study Area. Only the Scalloped Hammerhead has a higher probability of being found in the Study Area.

Species within certain genera have also been reported from the Indus Delta Ramsar Site which includes *Dasyatis sp.* a genus of Stringrays, *Pristis sp.* a genus of Sawfish and *Rhinobatos sp.* a genus of Guitarfish. Certain species of these three genera are of conservation importance, however, no information could be found about species within these genera that have been reported from the Indus Delta. Based on the IUCN Red List

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<sup>176</sup> WWF. Indus Delta: A Vanishing Ecosystem. Indus for All Programme. Programme Management Unit, WWF [not dated]

<sup>177</sup> Ahmed, M. Natural and human threats to biodiversity in the marine ecosystem of coastal Pakistan. In: Coastal zone management imperative for maritime developing nations (eds. B.U. Haq, S.M. Haq, G. Kullenberg and J.H. Stel), pp. 319-332. Kluwer Academic Publishers, Netherlands, 1997

<sup>178</sup> Ibid

<sup>179</sup> Based on surveys carried out by WWF Pakistan and Marine Fisheries Department and as reported by WWF and MFD.

<sup>180</sup> Hussain Bux Bhaagat, Sindh Wildlife Department, Information Sheet on Ramsar Wetlands (RIS), 30th September, 2002

<sup>181</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 08 December 2015

<sup>182</sup> Fishbase ver. (10/2015). <<http://www.fishbase.org/>>, accessed 7th December 2015

of Threatened Species, the ranges of certain species within these genera do extend into the Indus Delta and Study Area.<sup>183</sup> However, none of them were observed during the surveys conducted in Keti Bandar or within the Study Area during 2015. This is possibly because of their low abundance.

Many detritus feeders like Clupeids, Grey Mulletts and small carnivorous fish like Silver Biddies and Pony Fish find these coastal habitats suitable for their living. Mudskippers are adapted to live in the creek environment. Pleuronectiformes which represent bottom living fish move towards this area for their food.

The abundance of fish fauna varies from season to season. There are a number of settlements of fishermen along the creeks of Indus Delta which depend on the resources of these creeks (see **Section 6**).

### **5.5.1 Fish Diversity at Keti Bandar and Comparisons with Study Area**

A well-studied area in the Indus Delta, known as Keti Bandar (**Exhibit 5.1**), covers an area of 60,969 ha with the entire extent of it being mangrove forests, mudflats and creeks.<sup>184</sup> Compared to the Study Area it is a location that is less disturbed by anthropogenic activity, does not receive industrial or municipal effluents in any significant quantity, and receives comparatively more fresh water and silt from the River Indus in flood season compared to Study Area. Keti Bandar, therefore, is being used as a reference site for this Study. Fish surveys were carried out at Keti Bandar during May 2015.<sup>185</sup> The unpublished research for this study is provided in **Appendix C.2.1**. Four different methods were used to collect fish samples: drag netting, cast netting, gill netting, and trawl netting. The results of this survey for marine fish species are presented in **Exhibit 5.36**. Fish surveys have also recently been carried out by the Marine Fisheries Department (MFD) at locations within the Study Area, the results of which have not been released as yet.

The results of the fish survey carried out at Keti Bandar during May 2015<sup>186</sup> are given in **Exhibit 5.36**, **Exhibit 5.37** and **Exhibit 5.38**. **Exhibit 5.36** shows only the marine species diversity at the survey site. **Exhibit 5.37** shows the brackish water species which were also collected from the survey site. **Exhibit 5.38** shows the freshwater families (with their respective number of species) that were observed during the survey.

The fish species listed in **Exhibit 5.36** to **Exhibit 5.38** have been documented based on economic value and ecological importance. A total of 128 marine and brackish water fish species belonging to 42 families have been recorded<sup>187</sup>, of which 126 species are marine species. In addition to these species, 16 species were collected from freshwater while all the rest have been reported from marine water. Nearly all of the main fish families are

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<sup>183</sup> Information taken from IUCN Redlist database <<http://www.iucnredlist.org/>> accessed 23rd November 2015

<sup>184</sup> Kashif Majeed Salik, Md. Mobassarul Hassan, Shamen Prabhath Vidanage, Dr. Victor Hugo Rivera-Monroy, Impact of Climate Change on Mangroves Ecosystem in South Asia, FINAL REPORT for APN PROJECT, 2012

<sup>185</sup> Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research.

<sup>186</sup> Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research.

<sup>187</sup> Ibid.

represented. The marine fish fauna of Ketī Bandar is dominated by two species of Engrulids, *Thryssa hamiltonii* and *Coilia dussumieri*. The next three most abundant species were the clupeids including *Ilisia melastoma*, *Ilisha megaloptera* and *Anodontostoma chacunda* while juvenile of catfish, *Arius thalassinus* and a mullet *Liza parsia* was also in rich number. Other common species were *Arius maculatus* (catfish) and *Boleophthalmus dussumieri* (mudskippers). A typical coastal/estuarine fish Barramundi (*Lates calcarifer*), was represented by single specimen. A freshwater catfish, *Mystus golio* of the family Siluridae was also collected from marine water of Ketī Bandar.<sup>188</sup> A population censuses of important commercial species like barramundi (*Lates calcarifer*) and palla (*Tenualosa ilisha*) is urgently needed as their population may be at risk due to environmental degradation.<sup>189</sup> Other threats like the use of illegal fishing gears and fishing of undersize fish may be affecting the faunal diversity of the area.<sup>190</sup>

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<sup>188</sup> Ibid.

<sup>189</sup> Ibid

<sup>190</sup> Ibid

**Exhibit 5.36: Marine Water Fish Species at Ketī Bandar**

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
1.	<i>Albula vulpes</i>	Albulidae	Bonefish	Viaat	80	9,000	Average	Inhabits shallow coastal waters, estuaries and bays	Feeds on the bottom mollusks	Near Threatened	The species, once believed to be global, now has one of the most restricted distributions among bonefishes.
2.	<i>Arius arius</i>	Ariidae	Threadfin sea catfish	Singhara	20	150	Medium	Coastal waters	Prawns, shrimps, crabs	Least Concern	
3.	<i>Arius caelatus</i>	Ariidae	Engraved catfish	Khagga	45	250	Medium	Coastal waters	Prawns, shrimps, crabs	Not Assessed	
4.	<i>Arius crossocheilus</i>	Ariidae	Roughback sea catfish	Khagga	40	220	Medium	Coastal waters	Prawns, shrimps, crabs	Not Assessed	
5.	<i>Arius dussumieri</i>	Ariidae	Blacktip sea catfish	Khagga	30	200	Medium	Demersal; freshwater; brackish; marine;	Feeds on invertebrates and small fishes	Least Concern	
6.	<i>Arius maculatus</i>	Ariidae	Spotted catfish	Khagga	60	400	Medium	Inshore and estuarine water	Invertebrate and small fishes	Not Assessed	
7.	<i>Arius tenuispinis</i>	Ariidae	Thin spine catfish	Khagga	35	200	Medium	Coastal waters up to 50 m depth	Invertebrate and small fishes	Not Assessed	
8.	<i>Osteogeneiosus militaris</i>	Ariidae	Soldier catfish	Khagga	35	200	Medium	Demersal; potamodromous freshwater; brackish; marine	Invertebrate and small fishes	Not Assessed	
9.	<i>Strongylura leiura</i>	Belonidae	Banded needlefish	Kangi, Kango	80	250	Medium	Occur in marine as well as brackish and fresh waters.	Small fishes	Not Assessed	
10.	<i>Strongylura strongylura</i>	Belonidae	Banded needlefish	Kangho	100	500	Average	Coastal waters, estuaries as well as freshwaters	Small fishes	Not Assessed	
11.	<i>Pseudorhombus arsius</i>	Bothidae	Large toothed flounder	Kuker-jeeb	30	200	High	Estuarine Continental shelf	Bottom living animals	Not Assessed	



No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
12.	<i>Alepes djedaba</i>	Carangidae	Shrimp scad	Seem, Bangra	40	124	Average	Saltwater, Coastal water and reef areas.	Crustacean and copepods	Not Assessed	
13.	<i>Carangoides chrysophrys</i>	Carangidae	Longnose trevally	Seem, Bangra	72	4,350	Average	Open waters of coastal reefs	Crustacean, copepods	Not Assessed	
14.	<i>Caranx para</i>	Carangidae	Banded scad	Bangra, Kakkar	20	200	Low	Inshore coastal	Zooplankton	Not Assessed	
15.	<i>Decapterus macrosoma</i>	Carangidae	Short fin Scad	Seem	30	240	Low	A schooling species, usually occurring	Planktonic invertebrates	Not Assessed	
16.	<i>Megalaspis cordyla</i>	Carangidae	Tarpedo Scad	Bangra	80	1,000	High	A pelagic, schooling species	Feeds on fish and small crustaceans	Not Assessed	
17.	<i>Parastromateus niger</i>	Carangidae	Black pomfret	Kala poplet	55	700	High	Usually found over muddy bottoms between 15 and 40 m depth.	Zooplankton, crustaceans and small fishes	Not Assessed	
18.	<i>Scomberoides commersonnianus</i>	Carangidae	Blacktip leatherskin	Aal, Saram	120	12,000	high	Coastal waters	Fish, crustacean	Not Assessed	Indo-West Pacific: in tropical waters
19.	<i>Trachinotus blochii</i>	Carangidae	Snubnose Pompano	Sonab	65	9000	high	Juveniles in shallow sandy or muddy bays near river mouths	Molluscs and crabs	Not Assessed	
20.	<i>Trachinotus mookalee</i>	Carangidae	Indian pompano	Sonaf	90	1,200	Medium	Inhabits shallow coastal waters	Feeds on molluscs and on crabs	Not Assessed	
21.	<i>Scoliodon latucaudus</i>	Carcharhinidae	Spadenose shark	Mangra	75		Low	Coastal waters in rocky areas	Feeds on small schooling fishes	Not Assessed	
22.	<i>Chirocentrus dorab</i>	Chirocentridae	Dorab wolf herring	Kerli, gairi	100	700	Average	Pelagic, inshore	Small fishes and crustaceans	Not Assessed	
23.	<i>Nematalosa nasus</i>	Clupeidae	Long-ray bony bream	Daddi-palli	22	200	Average	Pelagic, coastal waters, entering estuaries, creeks	Detritus, phyto and zooplankton	Least Concern	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
24.	<i>Sardinella albella</i>	Clupeidae	White Sardinelle	Tarli, Luar	14	100	Low	A schooling species, usually in coastal waters	Feeds on zooplankton and on phytoplankton	Least Concern	
25.	<i>Sardinella gibbosa</i>	Clupeidae	Goldstripe sardinella	Tarli, Luar	17	75	Low	Coastal, pelagic, schooling.	Feeds on zooplankton and on phytoplankton	Not Assessed	
26.	<i>Sardinella longiceps</i>	Clupeidae	Oil Sardine	Tarli/ Luar	23	80	Medium	Pelagic species, mainly coastal	Feeds on planktons and detritus	Least Concern	
27.	<i>Sardinella sindensis</i>	Clupeidae	Sindh Sardinelle	Tarli, Luar	17	70	Low	A pelagic schooling species, found in coastal waters	Feeds on planktons and detritus	Not Assessed	
28.	<i>Anodontostoma chacunda</i>	Clupeidae	Shortnose Gizzard Shad	Daddi-palli	17	100	Low	Pelagic, in inshore waters	Detritus, phyto and zooplankton	Not Assessed	
29.	<i>Dussumieria acuta</i>	Clupeidae	Rainbow Sardine	Tel-tempori	20	130	Medium	Pelagic, in inshore waters	Detritus, phyto and zooplankton	Not Assessed	
30.	<i>Escualosa thoracata</i>	Clupeidae	White sardine	Mithoo	10	50	Low	Pelagic in coastal waters	Phytoplankton and Zooplankton (copepods, crabs, bivalve larvae, fish eggs)	Not Assessed	
31.	<i>Hilsa kelee</i>	Clupeidae	Kelee shad	Palli	25	75	Low	Pelagic in coastal waters	Small fish and crustacean	Not Assessed	
32.	<i>Ilisha megaloptera</i>	Clupeidae	Bigeye ilisha	Palli	28	200	Low	Pelagic in coastal waters	Fish and crustacean	Not Assessed	
33.	<i>Ilisha melastoma</i>	Clupeidae	Indian ilisha	Palli	12	70	Low	Pelagic in coastal waters	Mollusks	Not Assessed	
34.	<i>Opisthopterus tardoore</i>	Clupeidae	Tardoore	Koor, Palli	20	90	Low	Shallow waters, Creeks	Small crustacean and zooplankton	Not Assessed	
35.	<i>Pellona ditchela</i>	Clupeidae	Indian pellona	palli	16	80	Low	Shallow coastal waters, estuaries, creeks, lagoons.	Small crustacean and zooplankton	Not Assessed	
36.	<i>Tenuulosa ilisha</i>	Clupeidae	Hilsa shad	Palla	60	2,490	High	pelagic; anadromous	plankton, mainly by filtering, but apparently also by grubbing on muddy bottom	Least Concern	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
37.	<i>Tenualosa toli</i>	Clupeidae	Toli shad	Nur-Palla	50	1,000	High	Coastal waters, bays, lagoons	Detritus, Phytoplankton and Zooplankton	Not Assessed	
38.	<i>Cynoglossus macrostomus</i>	Cynoglossidae	(Malabar tonguesole	Sole	17	60	Medium	Inhabits shallow muddy and sandy bottoms of the continental shelf	Feeds mainly on benthic invertebrates, especially worms.	Not Assessed	Indian Ocean: restricted to the coast of India
39.	<i>Cynoglossus puncticeps</i>	Cynoglossidae	Speckled tonguesole	Sole	18	60	Medium	Inhabits shallow muddy and sandy bottoms of the continental shelf	Feeds mainly on benthic invertebrates, especially worms.	Not Assessed	
40.	<i>Cynoglossus bilineatus</i>	Cynoglossidae	Tongue soles	sole	44	225	High	Coastal areas and estuaries. May ascend into the freshwater	Bottom-living invertebrates	Not Assessed	
41.	<i>Cynoglossus dubius</i>	Cynoglossidae	Tonguesoles	sole	50	300	High	Continental shelf	Bottom-living invertebrates	Not Assessed	Western Indian Ocean: west coast of India
42.	<i>Cynoglossus arael</i>	Cynoglossidae	Brown Tongue soles	Sole	38	200	High	Continental shelf, estuaries	Bottom-living invertebrates	Not Assessed	
43.	<i>Aphanius dispar dispar</i>	Cyprinodontidae	Killi fish	Killi fish	7	15	No	Occurs in coastal zones, also found in oasis pools with hypersaline to fresh water	Chiefly a herbivorous species	Not Assessed	
44.	<i>Himantura walga</i>	Dasyatidae	Dwarf whipray	Pittan	-	-	No	Demersal; marine	Feeds on invertebrates and small fishes	Near Threatened	
45.	<i>Drepane punctata</i>	Drepanidae	Spotted sicklefish	Rupichand	40	1,000	High	Coastal, estuaries	Bottom-living invertebrates	Not Assessed	
46.	<i>Echeneis naucrates</i>	Echeneididae	Live Sharksucker	Masi	75	500	Medium	Shallow coastal waters	Food scraps of the host species	Not Assessed	
47.	<i>Elops machnata</i>	Elopidae	Tenpounder	Kinarhal	120	11,000	Average	Inhabits shallow coastal waters, estuaries and bays	Small fishes, mollusks, shrimps, crabs	Least Concern	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
48.	<i>Coilia dussumieri</i>	Engraulidae	Anchovy	Patia	20	15	low	Pelagic; Amphidromous	copepods, prawn and fish larvae	Not Assessed	
49.	<i>Thryssa dussumieri</i>	Engraulidae	Thryssa	Physa	11	50	No	Mostly inshore and estuarine conditions	Feeds on diatoms, prawn larvae, copepods and cypris.	Not Assessed	
50.	<i>Thryssa hamiltonii</i>	Engraulidae	Thryssa	Physa	20	40	Low	Pelagic in coastal waters, estuaries	Mainly on crustaceans (zoea larvae, amphipods, Acetes)	Not Assessed	
51.	<i>Thryssa mystax</i>	Engraulidae	Moustached thryssa	Physa	16	50	Low	Pelagic in coastal waters, estuaries	Mainly on crustaceans (zoea larvae, amphipods, Acetes)	Least Concern	
52.	<i>Thryssa setirostris</i>	Engraulidae	Thryssa	physa	15	40	Low	Pelagic in coastal waters, estuaries	Mainly on crustaceans (zoea larvae, amphipods, Acetes)	Not Assessed	
53.	<i>Thryssa vitrirostris</i>	Engraulidae	Orangemouth Anchovy	Physa	20	50	Low	Coastal waters, also in estuaries	Mainly feeds on crustaceans	Not Assessed	
54.	<i>Gerres filamentosus</i>	Gerreidae	Long-rayed silver-biddy	Jerkari	25	125	Medium	Shallow coastal waters	Crustaceans, polychaetes and forams on sand or muddy-sand bottoms	Least Concern	
55.	<i>Gerres poietii</i>	Gerreidae	Strongspine silver biddy	Jerki	20	125	Medium	Lives near the bottom	Small benthic invertebrates	Not Assessed	
56.	<i>Gerres oyena</i>	Gerreidae2	Lined silver-biddy	Jerki	30.	125	low	coast, saltwater lagoons, and estuaries	Crustaceans, polychaetes and forams on sand or muddy-sand bottoms	Not Assessed	
57.	<i>Boleophthalmus dussumieri</i>	Gobiidae	Mud skipper	Gullo	10	40	No	Coastal areas	Small fish, crabs and other arthropods	Not Assessed	
58.	<i>Scartelaos tenuis</i>	Gobiidae	Indian Ocean slender mudskipper	Gullo	10	30	No	Coastal areas	Small fish, crabs and other arthropods	Not Assessed	
59.	<i>Carangoides malabaricus</i>	Gobiidae	Malabar trevally	Kakkar	25	150	Medium	Sandy bays, rocky and coral reefs	Feeds on crustaceans, squids and shrimps	Not Assessed	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
60.	<i>Psammogobius biocellatus</i>	Gobiidae	Sleepy goby	Gullo	12	50	No	Inhabits intertidal areas, estuaries and lagoons	Small fish, crabs	Least Concern	
61.	<i>Periophthalmus barbarus</i>	Gobiidae	Atlantic mudskipper	Gobby	25	30	Low	Marine; freshwater; brackish; reef-associated	Arthropods (crabs, insects, etc.) of the mud surface	Least Concern	
62.	<i>Pomadasys argenteus</i>	Haemulidae	Grunter	Dhother	50		High	Coastal waters	Benthic invertebrates and small fishes	Least Concern	
63.	<i>Pomadasys kaakan</i>	Haemulidae	Grunter	Dhother	80	3,5000	High	Coastal waters	Benthic invertebrates and small fishes	Not Assessed	
64.	<i>Pomadasys maculatum</i>	Haemulidae	Saddle grunt	Dhother	50	2,000	High	Coastal waters	Benthic invertebrates and small fishes	Least Concern	
65.	<i>Pomadasys stridens</i>	Haemulidae	striped grunter	Bukra	20	15000	High	Coastal waters	Benthic invertebrates and small fishes	Not Assessed	
66.	<i>Harpadon nehereus</i>	Harpadontidae	Bumbay duck	Bombil	40	150	Low	Coastal waters and estuaries	Benthic invertebrates and small fishes	Not Assessed	
67.	<i>Hemiramphus far</i>	Hemiramphidae	Blackbarred halfbeak	Thute	45	150	Low	Marine and brackish waters	Benthic invertebrates and small fishes	Not Assessed	
68.	<i>Hyporhamphus dussumieri</i>	Hemiramphidae	Dussumieri halfbeak	Thute	30	100	Medium	Marine and brackish waters	Feed on small fishes	Not Assessed	
69.	<i>Hyporhamphus (Hyporhamphus) limbatus</i>	Hemiramphidae	Congaturi halfbeak	Thute	55	200	Average	Marine and brackish water	Omnivorous	Not Assessed	
70.	<i>Lactarius lactarius</i>	Lactariidae	False trevally	Bukko	40	175	Medium	Found in various types of habitats	Feeds on benthic invertebrates	Not Assessed	
71.	<i>Lates calcarifer</i>	Latidae	Baramundi	Dangri	200	80,000 (8kg)	High	Demersal; catadromous	Crustaceans, molluscs, and smaller fishes	Not Assessed	
72.	<i>Leiognathus blochi</i>	Leiognathidae	Twoblotch ponyfish	Kaanteri	10	30	Low	Inhabit shallow coastal waters	Feeds on small crustaceans, foraminifera and bivalves	Not Assessed	
73.	<i>Leiognathus brevisrostris</i>	Leiognathidae	Short nose ponyfish	Kaanteri	13	30	Low	Inhabit shallow coastal waters	Feeds on small crustaceans,	Not Assessed	



No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
									foraminifera and bivalves		
74.	<i>Leiognathus equulus</i>	Leiognathidae	Common Ponyfish	Kaanteri	25 cm	45	Low	Inhabit shallow coastal waters	Feed on polychaetes, small crustaceans, small fishes and worms	Least Concern	
75.	<i>Leiognathus daura</i>	Leiognathidae	GoldstripeP onyfish	Kaanteri	14	30	Low	Shallow waters	Polychaetes, bivalves, small crustaceans and sponges	Not Assessed	
76.	<i>Leiognathus splendens</i>	Leiognathidae	Splendid ponyfish	Kaanteri	17	40	Low	Coastal waters	Fish, crustaceans, foraminiferans , and bivalves	Least Concern	
77.	<i>Secutor insidiator</i>	Leiognathidae	Slender barred ponyfish	Kaanteri	11.3	25	Low	Shallow waters	Zooplankton including copepods, mysids, and larval fishes and crustaceans	Not Assessed	
78.	<i>Lutjanus johnii</i>	Lutjanidae	One spot golden snapper	Hira	90	10,000	High	Shallow coastal waters mainly around mangroves	Fishes and benthic invertebrates including shrimps, crabs and cephalopods	Not Assessed	
79.	<i>Lutjanus argentimaculatus</i>	Lutjanidae	Red snapper	Hira	120	10,000	High	Shallow coastal waters mainly around mangroves	Fishes and benthic invertebrates including shrimps, crabs and cephalopods	Not Assessed	
80.	<i>Liza carinata</i>	Mugilidae	Keeled mullet	Boi, Mori	25	40	Average	Marine coastal waters	Small benthic invertebrates, planktonic organism alga and detritus	Not Assessed	
81.	<i>Liza melinoptera</i>	Mugilidae	Large scale gery Mullet	Boi, Mori	22	30	Low	Coastal waters, Estuaries	Feeds on plant detritus, microalgae, minute benthic organisms, and organic matter in sand and mud	Least Concern	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
82.	<i>Liza parsia</i>	Mugilidae	Gold spot mullet	Boi, Parsi	16	30	Low	Shallow coastal waters	Small benthic invertebrates, planktonic organism alga and detritus	Not Assessed	
83.	<i>Liza subviridis</i>	Mugilidae	Green back mullet	Chhodi	30	500	High	Coastal waters, estuaries	Small algae, diatoms and benthic detrital material taken in with sand and mud	Not Assessed	
84.	<i>Mugil cephalus</i>	Mugilidae	Large scale mullet	Pharra, Boi	60	12,000	High	Coastal areas, enters estuaries and rivers	Omnivorous zooplankton, benthic organisms and detritus	Least Concern	
85.	<i>Valamugil cunnesius</i>	Mugilidae	Long arm mullet	Pharra, Boi	50	1000	high	Coastal waters, estuaries, enters rivers	Organic matter contained in sand and mud	Not Assessed	
86.	<i>Upeneus vittatus</i>	Mullidae	Yellow-striped goatfish	Manori	28	300	Average	Turbid waters	Small crustaceans	Not Assessed	
87.	<i>Congrosox talabonoides</i>	Muraenesocidae	Pike congers	Bam	250	50000	High	Continental shelf	Feeds at night, on bottom fishes and crustaceans	Not Assessed	
88.	<i>Muraenesox cinereus</i>	Muraenesocidae	Silver conger eel	Bam	200	2,000	High	Continental shelf	Feeds at night, on bottom fishes and crustaceans	Not Assessed	
89.	<i>Grammophites suppositus</i>	Platycephalidae	Softfin flathead	Kuker	25	300	Average	Rocky shores	Crustaceans and small fish	Not Assessed	
90.	<i>Platycephalus indicus</i>	Platycephalidae	Bartail flathead	Kuker	100	3000	High	Rocky shores	Crustaceans and small fish	Data Deficient	
91.	<i>Eleutheronema tetradactylum</i>	Polynemidae	Four finger threadfin	Seeri, Ranwas	200	80000	High	Shallow coastal waters entering river mouths	Prawns and fish	Not Assessed	
92.	<i>Filimnus heptadactylus</i>	Polynemidae	Sevenfinger Threadfin	Seeri	200	5000	High	Shallow coastal waters entering river mouths	Prawns and fish	Not Assessed	
93.	<i>Polynemus indicus</i>	Polynemidae	Indian threadfin	Seeri, Ranwas	200	8,0000	High	Shallow coastal waters	Feeds on diatoms, copepoda, crustaceans and smaller fish	Not Assessed	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
94.	<i>Polynemus sexfilis</i>	Polynemidae	Sixfinger threadfin		70	1,000	High	Shallow coastal waters	Feeds on diatoms, copepoda, crustaceans and smaller fish	Not Assessed	
95.	<i>Polynemus sextarius</i>	Polynemidae	Black spot threadfin	Seeri	150	4000	High	Shallow coastal waters	Feeds on diatoms, copepoda, crustaceans and smaller fish	Not Assessed	
96.	<i>Psettodes erumei</i>	Psettodidae	Indian flounder	Hajjam	60	900	High	Muddy and sandy bottoms of the continental shelf	Feeds on diatoms, copepoda, crustaceans	Not Assessed	
97.	<i>Johnieops sina</i>	Sciaenidae	Small salmon	sua	30	500	High	Inshore waters	Feeds on diatoms, copepoda, crustaceans	Not Assessed	
98.	<i>Johnius dussumieri</i>	Sciaenidae	Bearded croacker	Mushka	25	400	High	Coastal waters	Feeds on small fishes and invertebrates	Not Assessed	
99.	<i>Johnius belangerii</i>	Sciaenidae	Jewfish	Mushka	30	450	High	Coastal waters. Enters estuaries	Invertebrates, worms	Not Assessed	
100.	<i>Otolithes ruber</i>	Sciaenidae	Rosy jewfish	Mushka	90	7,000	High	Coastal waters	Fishes, prawns and other invertebrates	Not Assessed	
101.	<i>Protonibea diacanthus</i>	Sciaenidae	Jewfish	Sua	120	40000 (20kg)	High	Coastal waters	Crustaceans and small demersal fishes	Not Assessed	
102.	<i>Rastrelliger kanagurta</i>	Scombridae	Indian mackerel	Bangra	35	300	High	Coastal water	Fish and shrimp larvae	Data Deficient	
103.	<i>Scomberomorus guttatus</i>	Scombridae	Indo-Pacific king mackerel	Kalgund	76	800	High	Coastal to deeper water	Fishes and cephalopods	Not Assessed	
104.	<i>Epinephelus diacanthus</i>	Serranidae	Thornycheek grouper	Gisser	52	3,000	High	Continental shelf area	Fishes and large crustaceans	Near Threatened	
105.	<i>Epinephelus fuscoguttatus</i>	Serranidae	Brown-marbled Grouper	Gisser	90	11,000	High	Continental shelf area	Fishes and large crustaceans	Near Threatened	
106.	<i>Promicrops lanceolatus</i>	Serranidae	Giant Grouper	Dhambo	270	400,000	High	Common in estuaries	Feeds on fishes and large crustaceans	Not Assessed	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
107.	<i>Sillago sihama</i>	Sillaginidae	Silver whiting	Bhambore	25	40	High	Shores, Bays, Creeks, estuaries	Mainly on polychaetes and other benthic organisms	Not Assessed	
108.	<i>Brachirus orientalis</i>	Soleidae	Oriental sole	Phani	24	75	Low	Shallow coastal waters	Feeds mainly on bottom-dwelling invertebrates	Not Assessed	
109.	<i>Solea elongata</i>	Soleidae	Elongate Sole	Phani	30	45	Low	Shallow coastal waters	Benthic invertebrates, especially small crustaceans	Not Assessed	
110.	<i>Solea ovata</i>	Soleidae	Uvate Sole	Bans Patta	10	20	Low	Inhabits shallow sand and mud bottoms in coastal waters.	Feeds mainly on benthic invertebrates	Not Assessed	
111.	<i>Acanthopagrus berda</i>	Sparidae	Black Bream	Dandya	50	1,500	High	Muddy grounds in estuarine areas	Invertebrates, including worms, mollusks, crustaceans and echinoderms	Least Concern	
112.	<i>Acanthopagrus latus</i>	Sparidae	Yellow fin sea Bream	Dandya	50	1,500	High	Coastal waters, estuaries, river mouth	Echinoderms, worms, crustaceans and mollusks.	Data Deficient	
113.	<i>Sparidentex hasta</i>	Sparidae	Sobaity seabream	Dandya	35	50	Medium	Demersal; brackish; marine	Carnivorous	Least Concern	
114.	<i>Sphyraena putnamiae</i>	Sphyraenidae	Barracuda	Kund	90	4000	High	Inshore-pelagic	fishes and large invertebrates	Not Assessed	
115.	<i>Pampus argenteus</i>	Stromateidae	Silver pomfret	Achopito, Sufaid poplet	60	30000	High	Inshore species, Benthopelagic	Ctenophores, salps, medusae, and other zooplankton groups	Not Assessed	
116.	<i>Pseudosynanceia melanostigma</i>	Synanceiidae	Blackfin stonefish		13	20	No	Demersal; brackish; marine	Carnivore	Not Assessed	

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit	IUCN Status	Restricted Range Information (IUCN)
117.	<i>Terapon jarbua</i>	Teraponidae	Jerbua terapon	Ginghra	36	10000	Average	Vicinity of river mouths, Estuarine, demersal; catadromous	Omnivorous, feeds upon fishes, insects, benthic invertebrates, and algae	Least Concern	
118.	<i>Terapon puta</i>	Teraponidae	Smallscale terapon	Ginghra	15	25	Low	Inshore waters, estuaries	Small fishes and invertebrates	Not Assessed	
119.	<i>Lagocephalus lunaris</i>	Tetraodontidae	Lunartail puffer	Toroo	75	100	No	Mainly marine, occasionally enters estuaries	Invertebrates	Least Concern	
120.	<i>Lepturacanthus savala</i>	Trichiuridae	Hairtail	Talwar	120	350	High	Benthopelagic	Variety of small fishes and crustaceans	Not Assessed	
121.	<i>Trichiurus lepturus</i>	Trichiuridae	Large head hairtail	Talwar	46	150	Medium	tropical and temperate waters	Fishes, crabs, mollusks	Not Assessed	
122.	<i>Arius thalassinus</i>	Ariidae	Giant catfish	Khagga	185	1,000	High	Estuaries, brackish waters	Invertebrate and small fishes	Not Assessed	
123.	<i>Glossogobius giuris</i>	Gobiidae	Tank gobby	Gobby	50	50	Low	Rivers and Brackish water	Small insects, crustaceans and small fish	Least Concern	
124.	<i>Periophthalmus weberi</i>	Gobiidae	Weber's mudskipper	Gobby	10	20	Low	Brackish mangroves including the margin of estuaries and tidal creeks	Crabs and insects	Not Assessed	
125.	<i>Pisodonophis cancrivorus</i>	Ophichthidae	Longfin snake-eel	Bam	50	400	low	Demersal , brackish water, saltwater and entering freshwater	Spend most of the time buried in sand and hunt small fishes and crustacean.	Not Assessed	
126.	<i>Scatophagus argus</i>	Scatophagidae	Spoted scat	Korgi	38	2000	Average	Inhabit brackish estuaries and the lower reaches of freshwater	Worms, crustaceans, insects and plant matter	Least Concern	

**Source:** Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research.



### Exhibit 5.37: Brackish Water Species

No	Species	Family	English name	Local name	Max Size (cm)	Weight (gm)	Economic Importance	Habitat	Feeding habit
1.	<i>Mystus gulio</i>	Siluridae	Long whiskers catfish	Tengara	45	100	Medium	Primarily a brackish water fish that enters and lives in fresh water.	Benthic invertebrates
2.	<i>Gastrophysus lunaris</i>	Tetradontidae	Moontail blassop	Ginghra	45	50	Low	Brackish water environment	Aquatic insects

**Source:** Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research.

**Exhibit 5.38: Families of Freshwater Species at Ketī Bandar**

No.	Family	No. of Species
1	Ambassidae	1
2	Bagridae	3
3	Channidae	1
4	Cichlidae	1
5	Clupiedae	1
6	Cyprinidae	5
7	Gobiidae	1
8	Mastacembelidae	1
9	Siluridae	2
<b>Total</b>		<b>16</b>

Source: Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research

### 5.5.2 Diversity of Fish in the Study Area as Inferred from Diversity at Ketī Bandar and Fish Sampling

The differences and similarities between the Port Qasim Area and the Ketī Bandar area are summarized in **Exhibit 5.39**. These differences include physical conditions such as levels of pollutants, human activity derived disturbance, freshwater flows, water and sediment quality and the subsequent differences in susceptibility of biodiversity to various consequential pressures. Habitat at the Ketī Bandar site is stressed by human activity (see **Section 5.3.2**), however, compared to habitat in the Port Qasim Area, it is less stressed.

**Exhibit 5.39: Differences between Ketī Bandar Area and Port Qasim Area<sup>191</sup>**

No.	Physical and Ecological parameters	Ketī Bandar Area	Port Qasim Area
1	Freshwater fish fauna	16 species	No record available, not likely to exist as pollution levels are high and there are no sizeable freshwater areas.
2	Marine Fish fauna	128 species	98 species reported in literature with no species names. <sup>192</sup> 126 marine species found at Ketī Bandar are expected to be present in the Study Area. Two brackish water species found in Ketī Bandar not likely to be found as salinity levels are high and close to that of

<sup>191</sup> Based on Dr. Muhammed Rafique, Pakistan Museum of Natural History, Islamabad, unpublished research.

<sup>192</sup> Muhammad Waseem Khan of the MFD reported more than 180 species in Issaro Creek in June 2015. However, the report was not published at the time of writing of this report.

No.	Physical and Ecological parameters	Keti Bandar Area	Port Qasim Area
			seawater. However, a total of 66 species were observed during sampling within the Study Area. It should be noted that during sampling saturation could not be reached.
3	Pollution	Over time there is a trend of increasing pollution but there is no major industry or source of major pollution	About 6,000 industries mostly located along the coastal belt. Mangroves are considered to stabilize sediments and trap heavy metals. <sup>193</sup> Consistent with this Karachi coastal mangrove habitat also serves as a sink for heavy metals. The effluent from Pakistan Steel, Bin Qasim power plant and Bhains (cattle) Colony. 90,000 tons of oil products from vessels and port terminals are dumped every year. Large-scale shipping traffic at Port Qasim. Waste water pollution
4	Habitat and Biodiversity loss	Pressure from human activity such as pollution and disturbance is there but it is comparatively lower than at Port Qasim. Therefore the area is less susceptible. There is less spatial variation in fish abundance and diversity expected at Keti Bandar	More susceptible due to pollution and disturbance More spatial variation in fish abundance and diversity expected at Port Qasim compared to Keti Bandar due to greater levels of pollution near the coastline at Port Qasim associated with drainage of released industrial and municipal effluents into the creeks.
5	Freshwater and sediment	Close to Indus confluence, therefore during flooding a higher volume of freshwater flows into this area, compared to Port Qasim. In addition, sediment also reaches the Keti Bandar area with flows from Indus. The delta has shallow creeks and more mudflats.	Distant from Indus confluence. Ephemeral freshwater creeks only. The creeks are receiving pollution from the industries and sewage, and there are some wastewater drains. The delta has deeper creeks than Keti Bandar and lower proportion of mudflats, as there is lower sediment deposition.

<sup>193</sup> McLeod, Elizabeth and Salm, Rodney V. Managing Mangroves for Resilience to Climate Change. IUCN, Gland, Switzerland. 64pp, 2006

No.	Physical and Ecological parameters	Keti Bandar Area	Port Qasim Area
6	Protection from ocean waves	Lower protection	Greater protection
7	Fishing pressure	There is fishing pressure and over-fishing but fishing boats and trawlers are not highly mechanized	Fishing boats and trawlers are highly mechanized, resulting in greater fishing pressure than at Keti Bandar
8	Level of disturbance	Human disturbance is present but it is comparatively lower	Higher due to turbulence created by shipping, loading unloading, high sea traffic
9	Overexploitation of resources	Overexploitation is present but it is comparatively lower	Overexploitation is comparatively much higher

Based on the information in **Exhibit 5.39** the following differences in species composition and diversity can be expected within the Study Area relative to Keti Bandar.

1. All the 126 marine fishes that occur in Keti Bandar and are listed in **Exhibit 5.36** are likely to occur in the Study Area at Port Qasim.
2. The two fish species that occur in brackish water at Keti Bandar and are listed in **Exhibit 5.37** are not likely to occur in the Study Area as the brackish water zone has been much reduced in the Study Area due to reduction in inflows of fresh water, and a high level of pollution in the low salinity waste water that flows into the Study Area from residential and industrial areas.
3. The fresh water species that occur in Keti Bandar and families of which are listed in **Exhibit 5.38** are not likely to occur in the Study Area for the reason listed above for the brackish water species.

A fish survey of the Study Area was carried out in September 2015 (see **Appendix C.2.3**). Sampling was carried out at six sampling locations in the Study Area (**Exhibit C.94** in **Appendix C.2.3**). The sampling locations were distributed spatially to assess the effect of distance from Port Qasim and effluent release, on fish diversity and abundance.

A total of 66 species were observed during the sampling exercise. This is lower than the number of species observed at Keti Bandar during the sampling carried out at that site in May 2015 (see **Section 5.5.1**). It should be noted that saturation in number of species observed could not be reached due to limited resources and time available for the survey.

A list of the species observed as well as their relative abundance is given in **Exhibit 5.40**. Species observed along with their economic importance, IUCN status and restricted range information is given in **Exhibit 5.41**. There are no Threatened, Vulnerable or Endangered species in the list given in **Exhibit 5.41**.

**Exhibit 5.40:** List of Species Observed during Sampling in the Study Area along with their relative abundance at each Sampling Location

No	Species	FS1		FS2		FS3		FS4		FS5		FS6	
		Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)
1.	<i>Acanthopagrus berda</i>	6	3.8	2	1.2	0	0.0	0	0.0	0	0.0	8	1.4
2.	<i>Acanthopagrus latus</i>	3	1.9	22	13.3	3	0.9	0	0.0	0	0.0	12	2.2
3.	<i>Alepes djedaba</i>	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4.	<i>Anodontostoma chacunda</i>	0	0.0	0	0.0	3	0.9	0	0.0	1	0.4	0	0.0
5.	<i>Arius caelatus</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	15	2.7
6.	<i>Arius maculatus</i>	0	0.0	0	0.0	30	8.6	0	0.0	0	0.0	0	0.0
7.	<i>Arius thalassinus</i>	0	0.0	1	0.6	0	0.0	0	0.0	2	0.9	0	0.0
8.	<i>Bathygobius fuscus</i>	0	0.0	1	0.6	0	0.0	0	0.0	3	1.3	1	0.2
9.	<i>Caranx para</i>	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
10.	<i>Cociella crocodila</i>	0	0.0	7	4.2	1	0.3	0	0.0	1	0.4	0	0.0
11.	<i>Colletteichthys occidentalis</i>	0	0.0	0	0.0	0	0.0	3	3.8	0	0.0	0	0.0
12.	<i>Cynoglossus arel</i>	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0
13.	<i>Cynoglossus carpenteri</i>	0	0.0	0	0.0	1	0.3	0	0.0	2	0.9	70	12.6
14.	<i>Cynoglossus puncticeps</i>	0	0.0	0	0.0	1	0.3	0	0.0	5	2.2	0	0.0
15.	<i>Drepane punctata</i>	1	0.6	0	0.0	4	1.1	0	0.0	2	0.9	1	0.2
16.	<i>Dussumieria acuta</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8	1.4
17.	<i>Epinephelus tauvina</i>	0	0.0	0	0.0	0	0.0	1	1.3	0	0.0	0	0.0
18.	<i>Escualosa thoracata</i>	0	0.0	2	1.2	0	0.0	0	0.0	0	0.0	12	2.2
19.	<i>Euryglossa orientalis</i>	2	1.3	0	0.0	2	0.6	0	0.0	0	0.0	0	0.0



No	Species	FS1		FS2		FS3		FS4		FS5		FS6	
		Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)
20.	<i>Gerres filamentosus</i>	3	1.9	9	5.5	10	2.9	6	7.5	2	0.9	9	1.6
21.	<i>Gerres oyena</i>	1	0.6	6	3.6	20	5.7	4	5.0	1	0.4	11	2.0
22.	<i>Grammoplites suppositus</i>	3	1.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
23.	<i>Himantura walga</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
24.	<i>Ilisha megaloptera</i>	0	0.0	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0
25.	<i>Johnnieops sina</i>	0	0.0	2	1.2	40	11.4	0	0.0	1	0.4	0	0.0
26.	<i>Johnius glaucus</i>	0	0.0	0	0.0	0	0.0	4	5.0	0	0.0	0	0.0
27.	<i>Johnius belangerii</i>	0	0.0	17	10.3	30	8.6	0	0.0	0	0.0	0	0.0
28.	<i>Johnius carutta</i>	0	0.0	18	10.9	0	0.0	0	0.0	0	0.0	0	0.0
29.	<i>Johnius dussumieri</i>	0	0.0	8	4.8	30	8.6	0	0.0	1	0.4	0	0.0
30.	<i>Johnius glaucus</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
31.	<i>Kathala axillaris</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	34	6.1
32.	<i>Leiognathus daura</i>	3	1.9	7	4.2	5	1.4	0	0.0	23	10.1	35	6.3
33.	<i>Leiognathus dussumieri</i>	0	0.0	3	1.8	0	0.0	0	0.0	0	0.0	0	0.0
34.	<i>Leiognathus fasciatus</i>	3	1.9	5	3.0	6	1.7	3	3.8	35	15.4	70	12.6
35.	<i>Leiognathus splendens</i>	2	1.3	6	3.6	3	0.9	5	6.3	30	13.2	64	11.5
36.	<i>Liza subviridis</i>	13	8.3	0	0.0	0	0.0	1	1.3	1	0.4	0	0.0
37.	<i>Lutjanus johnii</i>	9	5.7	2	1.2	1	0.3	0	0.0	1	0.4	1	0.2
38.	<i>Megalaspis cordyla</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
39.	<i>Otolithes cuvleri</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	56	10.1
40.	<i>Otolithes ruber</i>	0	0.0	12	7.3	4	1.1	0	0.0	8	3.5	40	7.2

No	Species	FS1		FS2		FS3		FS4		FS5		FS6	
		Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)
41.	<i>Oxyurichthys ophthalmonema</i>	1	0.6	1	0.6	0	0.0	0	0.0	2	0.9	1	0.2
42.	<i>Platycephalus indicus</i>	1	0.6	1	0.6	0	0.0	0	0.0	0	0.0	18	3.2
43.	<i>Pomadasys argyreus</i>	0	0.0	15	9.1	0	0.0	50	62.5	0	0.0	0	0.0
44.	<i>Pomadasys commersonni</i>	0	0.0	0	0.0	0	0.0	0	0.0	12	5.3	0	0.0
45.	<i>Pomadasys kaakan</i>	15	9.6	0	0.0	8	2.3	0	0.0	0	0.0	15	2.7
46.	<i>Pomadasys stridens</i>	10	6.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
47.	<i>Promicrops lanceolatus</i>	1	0.6	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
48.	<i>Pseudorhombus arsius</i>	4	2.5	0	0.0	0	0.0	0	0.0	2	0.9	0	0.0
49.	<i>Pseudorhombus elevatus</i>	0	0.0	0	0.0	2	0.6	0	0.0	0	0.0	7	1.3
50.	<i>Pseudorhombus javanicus</i>	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	8	1.4
51.	<i>Pseudosynanceia melanostigma</i>	0	0.0	3	1.8	2	0.6	0	0.0	1	0.4	5	0.9
52.	<i>Rhabdosargus sarba</i>	0	0.0	0	0.0	1	0.3	1	1.3	0	0.0	0	0.0
53.	<i>Scomberoides tol</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
54.	<i>Secutor insidiator</i>	70	44.6	7	4.2	5	1.4	2	2.5	22	9.7	42	7.6
55.	<i>Sillago sihama</i>	3	1.9	2	1.2	37	10.6	0	0.0	50	22.0	4	0.7
56.	<i>Solea elongata</i>	0	0.0	1	0.6	60	17.1	0	0.0	5	2.2	0	0.0
57.	<i>Sparidentex hasta</i>	0	0.0	0	0.0	0	0.0	0	0.0	4	1.8	0	0.0
58.	<i>Synaptura commersoniana</i>	1	0.6	0	0.0	40	11.4	0	0.0	0	0.0	0	0.0
59.	<i>Terapon jebua</i>	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0
60.	<i>Terapon puta</i>	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0

No	Species	FS1		FS2		FS3		FS4		FS5		FS6	
		Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)	Count	Relative Abundance (%)
61.	<i>Terapon theraps</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	5	0.9
62.	<i>Thryssa hamiltonii</i>	0	0.0	0	0.0	0	0.0	0	0.0	2	0.9	2	0.4
63.	<i>Thryssa malabarica</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
64.	<i>Thryssa mystax</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
65.	<i>Trypauchen microcephalus</i>	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0
66.	<i>Uroconger lepturus</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
<b>Total Specimens Collected</b>		<b>157</b>	<b>100.0</b>	<b>165</b>	<b>100.0</b>	<b>350</b>	<b>100.0</b>	<b>80</b>	<b>100.0</b>	<b>227</b>	<b>100.0</b>	<b>555</b>	<b>100.0</b>
<b>Number of species</b>		<b>23</b>		<b>30</b>		<b>27</b>		<b>11</b>		<b>34</b>		<b>28</b>	
<b>Shannons' Diversity Index</b>		<b>2.17</b>		<b>2.93</b>		<b>2.62</b>		<b>1.46</b>		<b>2.59</b>		<b>2.79</b>	
<b>Shannons' evenness index</b>		<b>0.69</b>		<b>0.86</b>		<b>0.8</b>		<b>0.61</b>		<b>0.73</b>		<b>0.84</b>	

**Exhibit 5.41: Fish Species Recorded in the Study Area and their Status**

Nos.	Species	Economic Importance	IUCN Red list Status	Restricted Range
1.	<i>Acanthopagrus berda</i>	High	Least Concern	
2.	<i>Acanthopagrus latus</i>	High	Data Deficient	
3.	<i>Alepes djedaba</i>	Average	Not Assessed	
4.	<i>Anodontostoma chacunda</i>	Low	Not Assessed	
5.	<i>Arius caelatus</i>	Medium	Not Assessed	
6.	<i>Arius maculatus</i>	Medium	Not Assessed	
7.	<i>Arius thalassinus</i>	High	Not Assessed	
8.	<i>Bathygobius fuscus</i>	Low	Least Concern	
9.	<i>Caranx para</i>	Low	Not Assessed	
10.	<i>Cociella crocodila</i>	Medium	Not Assessed	
11.	<i>Colletteichthys occidentalis</i>	Low	Not Assessed	
12.	<i>Cynoglossus arel</i>	High	Not Assessed	
13.	<i>Cynoglossus carpenteri</i>	High	Not Assessed	
14.	<i>Cynoglossus puncticeps</i>	High	Not Assessed	
15.	<i>Drepane punctata</i>	High	Not Assessed	
16.	<i>Dussumieria acuta</i>	Medium	Not Assessed	
17.	<i>Epinephelus tauvina</i>	High	Data Deficient	
18.	<i>Escualosa thoracata</i>	Low	Not Assessed	
19.	<i>Euryglossa orientalis</i>	Low	Not Assessed	
20.	<i>Gerres filamentosus</i>	Medium	Least Concern	
21.	<i>Gerres oyena</i>	Low	Not Assessed	
22.	<i>Grammoplites suppositus</i>	Medium	Not Assessed	
23.	<i>Himantura walga</i>	No	Near Threatened	
24.	<i>Ilisha megaloptera</i>	Low	Not Assessed	
25.	<i>Johnnieops sina</i>	High	Not Assessed	
26.	<i>Johnius glaucus</i>	High	Not Assessed	
27.	<i>Johnius belangerii</i>	High	Not Assessed	
28.	<i>Johnius carutta</i>	High	Not Assessed	
29.	<i>Johnius dussumieri</i>	High	Not Assessed	
30.	<i>Johnius glaucus</i>	High	Not Assessed	
31.	<i>Kathala axillaris</i>	High	Not Assessed	
32.	<i>Leiognathus daura</i>	Low	Not Assessed	
33.	<i>Leiognathus dussumieri</i>	Low	Not Assessed	
34.	<i>Leiognathus fasciatus</i>	Medium	Least Concern	

Nos.	Species	Economic Importance	IUCN Red list Status	Restricted Range
35.	<i>Leiognathus splendens</i>	Low	Least Concern	
36.	<i>Liza subviridis</i>	High	Not Assessed	
37.	<i>Lutjanus johnii</i>	High	Not Assessed	
38.	<i>Megalaspis cordyla</i>	High	Not Assessed	
39.	<i>Otolithes cuvleri</i>	High	Not Assessed	
40.	<i>Otolithes ruber</i>	High	Not Assessed	
41.	<i>Oxyurichthys ophthalmoneura</i>	Low	Not Assessed	
42.	<i>Platycephalus indicus</i>	High	Data Deficient	
43.	<i>Pomadasys argyreus</i>	High	Not Assessed	
44.	<i>Pomadasys commersonni</i>	High	Not Assessed	
45.	<i>Pomadasys kaakan</i>	High	Not Assessed	
46.	<i>Pomadasys stridens</i>	High	Not Assessed	
47.	<i>Promicrops lanceolatus</i>	High	Not Assessed	
48.	<i>Pseudorhombus arsius</i>	High	Not Assessed	
49.	<i>Pseudorhombus elevatus</i>	Low	Not Assessed	
50.	<i>Pseudorhombus javanicus</i>	Low	Not Assessed	
51.	<i>Pseudosynanceia melanostigma</i>	No	Not Assessed	
52.	<i>Rhabdosargus sarba</i>	High	Least Concern	
53.	<i>Scomberoides tol</i>	High	Not Assessed	
54.	<i>Secutor insidiator</i>	Low	Not Assessed	
55.	<i>Sillago sihama</i>	High	Not Assessed	
56.	<i>Solea elongata</i>	Low	Not Assessed	
57.	<i>Sparidentex hasta</i>	Medium	Least Concern	
58.	<i>Synaptura commersoniana</i>	Low	Not Assessed	
59.	<i>Terapon jarbua</i>	Average	Least Concern	
60.	<i>Terapon puta</i>	Low	Not Assessed	
61.	<i>Terapon theraps</i>	Medium	Least Concern	
62.	<i>Thryssa hamiltonii</i>	Low	Not Assessed	
63.	<i>Thryssa malabarica</i>	Medium	Not Assessed	
64.	<i>Thryssa mystax</i>	Low	Least Concern	
65.	<i>Trypauchen microcephalus</i>	Low	Not Assessed	
66.	<i>Uroconger lepturus</i>	Low	Not Assessed	

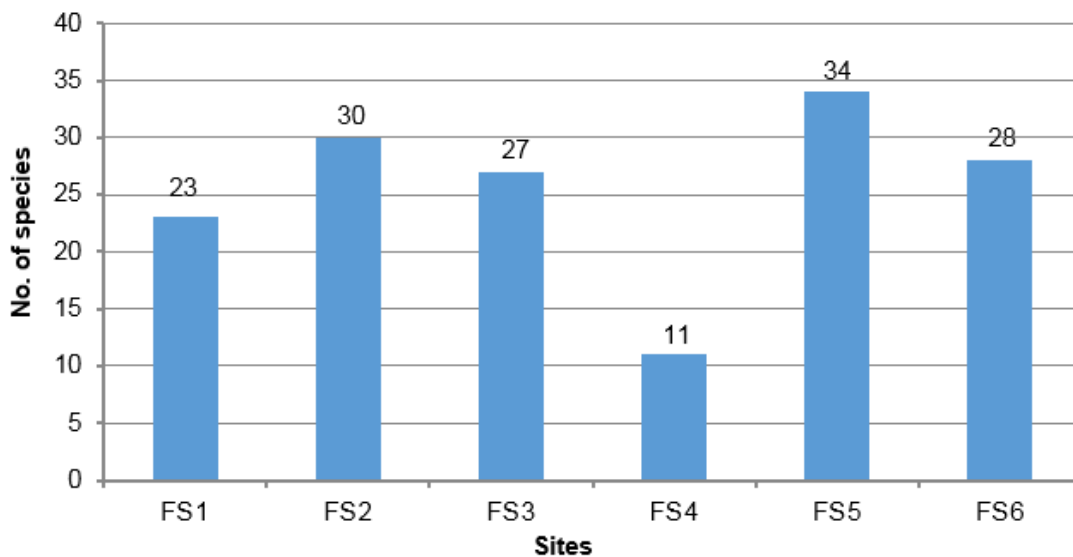
**Exhibit 5.42** shows the bar chart for fish species observed at each of the sampling locations. Similarly **Exhibit 5.43** shows the Shannon diversity index values for the fish



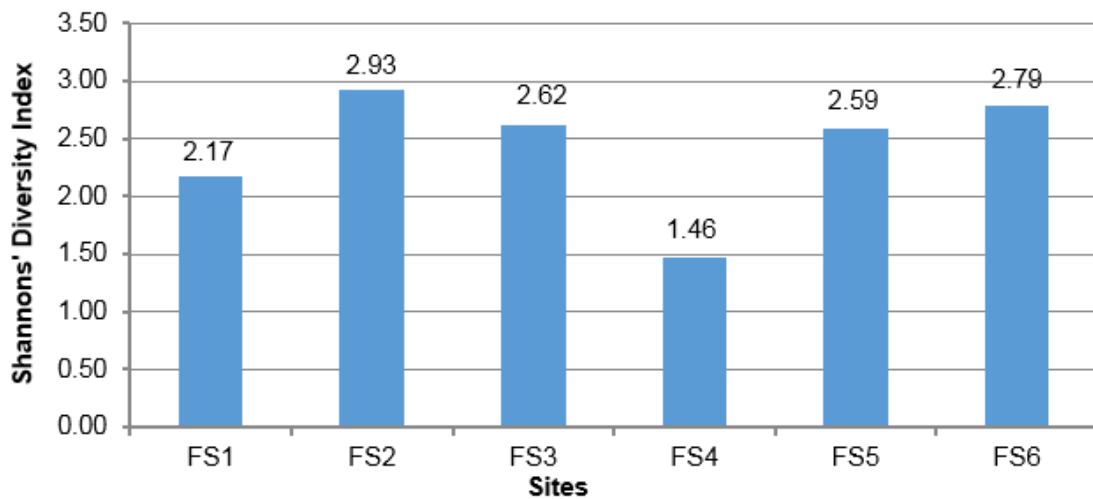
species observed at each of the sampling locations. From **Exhibit 5.42** it can be observed that:

1. The number of fish species is lowest at sampling locations FS1 and FS4. Both these sampling locations are situated closest to the coastline at Port Qasim relative to all the other sampling locations. The Shannon diversity index reflects the distribution trend that the number of species at different localities increases with distance from the Karachi coast, Port Qasim and Ibrahim Haidary.
2. The Korangi Creek (FS1) and the Kadiro Creek (FS4) have the lowest number of species (23 and 11 respectively) as compared to the other sampling locations which are comparatively far from the coastal area.
3. The number of species at the other four sampling locations which are comparatively further from the coast varies from 27-34 (30 at FS2, 27 at FS3, 34 at FS5 and 28 at FS6).
4. The Shannon's evenness index (values given in **Exhibit 5.40**) shows that evenness has a similar trend with lowest values observed for sampling locations FS1 and FS4 relative to all other sampling locations.

**Exhibit 5.42: Number of Species by Sampling Location**



**Exhibit 5.43:** Shanon Diversity Index Values by Sampling Location



Lower number of species at the two sampling locations close to the coastal areas (FS1 and FS4) can be attributed to more pollution, higher level of disturbance, and industrial and domestic sewerage at these sampling locations compared to at the sampling locations further away from the coast (FS2, FS3, FS5 and FS6).

During the mangrove sampling carried out in September 2015 some evidence of non-sustainable fishing practices was collected from statements by local fishermen. The locals stated that some fishermen were involved in the use of illegal fishing nets, known locally as 'Bulla Gujja'. The fishermen also shared that that the fishing nets were moored to the trees, often bringing them down (see **Appendix C.1.4.2**).

#### **Economic Importance**

The fish species listed in **Exhibit 5.36** include those of economic importance. The majority of the community at Keti Bandar relies on fishing as its source of livelihood. There are numerous species within the list of marine species sampled at Keti Bandar which are described as high, medium and average in terms of economic importance. Fish like snappers, groupers, grunts, and mackerel species locally known as Hira, Surmai, Dhotar, Gisser and Aall/Sarum are the high economic value fishes caught in Keti Bandar. They are of larger sizes and with good taste, not only consumed in the local market at a high rate but also exported to international markets. Clupids, sardines, and anchovies are considered low value species and generally of small sizes. These species are targeted only for fishmeal production. Even high value commercial species are used in fishmeal if they are caught in small sizes or they are not fit for human consumption due to improper preservation. Based on **Section 6.4.5** of the Socioeconomic Baseline, where value of the fish, shrimp and crab catch from the Study Area is estimated on the basis of the MFD data, provided in **Exhibit 6.30** of **Section 6**, almost all species of commercial importance caught in Keti Bandar are also being caught by the fishing community in the Study Area.

### Conservation Status

Of the 126 marine fish species in the Ketī Bander area 4 are listed as Near Threatened in the IUCN Red List.<sup>198</sup> These include *Albula vulpes*, *Himantura walga*, *Epinephelus diacanthus*, *Epinephelus fuscoguttatus*. There are also some species listed as Least Concern. Of the species observed during sampling in the Study Area (September 2015), none of the species were found to be Threatened, Endangered or Vulnerable. Certain species of sharks, stingrays and guitarfish of conservation importance have been reported from the Indus Delta Ramsar Site (see **Section 5.5.1**). These include *Carcharhinus melanopterus* Blacktip Reef Shark (Near Threatened), *Glyphis gangeticus* Ganges Shark (Critically Endangered) and *Sphyrna lewini* Scalloped Hammerhead (Endangered). Based on geographic range information regarding these species, the probability of them being found in the Study Area is low with the exception of the Scalloped Hammerhead. In addition to this the genera of conservation importance reported from the Indus Delta Ramsar Site include *Dasyatis* sp. a genus of Stingrays, *Pristis* sp. a genus of Sawfish and *Rhinobatos* sp. a genus of Guitarfish. The geographic ranges of some of these species do extend into the Study Area, however, they were not observed during sampling exercises carried out in 2015.

#### 5.5.3 Small Scale Local Fishery

Local fishing community members fish for mud crabs *Scylla serrata* during low tide (**Exhibit 5.44**). The mud crab, burrows in mudflats in close proximity to the mangrove plantation. The locals excavate the soft mud with bare hands or a hooked iron rod is used which is inserted into the mud crab dwelling during the exposed mud flats at low tide. The crabs are caught from their habitats and kept alive in moist gunny bags. The local fishermen, closer to Port Qasim, are also engaged in catching swimming crabs (*Portunus pelagicus* - family Portunidae) and shrimps (the shrimp found in the Study Area are *Parapenaeopsis* spp and *Metapenaeus* spp) (**Exhibit 5.44**) from the area.<sup>199</sup> Both kinds of shrimp were observed during a sampling exercise carried out in June 2015 for the present study. In addition to this, four species of shrimp were observed during the sampling carried out in September 2015. Of these two are *Parapenaeopsis* spp, namely *Parapenaeopsis sculptilis* and *Parapenaeopsis styliifera*. The other two are *Penaeus indicus* and *Penaeus japonicas* (see **Annexure B of Appendix C.2.3**).

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<sup>198</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 March 2015

<sup>199</sup> Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong.

**Exhibit 5.44: Fishing in areas close to Port Qasim**



Fishing activities at Port Qasim Area



Crab *Scylla serrata*



Shrimps *Metapenaeus* spp

Source: Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong.

**5.5.4 Heavy Metal Contamination in Fish, Crab, and Shrimp**

Information on heavy metal contamination in fish, crab and shrimp at Port Qasim was compiled and reviewed from the following sampling exercises:

- ▶ **2008 Survey:** Hagler Bailly Pakistan (HBP), March 2009, Environmental and Social Impact Assessment (ESIA), Marine Ecology Study of Port Qasim, Tethyan Copper Company Pakistan (Pvt.) Ltd.
- ▶ **2014 Survey:** Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong.
- ▶ **2105 Survey:** Sampling conducted as a part of this study.

During the 2008 Survey, reference samples were also taken from Ketī Bandar, a site outside the Port Qasim Area. The levels of heavy metals measured in tissue samples, liver samples were compared to maximum permissible limits from FAO (1983) and US FDA (1993) to determine the safety of consumption of fish caught from the area.

### **2008 Survey**

Samples were collected by HBP in the 2008 in the months of March, May, August, and November. Simultaneously, reference samples were also obtained from Ketī Bandar, a fishing settlement located about 100 km to the southeast of Port Qasim.

Samples of about 10 fish of different species were obtained from fishermen fishing in the area. Tissue and liver specimen from the fish were sent to the laboratory for determining the metal concentration. The fish were identified prior to their shipment or using extra samples obtained simultaneously with the samples for analysis.

In **Exhibit 5.45**, the average concentration of heavy metals in the tissue and liver samples from Port Qasim was compared with the corresponding average of samples from Ketī Bandar. In the case of liver samples, concentrations were within the limits prescribed by FAO<sup>200</sup> and US FDA<sup>201</sup>, with certain exceptions. At Ketī Bandar arsenic (2.33 mg/kg) was above the prescribed limit. At Port Qasim arsenic (2.50 mg/kg) as well as cadmium (2.49 mg/kg) and zinc (134.0 mg/kg) were above the prescribed limits. In the case of fish tissue samples, only the concentrations of the arsenic were above the prescribed limit at both Ketī Bandar and Port Qasim (1.29 mg/kg and 1.50 mg/kg respectively).

Comparisons of the two sites indicates that levels of heavy metals at the Ketī Bandar site were lower in the case of almost all heavy metals, for both liver and tissue samples. This was with the exception of silver in liver samples and mercury in tissue samples. The results indicate that the Ketī Bandar site has comparatively lower heavy metal pollution as compared to the Port Qasim site.

### **2014 Survey**

Fish tissue samples were extracted from the fish picked-up from local fishermen in the Port Qasim area and analyzed for the presence of heavy metals. Analysis of the edible tissues of fish, crab, and shrimp showed that levels of arsenic (0.80-3.55 mg/kg), copper (1.21-41.0 mg/kg) and zinc (11.3-57.2 mg/kg) were above the prescribed limit (considering maximum observed within range).

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<sup>200</sup> Cornelia E. Nauen, Compilation of Legal Limits for Hazardous Substances in Fish and Fishery Products. Fishery Resources and Environment Division. Food and Agriculture Organization of the United Nations, October 1983

<sup>201</sup> Anim A.K., Ahialey E.K., Doudu G.O., Ackah M., Bentil N.O. Accumulation of Heavy Metals in Fish Samples from Nsawam Along the Densu River, Ghana. Research Journal of Environmental and Earth Sciences 3 (1): 56-60, 2011



**Exhibit 5.45:** Concentration of Metal in Fish Samples Collected in 2008 from  
Port Qasim and Ketī Bandar and from the 2014 Survey

All concentrations are in mg/kg

	Antimony	Arsenic	Cadmium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Calcium	Selenium
	Sb	As	Cd	Cu	Pb	Hg	Ni	Ag	Zn	Ca	Se
<b>1. Liver Sample</b>											
<b>Keti Bandar, 2008</b>	<b>0.01</b>	<b>2.33</b>	<b>0.24</b>	<b>8.65</b>	<b>0.26</b>	<b>0.03</b>	<b>0.16</b>	<b>0.16</b>	<b>43.9</b>	-	-
Number of Samples 22 <sup>a</sup>	2	22	20	22	19	5	17	5	22	-	-
<b>Port Qasim, 2008</b>	<b>-</b>	<b>2.50</b>	<b>2.49</b>	<b>20.04</b>	<b>0.49</b>	<b>0.08</b>	<b>0.29</b>	<b>0.09</b>	<b>134.0</b>	-	-
Number of Samples 24	0	23	16	23	23	19	12	3	23	-	-
<b>2. Tissue Sample</b>											
<b>Keti Bandar, 2008</b>	<b>0.00</b>	<b>1.29</b>	-	<b>0.15</b>	<b>0.01</b>	<b>0.03</b>	<b>0.00</b>	-	<b>3.9</b>	-	-
Number of Samples 61	1	49	0	45	8	15	2	0	61	-	-
<b>Port Qasim, 2008</b>	<b>0.01</b>	<b>1.50</b>	-	<b>0.15</b>	<b>0.00</b>	<b>0.02</b>	<b>0.00</b>	-	<b>6.0</b>	-	-
Number of Samples, 56	2	39	0	35	2	13	2	0	55	-	-
<b>Port Qasim, 2014</b>	<b>&lt;0.05</b>	<b>0.80 -3.55</b>	<b>&lt;0.05</b>	<b>1.21 - 41.0</b>	<b>0.09-0.24</b>	<b>&lt;0.05</b>	<b>&lt;0.05</b>	<b>&lt;0.05</b>	<b>11.3– 57.2</b>	<b>1,860 – 10,100</b>	<b>0.1 – 0.76</b>
Maximum Limit	–	1.0	0.05	30	0.5	1.0	80	–	50		
Reference	–	FAO (1983)	FAO (1983)	FAO (1983)	FAO (1983)	FAO (1983)	US FDA (1993)	–	FAO (1983)		

Notes: a) The total number of samples and the number of samples in which the metal was detected and above the LOR; “–” means information is not available.

## 2015 Survey

A total of five tissue samples from fish, crab and shrimp were analyzed for heavy metals. The samples were obtained from fishermen fishing in the area near Sampling Location EC5. The samples were identified for scientific and common names at species level prior to their shipment to ALS Malaysia for analysis. **Exhibit 5.46** shows the results of the analysis. Arsenic was found to be very slightly above the prescribed limit (1.0 mg/kg) in one out of three fish samples (EC5-Fish 3, 1.06 mg/kg) (see **Exhibit 5.35** for location) and above the prescribed limit in crab sample (EC5-Crab, 2.89 mg/kg) (see **Exhibit 5.35** for location). For the rest of the metals including copper, lead, mercury and zinc, the concentration was below the prescribed limits. Detailed laboratory results are provided in **Appendix C.2.2**.

**Exhibit 5.46:** Concentration of Metals in Fish, Crab and Shrimp Tissue Samples from 2015 Survey

*All concentrations are in mg/kg*

Metal	Samples					Standard	
	EC5-Fish 1	EC5-Fish 2	EC5-Fish 3	EC5-Crab	EC5-Shrimp	Maximum Limit	Reference
Arsenic	0.30	0.49	1.06	2.89	0.53	1	FAO (1983)
Copper	0.49	1.03	0.62	15.4	2.52	30	FAO (1983)
Lead	0.13	0.18	0.15	0.24	0.13	0.5	FAO (1983)
Mercury	<0.05	<0.05	0.26	<0.05	<0.05	1	FAO (1983)
Nickel	<0.05	<0.05	0.06	0.2	<0.05	80	US FDA (1993)
Selenium	0.8	0.4	2.6	0.5	0.8	–	–
Zinc	0.9	6.8	8.4	22.8	11.4	50	FAO (1983)

In above table “–” means information is not available

## Summary and Analysis

The high concentration of heavy metals in fish liver and tissue indicated by the sampling and analysis in 2008, 2014 and 2015 is at odds with information presented in **Section 4.7.6** where the concentration of heavy metals in sediments, sampled from the bottom of the creeks, are low. Similarly, the water within the estuary is also relatively uncontaminated, even though there are multiple wastewater and sewage drains with comparatively high concentrations of arsenic, cadmium, copper and zinc that enter the estuary (see **Section 4.6.2**). This aspect is likely due to tidal flushing as well as good lateral and vertical mixing within the estuary, particularly during summer Monsoon i.e. during the time of sampling in 2015, there was good mixing of seawater and contaminated water within the estuary, and sediment (particularly lower grain size fractions) were in flux and suspended (see **Section 4.6.3**). Nonetheless, this indicates that the fish tissue and liver contamination has occurred and there is bioaccumulation of heavy metals in the ecosystem.

## 5.6 Marine Mammals and Reptiles

There is limited published information available on the number of cetaceans that visit the Port Qasim Area. Three cetacean species (Indian Ocean Humpback Dolphin *Sousa plumbea*, Bottle-nosed Dolphin *Tursiops truncatus*, and Finless Porpoise *Neophocaena asiaeorientalis*) have been reported from the Indus Delta.<sup>202,203</sup> Gore et al (2012)<sup>204</sup> reported the sighting of a Dwarf Sperm Whale from the Indus Delta and Ahmed and Rizvi (1985)<sup>205</sup> reported a Humpback Whale caught off Port Qasim on the Sindh coast. Kiani and Waerebeek (2015)<sup>206</sup> have recorded the presence of an important population of the Indian Ocean Humpback Dolphin *Sousa plumbea* in a number of creeks in the Indus Delta creek system including within the Study Area. The sightings have been reported from November 2005 and May 2009. A map of the sightings is given in **Exhibit 5.47**.

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<sup>202</sup> Hasnain, SA. Keti Bunder Village Development Plan. WWF-Pakistan, Karachi. pp30, 2005

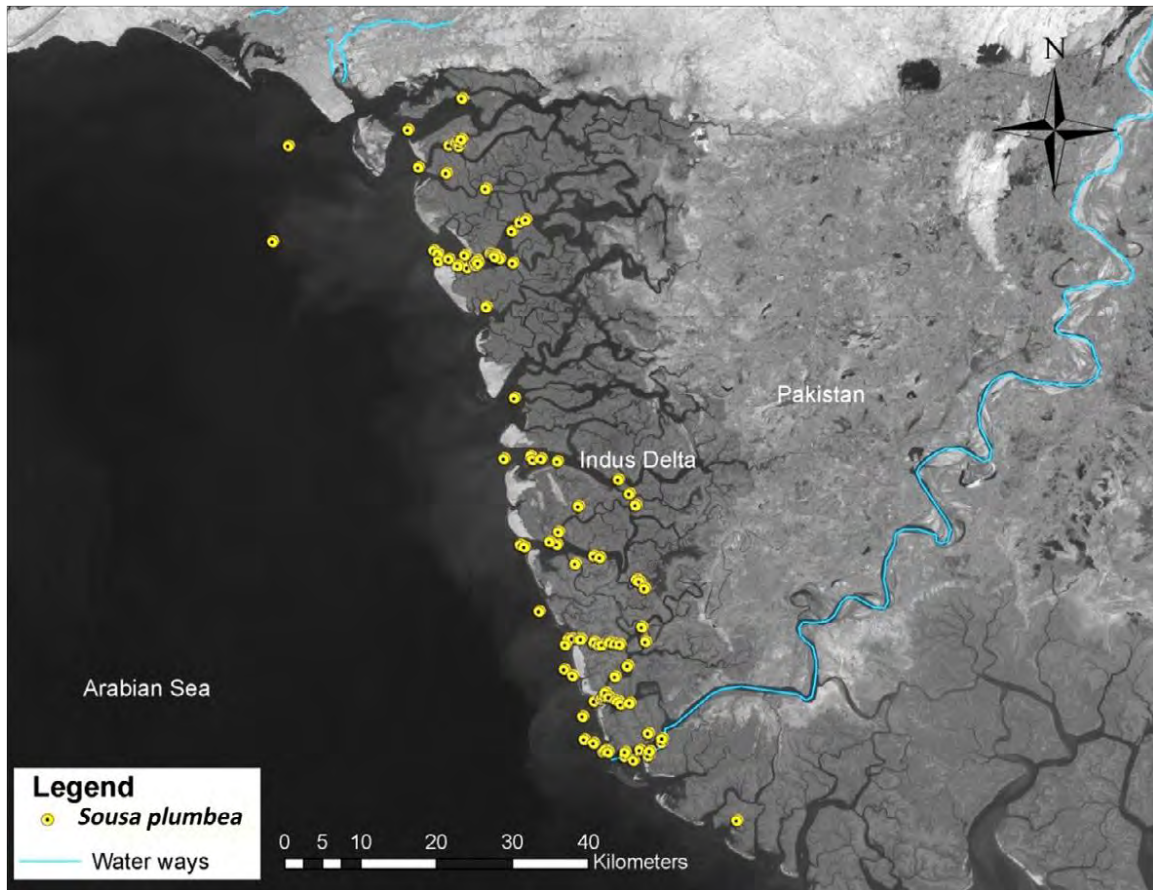
<sup>203</sup> Gore et al, Occurrence of Whales and Dolphins in Pakistan, J. CETACEAN RES. MANAGE. 12(2): 235-247 2012

<sup>204</sup> Ibid

<sup>205</sup> Ahmed, M.F. and Rizvi, S.N.H. Stranding of a humpback whale (Megapteranovaeangliae, Borowski 1781) on the Sind coast. Rec. Zool. Surv. Pak. 10(1, 2): 111–12, 1985

<sup>206</sup> Muhammad Shoaib Kiani and Koen Van Waerebeek, A Review of the Status of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) in Pakistan. Advances in Marine Biology, Vol. 72, pp 201-228, Oxford: Academic Press, 2015,

**Exhibit 5.47:** Sighting Locations of Indian Ocean Humpback Dolphin *Sousa plumbea*



Source: Muhammad Shoaib Kiani and Koen Van Waerebeek, A Review of the Status of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) in Pakistan. *Advances in Marine Biology*, Vol. 72, pp 201-228, Oxford: Academic Press, 2015,

Based on the IUCN Red List of Threatened Species *S. plumbea* has not yet been assessed.<sup>207</sup> It is listed in Appendix I of the CITES Species Appendices.<sup>208</sup> The IUCN Red List of Threatened Species database states that if this species was assessed it would probably qualify as Vulnerable or even Endangered. The chapter published in 2015 describes this as a threatened species.<sup>209</sup> There is a dispute amongst biologists regarding the taxonomic classification of this species and that of the Indo-pacific Hump-backed Dolphin *Sousa chinensis*.<sup>210</sup> According to the IUCN Red List of Threatened Species all Indo-pacific Humpback Dolphins are considered to be part of a single widespread and

<sup>207</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 19 February 2016

<sup>208</sup> UNEP-WCMC Species Database: CITES-Listed Species, Downloaded on 19 February 2016

<sup>209</sup> Muhammad Shoaib Kiani and Koen Van Waerebeek, A Review of the Status of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) in Pakistan. *Advances in Marine Biology*, Vol. 72, pp 201-228, Oxford: Academic Press, 2015,

<sup>210</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 19 February 2016

highly variable species called *Sousa chinensis*. If both *S. chinensis* and *S. plumbea* are considered together, the total population size is probably more than 10,000 mature individuals, therefore, the criterion for Vulnerable is not applicable.<sup>211</sup> Considering only *S. chinensis*, the species is listed as Near Threatened. In considering only the *plumbea*-type the abundance estimate across their range is unlikely to exceed 10,000 individuals.<sup>212</sup> Furthermore, their distribution has been described as discontinuous across most of their range, with the likelihood of discrete local subpopulations. Ongoing environmental degradation and loss of key habitats is likely further fragmenting the aggregate population. Exposure to serious environmental stressors throughout their range makes *plumbea*-type dolphins highly vulnerable, and there are indications of considerable declines in at least some locations.<sup>213</sup> Conservation actions currently are either meager or non-existent throughout the range. It is possible that the decline of *plumbea*-type animals has been large and pervasive enough throughout their range to cause a net reduction of at least 30% over a period of 3 generations.<sup>214</sup>

Research on Indian Ocean Humpback Dolphin *S. plumbea* in Pakistan has been limited.<sup>215</sup> However, studies carried out in other parts of the world have reported that this species is known to consume a variety of nearshore, estuarine and reef fish. Furthermore, they are usually seen in a narrow strip of shallow near-shore waters and in estuarine areas and seldom in waters deeper than 20-30 m. Seasonality of occurrence, movements, group sizes, and reproduction has been reported in several studies. The dolphins appear to be selective in their habitat choice.<sup>216</sup>

WWF-Pakistan reports the presence of Finless Porpoise *Neophocaena asiaeorientalis* in the Indus Delta and likely in the Study Area as well.<sup>217</sup> Information on distribution of this species in the Indus Delta is presently not available.

Among the reptiles, Beaked Sea Snake *Enhydrina schistose*, Annulated Sea Snake, *Hydrophis cyanocinctus*, Yellow Sea Snake *Hydrophis spiralis*, Dwarf Sea Snake *Hydrophis caeruleus*, Small headed Sea Snake *Hydrophis fasciatus* and Pelagic Sea Snake *Pelamis platurus* have been recorded from the mangroves in the Indus Delta.<sup>218</sup> All of these species are listed as least Concern in the IUCN Red List of Threatened Species.

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<sup>211</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 19 February 2016

<sup>212</sup> Ibid.

<sup>213</sup> Ibid.

<sup>214</sup> Ibid.

<sup>215</sup> Muhammad Shoaib Kiani and Koen Van Waerebeek, A Review of the Status of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) in Pakistan. Advances in Marine Biology, Vol. 72, pp 201-228, Oxford: Academic Press, 2015,

<sup>216</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 19 February 2016

<sup>217</sup> Personal communication with Umair Shahid, WWF-Pakistan, Karachi, February 2016.

<sup>218</sup> Ahmad, MF., Ghalib, SA., Niazi, MS., Perveen Z. and Hassan, A. Study of the Vertebrate Fauna of Mangrove Swamps of Sindh Coast. PARC Final Report Zoological Survey Department, Karachi, 1989 (Unpublished Report).



Two turtle species have been reported from the marine waters off the coast of Sindh. Olive Ridley Turtle *Lepidochelys olivacea* is listed as Vulnerable in the IUCN Red List<sup>219</sup> and included in Appendix I of the CITES Species List<sup>220</sup> while the Green Turtle *Chelonia mydas* is listed as Endangered in the IUCN Red List 2014, and included in the Appendix I of the CITES Species List.<sup>221</sup>

Fishermen interviewed in June 2015 during the ecology field surveys conducted for this study reported that they have seen turtles in the Study Area; however the evidence is anecdotal. Although there have been rare sightings of turtles of conservation importance in the Study Area, preliminary investigations show that these turtles do not use the Study Area for breeding or nesting.

### **Conservation Status**

Based on the information above the marine mammal and reptile species of conservation importance are not normally present in the Study Area. The exceptions are the Indian Ocean Humpback Dolphin *S. plumbea* and Finless Porpoise *Neophocaena asiaeorientalis*. The Finless Porpoise is listed in the IUCN Redlist as Vulnerable. The Indian Ocean Humpback Dolphin has been documented in the creeks of the Indus Delta system including the Study Area. Despite the fact that this species has not yet been assessed by the IUCN, the threat status is likely to be Vulnerable. It is prudent to keep conservation of these species in perspective considering the threats they currently face and the declining trend in their population. All species within the genus to which it belongs, Sousa, are listed on Appendix I of the CITES Species Appendices.<sup>222</sup>

## **5.7 Terrestrial Flora and Fauna**

### **5.7.1 Terrestrial Vegetation**

The terrestrial habitat in the Study Area largely consists of barren and dry plain land. Plant species reported from the area include Mesquite *Prosopis juliflora*, Milk Hedge *Euphorbia caducifolia*, Indian Milkweed *Calotropis procera* and Caper Bush *Capparis deciduas* (**Exhibit 5.48**).<sup>223</sup> The most abundant among these, Mesquite *Prosopis juliflora* is an alien invasive species and is harvested by the locals and sold in the local timber market for fire food and construction of local huts. Locals graze their camels on Mesquite *Prosopis juliflora*.

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<sup>219</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 March 2015

<sup>220</sup> UNEP-WCMC Species Database: CITES-Listed Species, Downloaded on 05 March 2015

<sup>221</sup> Ibid

<sup>222</sup> UNEP-WCMC Species Database: CITES-Listed Species, Downloaded on 19 February 2016

<sup>223</sup> Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong

**Exhibit 5.48: Vegetation Species observed in Port Qasim Area**



Xerophytic vegetation



Indian milkweed *Calotropis procera*



Mesquite *Prosopis juliflora*



Harvest of Mesquite *Prosopis juliflora* by locals

Source: Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong

**Conservation Status**

Based on information available in the ESIAs for projects in Port Qasim and literature, no threatened or endemic terrestrial plant species has been reported from the Study Area. In addition, their distribution is not limited to any specific site or habitat type, and is widespread.

**5.7.2 Terrestrial Mammals**

Some large mammals reported from the Port Qasim Area include the Asiatic Jackal *Canis aureus* and Fox *Vulpes vulpes*. Both animals are included in Appendix III of the CITES Species List<sup>224</sup> and listed as Near Threatened in Pakistan Mammals National Red List 2006.<sup>225</sup> However, both these species are listed as Least Concern in the IUCN Red List.<sup>226</sup>

<sup>224</sup> UNEP-WCMC. UNEP-WCMC Species Database: CITES-Listed Species, 02 March 2015

<sup>225</sup> Status and Red List of Pakistan Mammals. Biodiversity Programme IUCN Pakistan, 2006

<sup>226</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 March 2015

Locals report occasional sightings of wolf, hyena and wild boars. Small mammals such as rodents, hares, squirrels have also been reported from the area.<sup>227</sup>

### Conservation Status

Based on information available in previous ESIA's and literature, none of the mammals reported from Study Area are threatened or included in IUCN Red List.<sup>228</sup> Even though some mammals are included in the Pakistan's Mammals National Red List <sup>229</sup> and CITES Species List<sup>230</sup>, none of the mammal species is endemic, their distribution is not limited to any specific site or habitat type, and their distribution is widespread.

### 5.7.3 Avifauna

Birds reported from the Indus River Delta include Kentish Plover *Charadrius alexandrinus*, Terek Sandpiper *Tringa terek*, Common Sandpiper *Tringa hypoleucos*, Grey Heron *Ardea cinerea*, Bartailed Godwit *Limosa lapponica*, Little Stint *Calidris minutus*, Dunlin *Calidris alpina*, Herring Gull *Larus argentatus*, Slenderbilled Gull *Larus genei*, Blackheaded Gull *Larus ridibundus*, Caspian Tern *Hydroprogne caspia*, Sandwich Tern *Sterna sandvicensis*, Brahminy Kite *Haliastur indus*, Common Kite *Milvus migrans*, Cinereous Vulture *Aegypius monachus*, Common Crow *Corvus splendens*.<sup>231</sup>

Both water and land birds have been reported from the PQA. Most of these birds are omnivores while others scavenge on marine crabs and dead fish. During a survey carried out in March 2014<sup>232</sup> for the EIA of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, common bird species observed included Little Cormorant *Phalacrocorax niger*, Grey Heron *Ardea cinerea*, Indian Pond Heron *Ardeola grayii*, Great Egret *Casmerodius albus*, Little Egret *Egretta garzetta*, Common Myna *Acridotheres tristis*, Indian Robin *Saxicoloides fulicatus*, House Sparrow *Passer domesticus* and House Crow *Corvus splendens*.

Certain species of birds which are globally threatened do have ranges which overlap with the Study Area.<sup>233</sup> However, these bird species have not been reported within the Study Area. This could be because they are rare, declining or close to extirpation.<sup>234</sup> They include the Saker Falcon *Falco cherrug* (Endangered), the White Rumped Vulture *Gyps*

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<sup>227</sup> Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong

<sup>228</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 March 2015

<sup>229</sup> Status and Red List of Pakistan Mammals. Biodiversity Programme IUCN Pakistan, 2006

<sup>230</sup> UNEP-WCMC. UNEP-WCMC Species Database: CITES-Listed Species, 02 March 2015

<sup>231</sup> World Wildlife Fund Pakistan. Detailed Ecological Assessment of Fauna Including Limnology Studies at Ketu Bunder. Indus for All Program, WWF Pakistan, 2008

<sup>232</sup> Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong.

<sup>233</sup> Richard Grimmett, Tom Roberts and Tim Inskipp. "Birds of Pakistan", Helms Field Guides, Yale University Press, 2008

<sup>234</sup> Ibid

*bengalensis* (Critically Endangered), the Red Headed Vulture *Sarcogyps calvus* (Critically Endangered) and the Lesser Florican *Sypheotides indica* (Endangered).<sup>235</sup>

### Results of 2008 Bird Survey

**Exhibit 5.49** provides a list of the bird species found in the Port Qasim area based on a survey of bird species in the area conducted in 2008.<sup>236</sup> **Exhibit 5.49** shows the bird species along with their IUCN status<sup>237</sup> and counts for the months of March, June and August.

**Exhibit 5.49: Bird Survey in the Port Qasim Area - 2008<sup>237</sup>**

Common Name	Scientific Name	IUCN Status <sup>a</sup>	Restricted Range Information	March Count	June Count	August Count
Black Headed Bunting	<i>Emberiza melanocephala</i>	LC		12	0	0
Black Kite	<i>Milvus migrans migrans</i>	LC		57	21	22
Black Tailed Godwit	<i>Limosa limosa</i>	NT		59	0	0
Black Winged Stilt	<i>Himantopus himantopus</i>	LC		0	17	0
Black-bellied Plover	<i>Pluvialis squatarola</i>	LC		0	0	3
Black-headed Gull	<i>Larus ridibundus</i>	LC		28	31	33
Blue Rock Pigeon	<i>Columba livia</i>	LC		14	44	213
Blyth's Reed Warbler	<i>Acrocephalus dumetorum</i>	LC		6	8	10
Brahminy Kite	<i>Haliastur indus</i>	LC		22	14	12
Caspian Tern	<i>Sterna caspia</i>	LC		3	0	7
Cattle Egret	<i>Bulbulcus ibis</i>	LC		0	38	0
Common Heron	<i>Ardea cinerea</i>	LC		0	8	2
Common Sandpiper	<i>Actitis hypoleucos</i>	LC		0	0	2
Common Swallow	<i>Hirundo rustica</i>	LC		0	0	6
Common Tern	<i>Sterna hirundo hirundo</i>	LC		0	7	49
Curlew Sandpiper	<i>Calidris ferruginea</i>	LC		0	0	36
Dunlin	<i>Calidris alpina</i>	LC		23	0	0
Eurasian Curlew	<i>Numenius arquata</i>	NT		28	0	21
Great Cormorant	<i>Phalacrocorax carbo</i>	LC		3	0	0
Greater Black-headed Gull	<i>Larus ichthyaetus</i>	LC		0	0	9
Greater Flamingo	<i>Phoenicopterus roseus</i>	LC		0	175	0
Gull-billed Tern	<i>Gelochelidon nilotica</i>	LC		28	15	7
Herring Gull	<i>Larus argentatus</i>	LC		44	0	21

<sup>235</sup> Richard Grimmett, Tom Roberts and Tim Inskipp. "Birds of Pakistan", Helms Field Guides, Yale University Press, 2008

<sup>236</sup> Hagler Bailly Pakistan (HBP), March 2009, Environmental and Social Impact Assessment (ESIA), Marine Ecology Study of Port Qasim, Tethyan Copper Company Pakistan (Pvt.) Ltd.

<sup>237</sup> Ibid

Common Name	Scientific Name	IUCN Status <sup>a</sup>	Restricted Range Information	March Count	June Count	August Count
Indian Cormorant	<i>Phanacrocorax fuscicollis</i>	LC		3	0	0
Indian House Crow	<i>Corvus splendens</i>	LC		145	102	179
Indian House Sparrow	<i>Passer domesticus indicus</i>	LC		0	6	74
Indian Myna	<i>Acridotheres tristis</i>	LC		0	8	40
Indian Pond Heron	<i>Ardeola grayii</i>	LC		18	49	12
Indian reef Heron	<i>Egretta gularis</i>	LC		16	20	13
Large Egret	<i>Egretta alba</i>	LC		3	0	0
Large Sand Plover	<i>Charadrius leschenaultii</i>	LC		0	0	16
Lesser Sand Plover	<i>Charadrius mongolus</i>	LC		20	81	171
Little Brown Dove	<i>Streptopelia senegalensis</i>	LC		0	13	9
Little Cormorant	<i>Phanacrocorax niger</i>	LC		20	2	5
Little Egret	<i>Egretta garzetta</i>	LC		27	17	3
Little Green Bee-eater	<i>Merops orientalis</i>	LC		0	22	0
Little green Heron	<i>Butorides striatus</i>	LC		0	4	6
Laughing Dove	<i>Streptopelia senegalensis</i>	LC		0	13	9
Little Ringed Plover	<i>Charadrius dubius</i>	LC		0	2	2
Little Stint	<i>Calidris minuta</i>	LC		806	29	287
Little Tern	<i>Sterna albifrons</i>	LC		9	56	16
Osprey	<i>Pandion haliaetus</i>	LC		2	0	0
Painted Stork	<i>Mycteria leucocephala</i>	NT	In Pakistan it is mainly confined to the Indus Delta although it does occur in other countries	0	2	0
Purple Sunbird	<i>Nectarinia asiatica</i>	LC		0	4	0
Redshank	<i>Tringa totanus</i>	LC		17	0	25
Red-wattled Lapwing	<i>Hoplopterus indicus</i>	LC		0	8	2
Sandwich Tern	<i>Sterna sandvicensis</i>	LC		0	9	3
Slender-billed Gull	<i>Larus genei</i>	LC		22	6	7
Snowy Plover	<i>Charadrius alexandrinus</i>	LC		0	7	0
Tailor Bird	<i>Orthotomus sutorius</i>	LC		0	7	0
Temminck's Stint	<i>Clidris temminckii</i>	LC		215	0	0
Whimbrel	<i>Numenius phaeopus</i>	LC		0	0	108
Whiskered Tern	<i>Chlidonias hybridus</i>	LC		98	229	158



Common Name	Scientific Name	IUCN Status <sup>a</sup>	Restricted Range Information	March Count	June Count	August Count
White Cheeked Tern	<i>Sterna repressa</i>	LC		0	0	0
White wagtail	<i>Motacilla alba</i>	LC		2	0	0
Yellow-wattled Lapwing	<i>Hoplopterus malabaricus</i>	LC		0	0	2
<b>Total</b>				<b>1,750</b>	<b>1,074</b>	<b>1,600</b>

a. LC: Least Concern; NT: Near Threatened

Source: Hagler Bailly Pakistan (HBP), March 2009, Environmental and Social Impact Assessment (ESIA), Marine Ecology Study of Port Qasim, Tethyan Copper Company Pakistan (Pvt.) Ltd.

**Exhibit 5.50** shows a flock of Greater Flamingos *Phoenicopterus roseus* in flight, photographed within the Study Area during the survey conducted in 2008.

**Exhibit 5.50:** Flock of Greater Flamingos *Phoenicopterus roseus* in flight



Source: Hagler Bailly Pakistan (HBP), March 2009, Environmental and Social Impact Assessment (ESIA), Marine Ecology Study of Port Qasim, Tethyan Copper Company Pakistan (Pvt.) Ltd.

### **Resident Birds of Indus Delta**

The mangroves of the Indus Delta provide abundant food and shelter to a number of species of birds. The common birds are Oystercatcher *Haematopus ostralegus*, Lesser Sand Plover *Charadrius mongolus*, Greater Sand Plover *Charadrius leschenaultii*, Grey Plover *Pluvialis squatarola*, Golden Plover *Pluvialis apricaria*, Little Ringed Plover *Charadrius dubius*, Kentish Plover *Charadrius alexandrinus*, Sanderling *Calidris alba*, Dunlin *Calidris alpina*, Curlew *Numenius arquata*, Whimbrel *Numenius phaeopus*, Marsh Sandpiper *Tringa stagnatilis* and Common Sandpiper *Actitis hypoleucos*.

Breeding activities of a number of birds have been reported in the coastal wetlands of the Delta particularly Little Tern *Sterna albifrons*, Common Tern *Sterna hirundo*, Gullbilled Tern *Gelochelidon nilotica*, Yellow legged Gull *Larus michahellis*, Lesser Black backed Gull *Larus fuscus* and Great Black headed Gull *Ichthyaelus ichthyaelus*.

### **Migratory Birds of Indus Delta**

Pakistan is host to a large number of guest birds from Europe, Central Asian States and India every year. These birds originally reside in the northern states and spend winters in various wetlands and deserts of Pakistan from the high Himalayas to coastal mangroves and mud flats in the Indus delta. After the winter season, they go back to their native habitats.

This famous route from Siberia to various destinations in Pakistan over Karakorum, Hindu Kush, and Suleiman Ranges along Indus River down to the delta is known as International Migratory Bird Route Number 4. It is also known as the Green Route or, more commonly, as the Indus Flyway and is one of the important migratory routes in the Central Asian - Indian Flyway<sup>238</sup> (**Exhibit 5.51**). The birds start on this route in November. February is the peak time and by March they start flying back home. These periods may vary depending upon weather conditions in Siberia and/or Pakistan. As per an estimate based on regular counts at different Pakistani wetlands, between 700,000 and 1,200,000 birds arrive in Pakistan through Indus Flyway every year.<sup>239</sup> Some of these birds stay in the lakes but majority migrate to coastal areas.

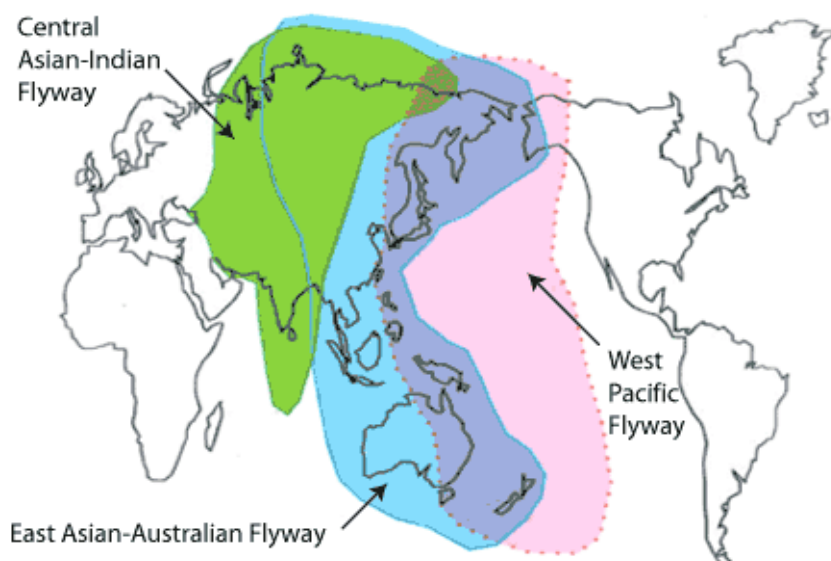
The common migratory waterfowl of the lakes in the Indus Delta include a variety of ducks including Dunlin *Calidris alpina*, Redshank *Tringa totanus*, Coot *Fulica atra*, White Pelicans *Pelecanus onocrotalus*, Flamingoes *Phoenicopterus minor*, The greater flamingo *Phoenicopterus roseus* and Spoonbills *Platalea leucorodia*. The Indus Delta also provides refuge for the rare species of birds such as Painted Stork *Mycteria leucocephala*, White Stork *Ciconia ciconia*, Greater Knot *Calidris tenuirostris*, Crane *Grus grus*, Ruddy Shelduck (Surkhab) *Tadorna ferruginea*, Greyleg Geese *Anser anser*, Common Shelduck *Tadorna tadorna*, The Dalmatian pelican *Pelecanus crispus* and Marbled Teal *Marmaronetta angustirostris*.

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<sup>238</sup> Convention on the Conservation of Migratory Species. 1 February 2006. Central Asian Flyway Action Plan for the Conservation of Migratory Waterbirds and their Habitats. New Delhi, 10-12 June 2005: UNEP/CMS Secretariat.

<sup>239</sup> Pakistan Wetlands Programme. Migratory Birds Census Report, 2012

**Exhibit 5.51: Asian Migratory Bird Flyways**



**Source:** U.S. Fish and Wildlife Service 2008. Available at: [http://alaska.fws.gov/media/avian\\_influenza/ak-flyway2.gif](http://alaska.fws.gov/media/avian_influenza/ak-flyway2.gif) U.S. Fish and Wildlife Service/Alaska

### **Congregatory Birds of Indus Delta**

Congregatory behavior is a feature of many bird families and often occurs at particular stages of the life-cycle. Congregation is particularly common in waterbirds. Although less common in landbirds, congregatory behavior occurs across a wide taxonomic range. Millions of birds may congregate at a single site, moving on to another when local conditions change.<sup>240</sup> Conservation of each of these sites is vital for the species' continued survival. Some migratory waterbirds are heavily reliant on a small number of suitable stopover sites, at which most of the population may congregate over a short time period to refuel and rest while on migration. Congregation has advantages such as providing safety from natural predators, but it can also increase vulnerability to site-related threats. Destruction or degradation of key sites can have serious impacts on congregatory birds at the population level.<sup>241</sup>

Congregatory behavior is observed for certain bird species found in the Indus Delta. Some of these congregatory species are migratory as well, whilst others are not. A list of bird species reported from the designated Ramsar Site in the Indus Delta<sup>242</sup> (adjacent to the Study Area) along with bird species observed during the survey in 2008 is given in **Exhibit 5.52**. Information on migratory and congregatory behavior is available for 65 of these bird species from the IUCN Redlist database and is given in **Exhibit 5.52**. There are 65 bird species that show congregatory behavior (30 species in the 2008 survey list

<sup>240</sup> Bird Life International, Congregation at particular sites is a common behaviour in many bird species < <http://www.birdlife.org/datazone/sowb/casestudy/58>> accessed 22nd November 2015

<sup>241</sup> Ibid

<sup>242</sup> Hussain Bux Bhaagat, Sindh Wildlife Department, Information Sheet on Ramsar Wetlands (RIS), 30th September, 2002

and 55 species in the Ramsar Site List) out of which most (62) show both migratory and congregatory behavior.

**Exhibit 5.52: List of Species Reported from the Indus Delta with Identification of Species showing Migratory and Congregatory Behavior**

'Y' is Confirmation of Status/Presence, 'N' is Negation of Status, 'No entry' is lack of information/absence from list

No	Common Name	Scientific Name	IUCN Status <sup>a</sup>	Migratory <sup>243</sup>	Congregatory <sup>244</sup>	2008 Survey List	Ramsar Site List
1.	Shikra	<i>Accipiter badius</i>	LC				Y
2.	Eurasian Sparrowhawk	<i>Accipiter nisus</i>	LC	Y	Y		Y
3.	Bank Myna	<i>Acridotheres ginginianus</i>	LC				Y
4.	Common Myna	<i>Acridotheres tristis</i>	LC			Y	
5.	Blyth's Reed-warbler	<i>Acrocephalus dumetorum</i>	LC			Y	
6.	Common Sandpiper	<i>Actitis hypoleucos</i>	LC	Y	Y	Y	Y
7.	Hoopoe Lark	<i>Alaemon alavdipus</i>	N/A				Y
8.	Common King Fisher	<i>Alcedo atthis</i>	LC				Y
9.	White Brested Waterhen	<i>Amaurornis phoenicurus</i>	LC				Y
10.	Northern Pintail	<i>Anas acuta</i>	LC	Y	Y		Y
11.	Northern Shoveler	<i>Anas clypeata</i>	LC	Y	Y		Y
12.	Common Teal	<i>Anas crecca</i>	LC	Y	Y		Y
13.	Eurasian Wigeon	<i>Anas penelope</i>	LC	Y	Y		Y
14.	Garganey	<i>Anas querquedula</i>	LC	Y	Y		Y
15.	Gadwall	<i>Anas strepera</i>	LC	Y	Y		Y
16.	Little swift	<i>Apus affinis</i>	LC				Y
17.	Tawny Eagle	<i>Aquila rapax</i>	LC	N	Y		Y
18.	Grey Heron	<i>Ardea cinerea</i>	LC	Y	Y	Y	Y
19.	Purple Heron	<i>Ardea purpurea</i>	LC	Y	Y		Y
20.	Indian Pond-heron	<i>Ardeola grayii</i>	LC			Y	
21.	Common Poachard	<i>Aythya ferina</i>	VU	Y	Y		Y
22.	Cattle Egret	<i>Bubulcus ibis</i>	LC	Y	Y	Y	
23.	White-eyed Buzzard	<i>Butastur teesa</i>	LC				Y

<sup>243</sup> Information taken from IUCN Redlist database <<http://www.iucnredlist.org/>> accessed 23rd November 2015

<sup>244</sup> Ibid

No	Common Name	Scientific Name	IUCN Status <sup>a</sup>	Migratory <sup>243</sup>	Congregatory <sup>244</sup>	2008 Survey List	Ramsar Site List
24.	Striated heron	<i>Butorides striatus</i>	N/A			Y	
25.	Indian Short-toed Lark	<i>Calandrella raytal</i>	LC				Y
26.	Dunlin	<i>Calidris alpina</i>	LC	Y	Y	Y	Y
27.	Curlew Sandpiper	<i>Calidris ferruginea</i>	NT	Y	Y	Y	
28.	Little Stint	<i>Calidris minuta</i>	LC	Y	Y	Y	Y
29.	Temminck's Stint	<i>Calidris temminckii</i>	LC	Y	Y	Y	
30.	Pied Kingfisher	<i>Ceryle rudis</i>	LC				Y
31.	Kentish Plover	<i>Charadrius alexandrinus</i>	LC	Y	Y	Y	Y
32.	Little Ringed Plover	<i>Charadrius dubius</i>	LC	Y	Y	Y	Y
33.	Common Ringed Plover	<i>Charadrius hiaticula</i>	LC	Y	Y		Y
34.	Greater Sandplover	<i>Charadrius leschenaultii</i>	LC	Y	Y	Y	Y
35.	Lesser Sandplover	<i>Charadrius mongolus</i>	LC	Y	Y	Y	
36.	Whiskered Tern	<i>Chlidonias hybridus</i>	LC	Y	Y	Y	
37.	Short-toed Snake-eagle	<i>Circaetus gallicus</i>	LC	Y	Y		Y
38.	Western Marsh-harrier	<i>Circus aeruginosus</i>	LC	Y	Y		Y
39.	Indian Roller	<i>Coracias benghalensis</i>	LC				Y
40.	House Crow	<i>Corvus splendens</i>	LC			Y	
41.	Rufous Treepie	<i>Dendrocitta vagabunda</i>	LC				Y
42.	Black Drongo	<i>Dicrurus macrocercus</i>	LC				Y
43.	Great White Egret	<i>Egretta alba</i>	LC	Y	Y	Y	Y
44.	Little Egret	<i>Egretta garzetta</i>	LC	Y	Y	Y	Y
45.	Western Reef-egret	<i>Egretta gularis</i>	LC	N	Y	Y	Y
46.	Intermediate Egret	<i>Egretta intermedia</i>					Y
47.	Black-headed Bunting	<i>Emberiza melanocephala</i>	LC			Y	
48.	Western Koel	<i>Eudynamis scolopacea</i>	LC				Y
49.	Peregrine Falcon	<i>Falco peregrinus</i>	LC	Y	Y		Y



No	Common Name	Scientific Name	IUCN Status <sup>a</sup>	Migratory <sup>243</sup>	Congregatory <sup>244</sup>	2008 Survey List	Ramsar Site List
50.	Common Coot	<i>Fulica atra</i>	LC	Y	Y		Y
51.	Crested Lark	<i>Galerida cristata</i>	LC				Y
52.	Common Snipe	<i>Gallinago gallinago</i>	LC				Y
53.	Common Moorhen	<i>Gallinula chloropus</i>	LC	Y	Y		Y
54.	Common Gull-billed Tern	<i>Gelochelidon nilotica</i>	LC	Y	Y	Y	
55.	Eurasian Oystercatcher	<i>Haematopus ostralegus</i>	NT	Y	Y		Y
56.	White-breasted Kingfisher	<i>Halcyon smyrnensis</i>	LC				Y
57.	White-tailed Sea-eagle	<i>Haliaeetus albicilla</i>	LC	Y	Y		Y
58.	Pallas Fishing Eagle	<i>Haliaeetus leucorhynchus</i>	N/A				Y
59.	Brahminy Kite	<i>Haliastur indus</i>	LC			Y	
60.	Stilt Sandpiper	<i>Himantopus himantopus</i>	LC			Y	Y
61.	Barn Swallow	<i>Hirundo rustica</i>	LC			Y	
62.	Red-wattled Lapwing	<i>Hoplopterus indicus</i>	LC			Y	
63.	Yellow-wattled Lapwing	<i>Hoplopterus malabaricus</i>	LC			Y	
64.	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	LC				Y
65.	Great Grey Shrike	<i>Lanius excubitor</i>	LC				Y
66.	European Herring Gull	<i>Larus argentatus</i>	LC	Y	Y	Y	
67.	Slender-billed Gull	<i>Larus genei</i>	LC	Y	Y	Y	Y
68.	Sooty Gull	<i>Larus hemprichii</i>	LC	Y	Y		Y
69.	Pallas's Gull	<i>Larus ichthyaetus</i>	LC	Y	Y	Y	Y
70.	Black-headed Gull	<i>Larus ridibundus</i>	LC	Y	Y	Y	Y
71.	Black-tailed Godwit	<i>Limosa limosa</i>	NT	Y	Y	Y	
72.	Asian Green Bee-eater	<i>Merops orientalis</i>	LC			Y	Y
73.	Black Kite	<i>Milvus migrans</i>	LC	Y	Y	Y	Y
74.	White Wagtail	<i>Motacilla alba</i>	LC			Y	
75.	Painted Stork	<i>Mycteria leucocephala</i>	NT	N	Y	Y	
76.	Purple Sunbird	<i>Nectarinia asiatica</i>	LC			Y	

No	Common Name	Scientific Name	IUCN Status <sup>a</sup>	Migratory <sup>243</sup>	Congregatory <sup>244</sup>	2008 Survey List	Ramsar Site List
77.	Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>	LC				Y
78.	Eurasian Curlew	<i>Numenius arquata</i>	NT	Y	Y	Y	Y
79.	Whimbrel	<i>Numenius phaeopus</i>	LC	Y	Y	Y	
80.	Common Tailorbird	<i>Orthotomus sutorius</i>	LC			Y	
81.	Great white Pelican	<i>Pelecanus onocrotalus</i>	LC	Y	Y		Y
82.	Osprey	<i>Pandion haliaetus</i>	LC	Y	Y	Y	Y
83.	House Sparrow	<i>Passer domesticus</i>	LC			Y	Y
84.	Dalmatian Pelican	<i>Pelecanus crispus</i>	VU	Y	Y		Y
85.	Great Cormorant	<i>Phalacrocorax carbo</i>	LC	Y	Y	Y	Y
86.	Little Cormorant	<i>Phalacrocorax niger</i>	LC			Y	Y
87.	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	LC			Y	
88.	Ruff	<i>Philomachus pugnax</i>	LC	Y	Y		Y
89.	Lesser Flamingo	<i>Phoeniconaias minor</i>	NT		Y		Y
90.	Greater Flamingo	<i>Phoenicopterus roseus</i>	LC	Y	Y		Y
91.	American Flamingo	<i>Phoenicopterus ruber</i>	LC				Y
92.	Grey Plover	<i>Pluvialis squatarola</i>	LC	Y	Y		Y
93.	Rose-ringed Parakeet	<i>Psittacula krameri</i>	LC				Y
94.	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	LC				Y
95.	Pied Avocet	<i>Recurvirostra avosetta</i>	LC	Y	Y		Y
96.	Indian Robin	<i>Saxicoloides fulicatus</i>	LC				Y
97.	Little Tern	<i>Sterna albifrons</i>	LC	Y	Y		Y
98.	Swift Tern	<i>Sterna bergii</i>	LC	Y	Y		Y
99.	Caspian Tern	<i>Sterna caspia</i>	LC	Y	Y	Y	Y
100.	Common Tern	<i>Sterna hirundo</i>	LC	Y	Y	Y	Y
101.	White-cheeked Tern	<i>Sterna repressa</i>	LC	Y	Y		Y

No	Common Name	Scientific Name	IUCN Status <sup>a</sup>	Migratory <sup>243</sup>	Congregatory <sup>244</sup>	2008 Survey List	Ramsar Site List
102.	Sandwich Tern	<i>Sterna sandvicensis</i>	LC	Y	Y	Y	Y
103.	Eurasian Collared-dove	<i>Streptopelia decaocto</i>	LC				Y
104.	Laughing Dove	<i>Streptopelia senegalensis</i>	LC			Y	Y
105.	Little Grebe	<i>Tachybaptus ruficollis</i>	LC	Y	Y		Y
106.	Ruddy Shelduck	<i>Tadorna ferruginea</i>	LC	Y	Y		Y
107.	Common Shelduck	<i>Tadorna tadorna</i>	LC	Y	Y		Y
108.	Green Sandpiper	<i>Tringa ochropus</i>	LC	Y	Y		Y
109.	Common Redshank	<i>Tringa totanus</i>	LC	Y	Y	Y	Y
110.	Common Babbler	<i>Turdoides caudatus</i>	LC				Y
	Northern Lapwing	<i>Vanellus vanellus</i>	NT	Y	Y		Y
111.	Terek Sandpiper	<i>Xenus cinereus</i>	LC	Y	Y		Y

a. LC: Least Concern; NT: Near Threatened; VU: Vulnerable

### Conservation Status

Out of the list of bird species in **Exhibit 5.52** two species are listed as Vulnerable on the IUCN Red List of Threatened Species. These include Common Poachard *Aythya ferina* and the Dalmatian Pelican *Pelecanus crispus*, both of which shows migratory as well as congregatory behavior. In addition to this there are seven species which are listed as Near Threatened on the IUCN Redlist of Threatened Species including Curlew Sandpiper *Calidris ferruginea*, Eurasian Oystercatcher *Haematopus ostralegus*, Black-tailed Godwit *Limosa limosa*, Painted Stork *Mycteria leucocephala*, Eurasian Curlew *Numenius arquata*, Lesser Flamingo *Phoeniconaias minor* and Northern Lapwing *Vanellus vanellus*. All seven of these species are congregatory and five are both migratory and congregatory. The Lesser Flamingo *Phoenicopterus minor* is also included in CITES Appendix II. Taking into consideration the conservation importance of sites used by congregatory bird species, as highlighted above, it is necessary to recognize the Indus Delta and the Study Area as important for significant numbers of congregatory birds. Amongst the rare birds known to winter in the area, Cinereous Vulture *Aegypius monachus* is listed as Near Threatened while the Greater Knot *Calidris tenuirostris* and Marbled Teal *Marmaronetta angustirostris* are listed as Vulnerable in the IUCN Redlist of Threatened Species.<sup>245</sup>

Of the birds reported from the Korangi Phitti Creek System, three are included in the IUCN Red List<sup>246</sup> and listed as Near Threatened. These are Painted Stork *Mycteria*

<sup>245</sup> The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 29 May 2015

<sup>246</sup> Ibid

*leucocephala*, Black Tailed Godwit *Limosa limosa*, and Eurasian Curlew *Numenius arquata*. The results of the bird survey of the Port Qasim Area conducted in 2008 (results shown in **Exhibit 5.49**) identified these three species in the area and these three are the only ones in **Exhibit 5.49** listed as Near Threatened in the IUCN Red List. No bird species given in **Exhibit 5.49** has a restricted range based on the IUCN database.<sup>247</sup> However, the distribution of these birds of conservation importance is not limited to any specific site or habitat type, and their distribution is widespread.

#### 5.7.4 Terrestrial Reptiles

Commonly observed terrestrial reptiles include the Short-toed Sand Swimmer *Ophiomorus brevipes* and Sindh Gecko *Crossobamon orientalis*.<sup>248</sup> Reptiles are usually associated with terrestrial vegetation. A low abundance and diversity of reptiles species has been reported from the Study Area<sup>249</sup> which could be attributed to degradation in vegetation.

#### Conservation Status

Based on information available in previous ESIA's and secondary literature, none of the reptiles reported from the Study Area and vicinity are range restricted or included in the IUCN Red List.<sup>250</sup>

### 5.8 Determination of Critical Habitat

The area is considered Critical Habitat according to the International Finance Corporation<sup>251</sup> (IFC) Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources and secondarily the Asian Development Safeguard Policies.<sup>252</sup>

- i. Critical Habitats are areas with high biodiversity value, including Habitat of significant importance to Critically Endangered and/or Endangered species;
- ii. Habitat of significant importance to endemic and/or restricted-range species;
- iii. Habitat supporting globally significant concentrations of migratory species and/or congregatory species;
- iv. Highly threatened and/or unique ecosystems; and/or
- v. Areas associated with key evolutionary processes.

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<sup>247</sup> *Mycteria leucocephala* has a range restriction only in Pakistan where it is mainly confined to the Indus Delta. However, it is found in other countries.

<sup>248</sup> Hagler Bailly Pakistan (HBP), March 2014, Environmental Impact Assessment of SinoHydro's 2×660 MW Coal Power Plant, Bin Qasim, Karachi, SinoHydro Holding Ltd. HongKong

<sup>249</sup> Ibid

<sup>250</sup> The IUCN Red List of Threatened Species. Version 2014.3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 02 March 2015

<sup>251</sup> Biodiversity Conservation and Sustainable Management of Living Natural Resources, Performance Standard 6, International Finance Corporation, 2012

<sup>252</sup> Environmental Safeguards, A Good Practice Sourcebook Draft Working Document, Asian Development Bank, 2012

The mangrove habitat is considered Critical Habitat according to criteria (iii) and (iv) The reasons for the application of these criteria are as follows:

- i. Significant concentrations of migratory and congregatory bird species are found in the adjacent Indus Delta Ramsar Site. At least 65 species identified as migratory and/or congregatory including those with Vulnerable and Near Threatened Status on the IUCN Red List of Threatened Species have been observed in the Study Area as well (see **Section 5.7.3**). Considering the quality of bird habitat which is comparatively better than that in the adjacent Ramsar Site (**Section 5.2.3**), the Study Area is a continuum and can be considered as an integral part of the bird habitat in the adjacent Ramsar Site. IFC criteria<sup>253</sup> defines globally significant concentration as more than or equal to 1% but less than 95% of the global population of the species. While the population of congregatory bird species in the Study Area itself is likely to be less than 1% of the global population of the identified congregatory bird species, the combined population of the congregatory bird species in the Study Area and the Indus Delta Ramsar Site meets the criteria.
- ii. This is a unique ecosystem based on its description by the WWF<sup>254</sup> (see **Section 5.1**) and is highly threatened.

There are certain species of sharks, stingrays and guitarfish reported from the Indus Delta Ramsar Site, adjacent to the Study Area, which appear on the IUCN Red List of Threatened Species and may be present in the Study Area (see **Section 5.5.1**). However these were not observed during the sampling carried out in 2015.

In addition to this, the application of the Asian Development Bank's (ADB) criteria for identification of a Critical Habitat indicates the following: <sup>255</sup>

“A subset of both natural and modified habitat that deserves particular attention. Critical habitat includes areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities.”

The mangrove habitat falls in the category of areas having biodiversity of significant social, economic, or cultural importance to local communities. This is based on the local community's dependence on the habitat for their livelihoods (see **Section 5.3.1**). Also mangrove habitat is identified as a key fishing location for the local communities (Fishing Communities). Approximately 51% of the commercial fish catch of the Study

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<sup>253</sup> Biodiversity Conservation and Sustainable Management of Living Natural Resources, Criterion 3, Guidance Note 6, International Finance Corporation, 1 January 2012

<sup>254</sup> Official website for World Wide Fund for Nature.: <https://www.worldwildlife.org/biomes>, accessed in June 2015

<sup>255</sup> Environmental Safeguards, A Good Practice Sourcebook Draft Working Document, Asian Development Bank, 2012

Area comes from the mangroves of the PQA area (see **Exhibit 6.32**, **Exhibit 6.33** and **Section D.5.2** of **Appendix D**).

Inland, the Northwestern Thorn Scrub Forests eco-region represents a large expanse of degraded dry forest neither exceptionally species-rich nor high in endemism.



## 6. Socioeconomic Baseline

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### 6.1 Introduction

This socioeconomic baseline provides an overview of the socioeconomic conditions of the communities residing in the Study Area, focusing on:

- ▶ perceptions of communities on ecosystem services and to any changes that may take place in them,
- ▶ demographic and cultural profile,
- ▶ community assets and infrastructure,
- ▶ baseline status of livelihoods associated with ecosystem services, and
- ▶ community dependence on ecosystem services and their vulnerability to change in ecosystem services.

The study relied primarily on information collected through surveys conducted by HBP in the communities as a part of this study. Information from secondary sources consisting mainly of previous ESIA's done by HBP, and others as well as published reports, and literature was also consulted.

#### 6.1.1 Narrative Description of Socioeconomic Zones

As mentioned in **Section 3**, the Study Area has been divided into zones largely on the basis of predominant land-use and resource-use as well as documented variations in socioeconomic setting. The Study Area is divided into the following Socioeconomic Zones<sup>256</sup> (see **Exhibit 6.1**):

- ▶ Fishing communities
- ▶ Non-fishing communities
- ▶ Urban communities
- ▶ Planned housing schemes
- ▶ Fishing/agricultural communities

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<sup>256</sup> Some overlap between zones occurs, zone boundaries were defined in consultation with HBP field survey teams and key informants in the communities.

**Exhibit 6.1: Socioeconomic Zones in the Study Area**

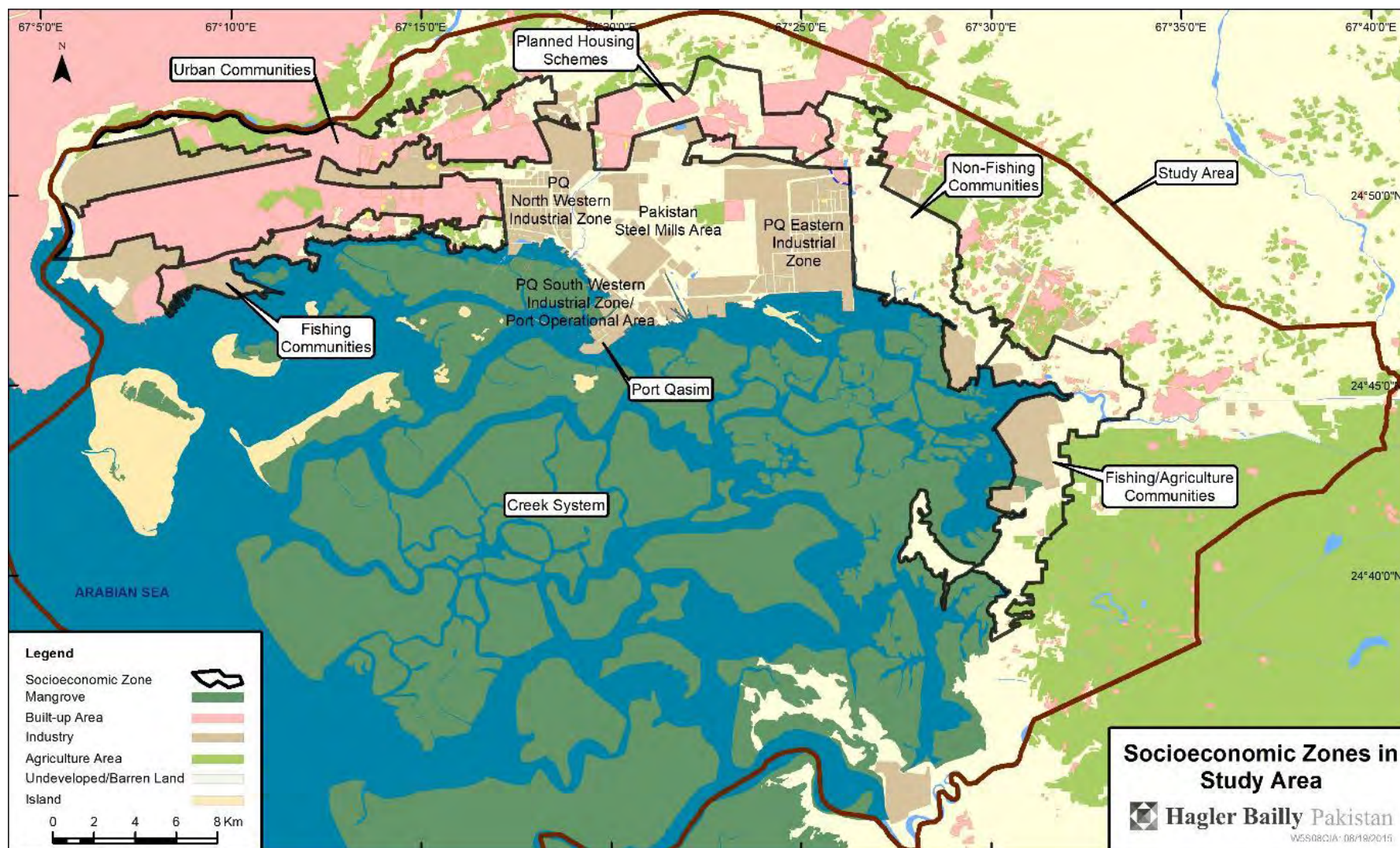
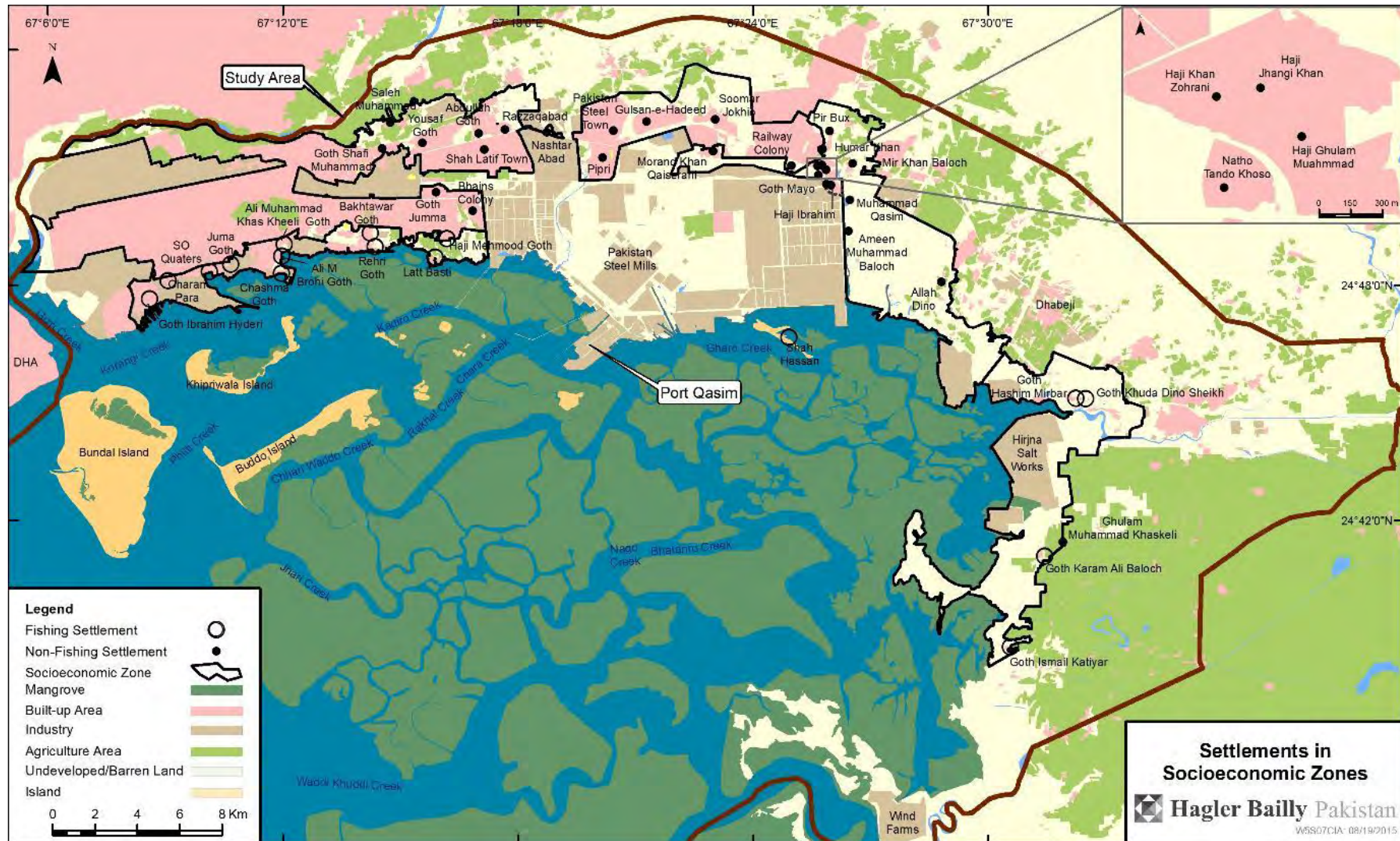




Exhibit 6.2: Settlements in Socioeconomic Zones



The communities that have direct dependence on ecosystem services derived from the mangrove ecosystem (see Ecosystem Services Review for Port Developments at Port Qasim, June 2015, prepared as a part of this study, HBP Ref: D5E01CIA) are:

- ▶ Fishing communities (e.g. Ibrahim Hyderi, Rehri Goth and Latt Basti)
- ▶ Fishing/agricultural communities (e.g. Goth Karam Ali Baloch and Hasim Mirbehar)

With respect to changes in demographics triggered by Developments (see **Section 2** for definition), as well as associated increase in reliance on ecosystem services, the following zones are of relevance:

- ▶ Urban communities
- ▶ Planned housing schemes (including Gulshan-e-Hadeed, Pipri, and Steel Town)
- ▶ Non-fishing communities

In addition to communities in the Study Area, the dependence of local businesses on the ecosystem services is also of relevance. These include, but are not limited to, the:

- ▶ fishing industry
- ▶ fish processing industry
- ▶ salt production facilities
- ▶ net weaving and repairing
- ▶ boat making and repairing; and
- ▶ tourism

In addition to the services above, the structural properties of mangroves carry great importance for the PQA, as they prevent erosion by interlocking soils and provide protection against floods. The importance of mangrove habitat is discussed in detail in **Section 5.3.1**, while the dependence for PQA is characterized in the Ecosystem Services Review for Port Developments at Port Qasim, June 2015, prepared as a part of this study (HBP Ref: D5E02CIA).

A narrative description of the Socioeconomic Zones in Study Area is provided below. Locations of the settlements in the Socioeconomic Zones are provided in **Exhibit 6.2**.

### **Fishing Communities**

Fishing Communities located in the northwest of the Study Area (see **Exhibit 6.1**) are home to a diverse group of communities who rely on the ecological resources (creeks/mangroves, fish, crab, shrimp, etc.) of the marine ecosystem for their livelihood. The Fishing Communities are located along the coastal line of Korangi Creek with Ibrahim Hyderi shown in **Exhibit 6.3 (photograph 6.3a)** and Rehri Goth (**photograph 6.3b**) which are the two largest fishing settlements.

Almost 90% of the residents of the Fishing Communities are directly or indirectly connected to the fishing business as a source of livelihood including fishing in creeks/mangroves of Notified PQA Area (see **Section 2** and **Section 3**) and open sea, fish processing, ship building and net making (**photograph 6.3c** and **photograph 6.3d**),

providing recreational fishing and tourism services to the visitors from Karachi (**photograph 6.3e**). According to the local communities, the decline in the fish population of the creeks in the PQA Area is mainly due to effluent and sewage discharge into the Korangi Creek through Malir River, as well as direct discharge into Korangi Creek (**photograph 6.3f**). The discharge of these effluents into the creeks has also resulted in deterioration of natural aesthetics, especially of those close to the shoreline.

The infrastructure in the Fishing Communities zone is poorly developed with limited health and educational facilities, below par road networks and poorly maintained electricity transmission lines. Housing mostly consists of old masonry structures (**photograph 6.3g**) with some huts made out of wood and straw (**photograph 6.3h**) scattered along the shoreline of the Korangi Creek. Due to interrupted natural gas supply, the use of mangrove wood as fuel source for heating and cooking purpose is also observed (**photograph 6.3i**).

### **Exhibit 6.3: Fishing Communities**



**Photograph 6.3a:** A view of main jetty at Ibrahim Hyderi





**Photograph 6.3b:** A view of main jetty at Rehri Goth



**Photograph 6.3c:** Boat building at Ibrahim Hyderi





**Photograph 6.3d:** A view of the locals engaged in net repairing



**Photograph 6.3e:** A group leaving for recreational fishing from Ibrahim Hyderi





**Photograph 6.3f:** Effluent discharge near the shoreline of Korangi Creek



**Photograph 6.3g:** Residential area with flooded streets and piles of waste



**Photograph 6.3h:** Wood and straw huts of fishing community



**Photograph 6.3i:** Mangrove wood for sale in Ibrahim Hyderi



### **Non-Fishing Communities**

Non-Fishing Communities are located in the northeast of the Study Area (see **Exhibit 6.1**) with most of the population concentrated near Ghaghar Phattak in **Exhibit 6.4** (commonly known as Ghaghar Crossing) (**photograph 6.4a**) on main national highway (N-5). These communities were categorized as ‘Non-Fishing Communities’ as their livelihood is mainly daily wage labor in the industries located in PQA industrial and commercial zones, towns of Gharo and Dhabeji, and Karachi city. A significant number of the residents of Non-Fishing Communities are reported to be employed at Fauji Fertilizer Bin Qasim Limited (**photograph 6.4b**), Engro Zarkhez Limited, Lotte Chemicals Pakistan, and Linde Pakistan (**photograph 6.4c**) in PQA industrial zones.

The lack of economic resources and permanent sources of income has resulted in compromised socioeconomic conditions of these communities resulting in poor health and low level of education, and an overall reduction in the quality of life.

Accommodation largely consists of single room masonry houses with 6 to 8 persons in a household (**photograph 6.4d**). The area is not connected to natural gas pipeline network. The locals rely on wood from mesquite bushes and other terrestrial vegetation to meet their daily fuel requirements (**photograph 6.4e**). The terrestrial vegetation including mesquites and other thorny bushes are reported to be adequate to meet the daily fuel requirements of the population of Non-Fishing Communities. However, continuous growth in population of this area may have significant impact on terrestrial vegetation due to increased demand of fuel wood. The continuous extraction of fuel wood from terrestrial vegetation, as well as land development, is expected to exhaust these resources.

**Exhibit 6.4: Non-Fishing Communities**



**Photograph 6.4a:** A view of Ghaghar Phattak crossing



**Photograph 6.4b:** Fauji Fertilizer Bin Qasim plant





**Photograph 6.4c:** *Linde Pakistan, PQA*



**Photograph 6.4d:** *Masonry house*



**Photograph 6.4e:** Mesquite wood used as fuel

### **Planned Housing Schemes**

Planned Housing Schemes are located in the north of the Study Area (see **Exhibit 6.1**). These include densely populated settlements having relatively well-developed infrastructure (see photographs in **Exhibit 6.5**). Two urban (Gulshan-e-Hadeed and Pakistan Steel Town<sup>257</sup>) and one semi-urban (Pipri) settlements fall in this zone.

Gulshan-e-Hadeed (**photograph 6.5a**) is the largest settlement in the Zone and in the Study Area. The land on which Gulshan-e-Hadeed is located was originally owned by Pakistan Steel Mills (PSM) but later sold to private investors. The town now comprises of a population from various parts of Karachi with mixed social and economic characteristics, and smaller settlements (mostly dependent on wage labor) located in the surroundings of Gulshan-e-Hadeed. The poor security situation in other parts of Karachi city and potential employment opportunities in PSM and other industries in the PQA Area appear to be the main reasons for an expanding population in this town.

Pakistan Steel Town (**photograph 6.5b**) stretches over an area of 3,288 hectares (8,126 acres) and offers subsidized residence to PSM employees. The land for the development was leased by PSM from Sindh government. Steel Town was developed by PSM and is equipped with all the basic facilities which include drainage and sanitation system, police station, utility stores and electricity and natural gas transmission infrastructure. The Steel Town offers a cricket stadium, football ground and a hockey

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<sup>257</sup> Also known as Steel Town

stadium, and has a post office ((**photograph 6.5c**), police station ((**photograph 6.5d**) and a 100-bed hospital (**photograph 6.5e**) providing services not only to its residents but also to other settlements, especially Pipri located to its north and Non-Fishing Communities located to its south east.

The settlement of Pipri is located 6.5 km to the northwest of the Port Qasim. The settlement consists of numerous small clusters of communities (*Goths*)<sup>258</sup> named after the elders of the family or the ethnic group residing in it. As compared to Gulshan-e-Hadeed and Steel Town, Pipri is a less developed, with poor infrastructure. Electricity and gas transmission networks exist. Pipri has a water pumping station located in Shanawaz Goth. The water is extracted from Keenjar Lake, Thatta, and is stored in a water tower (**photograph 6.5f**) from where it is supplied to the settlement through a gravity-driven water supply system.

Pipri, near Pathan Goth, has the largest graveyard (**photograph 6.5g**) located in the Study Area. The graveyard meets the needs of Pipri, Gulshan-e-Hadeed and Steel Town.

#### Exhibit 6.5: Planned Housing Schemes



**Photograph 6.5a:** Main entrance of Gulshan-e-Hadeed

<sup>258</sup> *Goth* is a Sindhi word for village.





**Photograph 6.5b:** Main entrance of Steel Town



**Photograph 6.5c:** Post office Steel Town





**Photograph 6.5d:** Police station of Steel Town



**Photograph 6.5e:** 100 bed hospital at Steel Town





**Photograph 6.5f:** Water storage tank in Pipri



**Photograph 6.5g:** Graveyard at Pipri

### **Fishing/Agriculture Communities**

Fishing/Agriculture Communities in the east of the Study Area are located at a distance of 60 km from Karachi city on Bhambore road leading to Mipur Sakro. The livelihoods of these communities are dependent on fishing in the Gharo and Bhambore creeks (**photograph 6.6a**) and farm labor. There is only one landing point offering services to the fish labor to enter the creeks for fishing, located near Goth Hashim Mirebehar (**photograph 6.6b**). Similar to Non-Fishing Communities, these communities do not have access to gas or electricity, and rely on cutting mesquite wood for use as fuel for cooking. The houses are mostly made of straw and wood (**photograph 6.6c**), with well-off households using larger quantities of wood to build huts on elevated platforms to avoid damage from floods caused by rains every year.

Dhabeji located at an approximate distance on 10 km to the north of these communities is the only developed town with proper markets (**photograph 6.6d**) offering basic necessities to the residents of these communities.

A very small number of households from these communities are also employed as daily wage labor at salt production facilities operating on Bhambore road. Salt is produced by pumping saline sea water from Gharo Creek and concentrating it in salt pans (**photograph 6.6e**).

#### **Exhibit 6.6: Fishing/Agriculture Communities**



**Photograph 6.6a:** A view of Gharo Creek from shoreline near Ismail Katiyar village





**Photograph 6.6b:** Bhambore Landing Point



**Photograph 6.6c:** Commonly found wood and straw huts



**Photograph 6.6d:** A view of market at Dhabeji



**Photograph 6.6e:** Salt pans

### 6.1.2 Administrative Setting

**Exhibit 6.7** presents a map of the administrative setting of the entire Study Area. Administratively, the communities located in the Study Area fall in Malir and Thatta Districts of Sindh province of Pakistan.

The UC is the third tier of the basic administrative structure following the District and Provincial divisions in Pakistan. The UC is a government body, elected through local government elections. It is headed by a District *Nazim*<sup>259</sup> and has 13 elected members responsible for management and administration of the UC.<sup>260</sup>

The communities of Malir District are located in Bin Qasim town of the district and are administrated under the seven union councils (UC), while the communities of Thatta District fall in Dhabeji UC.

The list of UCs of the Study Area is provided below:

Malir District	Thatta District
UC 1: Ibrahim Hyderi	UC: Dhabeji
UC 2: Rehri Miani	UC: Gharo
UC 3: Cattle Colony	UC: Choubandi
UC 4: Qaidabad	UC: Haji Ghirano
UC 5: Landhi	
UC 6: Gulshan-e-Hadeed	
UC 7: Ghaggar	

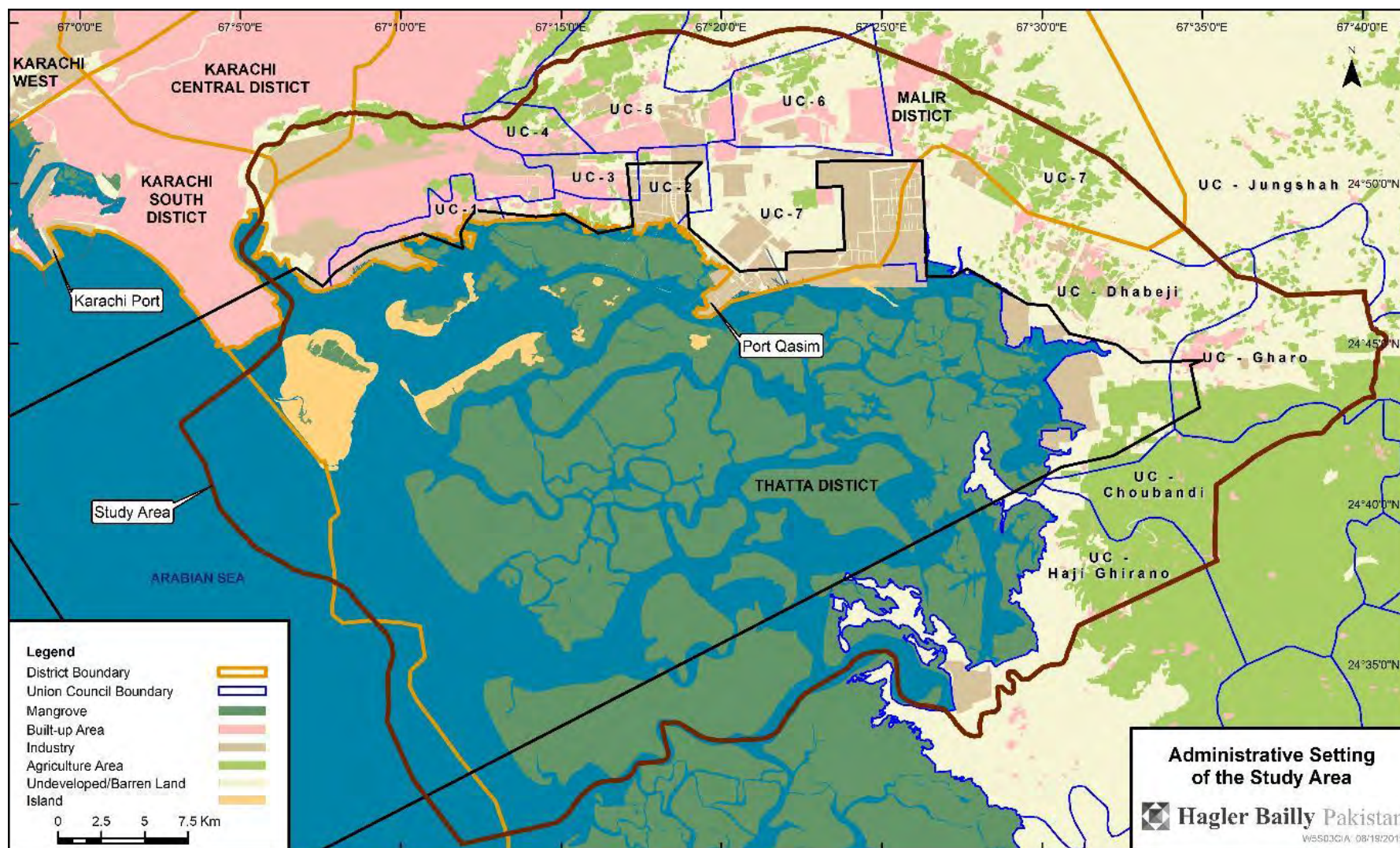
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<sup>259</sup> Administrator

<sup>260</sup> Saadia Saleem and Mughees Ahmed, "Political and Administrative Structure of Local Bodies in Pakistan A Case Study of City District Government Faisalabad" Berkeley Journal of Social Sciences, Vol 2, Issue 6-7, July, 2012.



**Exhibit 6.7: Administrative Setting of the Study Area**



## 6.2 Summary of Stakeholder Consultations

This section describes the issues raised by the stakeholders during the ESR and CIA Scoping Consultation and Survey conducted from June 10 to 14, 2015. The informal discussions with the community members focused on determining the perceptions of the local communities (particularly Fishing Communities and Fishing/Agriculture Communities) on the Developments and ecosystem services.

The community dependence on the identified ecosystem services and prioritization of ecosystem services based on the findings of the consultations is presented in **Appendix D section D.2**. In addition to the issues related to the dependence of communities on ecological resources for livelihood, the key respondents from the communities also reported other issues including; legacy conflicts with PQA over the resettlement of communities from the PQA area during early period of PQA development (1970's and early 1980's); inter-community clashes due to illegal fishing activities introduced by fishermen migrated to these area from upper Sindh and Bangladesh; and, issues related to unemployment and absence of any alternate sources of income. A more detailed summary of issues raised is provided in **Section 6.2.2**.

The key stakeholder groups consulted in different Socioeconomic Zones and segments of the Study Area (**Exhibit 6.1**) are listed below.

In the center of the Study Area:

Port Area (PQA Southwest Zone)	<ul style="list-style-type: none"><li>▶ Owners, operators and employees of industrial jetties and terminals</li><li>▶ Interested investors in the area</li></ul>
PQA Northwest Industrial Zone	<ul style="list-style-type: none"><li>▶ Owners, operators and employees of industrial units</li><li>▶ Interested investors in the area</li></ul>
PQA Eastern Industrial Zone	<ul style="list-style-type: none"><li>▶ Owners, operators and employees of industrial units</li><li>▶ Interested investors in the area</li></ul>
Pakistan Steel Mills Area	<ul style="list-style-type: none"><li>▶ Owners, operators and employees of steels mills, water treatment plant, and railway yard</li><li>▶ Interested investors in the area</li></ul>
Planned Housing Schemes	<ul style="list-style-type: none"><li>▶ Residents of the housing schemes who are potentially adversely affected by Port Qasim developments.</li></ul>
Non-Fishing Communities	<ul style="list-style-type: none"><li>▶ Non-Fishing Communities, with expected or established reliance on existing Port Qasim developments as a source of livelihood and potentially adversely affected by Port Qasim developments (e.g. air quality issues, traffic, noise, etc.).</li><li>▶ Residents</li><li>▶ Local government</li></ul>

In the west of the Study Area:

- Korangi and Landhi Industrial Areas
  - ▶ The industry associations
  - ▶ Owners and operators of large industrial units
- Urban Communities
  - ▶ Local government
  - ▶ Agencies responsible for treatment and disposal of sewerage
  - ▶ Communities that may or may not be dependent upon industries in PQA Area and Pakistan Steel Mills
- Fishing Communities
  - ▶ Fishing Communities located along at or near shoreline and possibly reliant on fishing within the PQA notified area, and possibly affected by existing activities within the Port Qasim shipping lane
  - ▶ Owners and operators of salt works
  - ▶ Government agencies responsible for fishery management

In the east of the Study Area:

- Fishing/Agriculture Communities
  - ▶ Fishing Communities
  - ▶ Owners and operators of salt works
- Non-Fishing Communities
  - ▶ Other Non-Fishing Communities with expected or established reliance on existing Port Qasim developments as a source of livelihood and potentially adversely affected by Port Qasim developments

The community stakeholder consultations focused on identifying ecosystem services and the dependence of the communities located in the Study Area on them. The consultations focused on determining the perception of the communities concerning ecosystem services offered by Valued Environmental and Social Components (VECs).

This section summarizes the findings of the consultations and provides an overview of dependence of the communities in the Study Area on ecosystem services and their concerns relating to the existing and proposed Developments at Port Qasim.

### **6.2.1 Consultation Methodology**

A Stakeholder Engagement Plan (**Appendix D** section **D.1**) was prepared. Main features of the process followed are described below.

### **Consultation Material**

A Background Information Document (BID) containing information on the purpose of the PESR and CIA studies and expected outcomes was prepared in both Urdu and English and shared with the stakeholders according to their backgrounds.

### **Community Stakeholder Consultations**

The community stakeholder consultations were conducted within settlements to ensure, encourage, facilitate, and maximize participation. The information from the BID, along with a map showing the location of the communities with respect to Port Qasim was shared with the participants.

Fourteen consultation meetings were held in 30 communities from June 10 to June 14, 2015. Two communities, Goth Ameen Muhammad Baloch and Allah Dino, which are located to the northeast of Port Qasim, refused to share any information with the consultation team as they were visited by a number of teams from NGOs and other consultants in the past and were not inclined to discuss their issues again. During previous consultations held with these communities for other ESIAs, the respondents reported the following key issues:

- ▶ absence of adequate health and education facilities;
- ▶ unemployment; and
- ▶ lack of alternate sources of income.

Urban communities located to the northwest of the Port Qasim were not consulted due to prevailing security conditions. These include Razzaqabad, Shah Latif Town, Nashtarabad, Bhains Colony and other small settlements located in their vicinity.

Consultations were conducted with both men and women except for the fishing community in Hirjna fishing area and in Gulshan-e-Hadeed.

Women in Hirjna were not involved in fishing activities in any manner, while Gulshan-e-Hadeed is a conservative urban community that did not allow the consultation team to meet with women in the community. However, these communities in the area were consulted in previous studies conducted by HBP. The respondents from these communities reported no dependence on ecosystem services, such as fuel wood and fodder from mangroves and surrounding terrestrial vegetation, as households in Gulshan-e-Hadeed have access to piped natural gas. The workers from Hirjna fishing area are daily wage laborers working in Hirjna and other salt production facilities in the area. They visit the salt pans located in Fishing/Agriculture Communities only during their working hours.

**Exhibit 6.8** provides a list of consultation meetings held, geographical coordinates of the consultations, and date when consultation took place. The location of communities where consultations were conducted is shown on a map in **Exhibit 6.9**. Photographic records of the consultations with the men and women from the communities are presented in **Exhibit 6.10**. The meetings progressed in the following manner:

- ▶ An overview of the ESR and CIA studies was provided to the community representatives. The main points of the BID were read out to them in Urdu/Sindhi.

- ▶ Members of the communities were asked to identify possible VECs and associated ecosystem services. The informal discussions with the communities focused on identifying the dependence of the communities on ecosystem services.
- ▶ Members of the communities were given the opportunity to raise queries or concerns regarding the existing and future development at PQ.
- ▶ Informal questions were asked to determine the socioeconomic status and livelihood of the communities to determine their dependence on VECs.

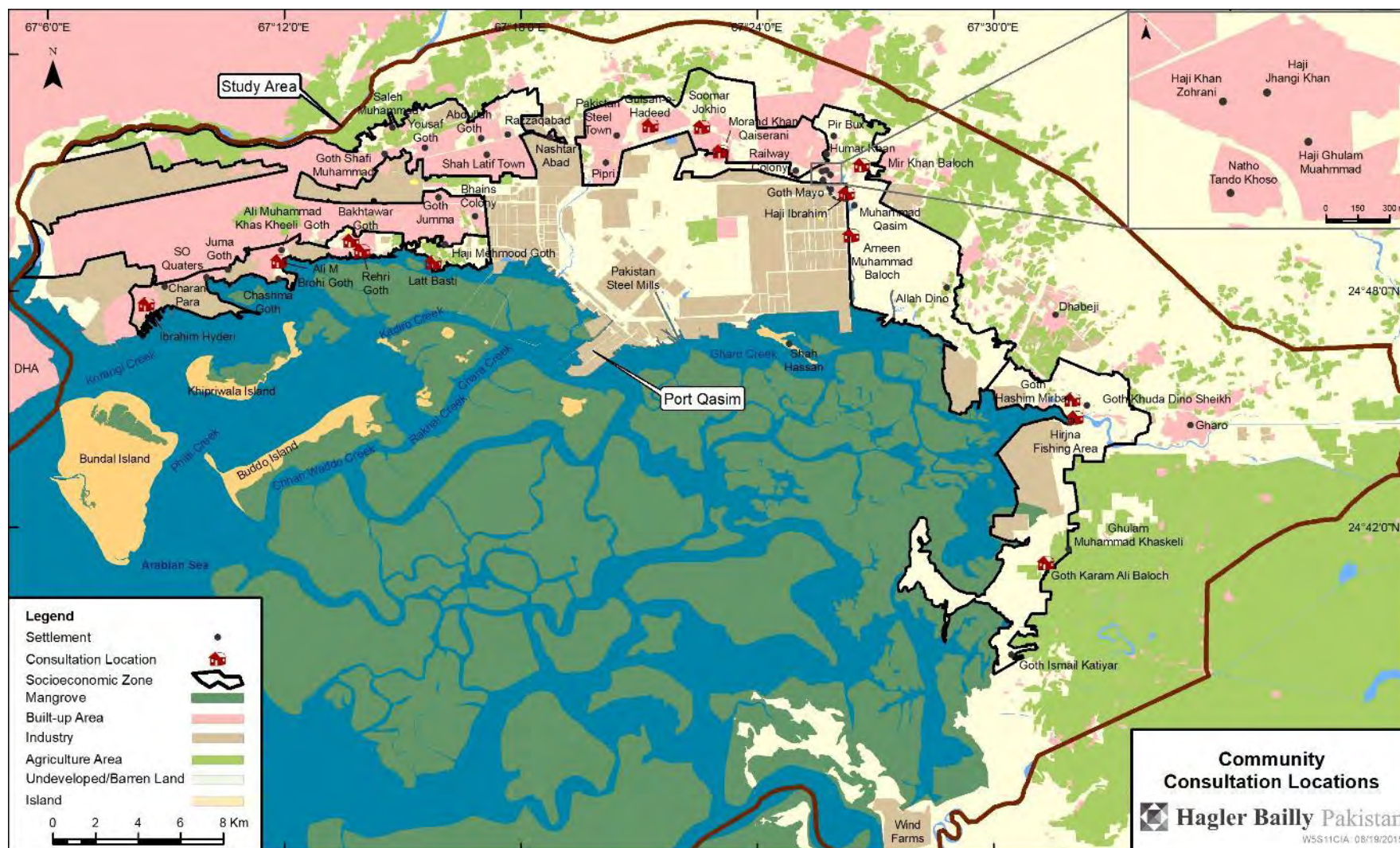


**Exhibit 6.8: List of Communities Consulted**

Consultation Location	Consulted Community	Date of Consultation	Geographical Coordinates	
			Latitude (N)	Longitude (E)
Muhammad's Office (fishermen and owner of a local petrol depot)	Ibrahim Hyderi	June 10, 2015	24° 47' 39.4"	67° 08' 29.7"
Common Baithak local fishermen	Latt Basti	June 10, 2015	24° 48' 42.9"	67° 15' 46.8"
Office of Community Based Organization; Firdous Training Organization ( <i>Firdous Tarbiyati Tanzeem</i> )	1. Rehri Goth 2. Chashma Goth 3. Siddique Khaskheli Goth	June 11, 2015	24° 49' 00.5"	67° 13' 58.5"
Outside Residence of Muhammad Alam (President Youth Welfare Association)	Ali M Brohi Goth	June 11, 2015	24° 48' 44.5"	67° 11' 51.9"
Baithak of Nazir Bhutto (local contractor and political and tribal leader)	Bakhtawar Goth	June 11, 2015	24° 49' 16.2"	67° 13' 41.9"
Dera of Goth Karam Ali Baloch	1. Goth Karam Ali Baloch 2. Goth Ismail Katiyar 3. Ghulam Muhammad Khaskheli 4. Abdul Ghani Goth 5. M Azeem Mirbar Goth 6. Mohsin Khaskheli Goth 7. Goth Hasil Rindh Baloch	June 12, 2015	24° 41' 05.5"	67° 31' 20.1"
Hirjna Fishing Area	Fishermen	June 12, 2015	24° 44' 47.0"	67° 32' 05.1"
Baithak of Muhammad Azeem	Goth Hashim Mirbehar	June 12, 2015	24° 45' 14.4"	67° 32' 00.0"
Outside Goth Ameen M Baloch	1. Goth Ameen Muhammad Baloch 2. Goth Allah Dino	June 12, 2015	24° 49' 24.2"	67° 26' 24.0"

<i>Consultation Location</i>	<i>Consulted Community</i>	<i>Date of Consultation</i>	<i>Geographical Coordinates</i>	
			<i>Latitude (N)</i>	<i>Longitude (E)</i>
Outside local market of Goth Haji Ibrahim	<ol style="list-style-type: none"> <li>1. Goth Haji Ibrahim</li> <li>2. Mir Khan Baloch</li> <li>3. Hajo Khan Zohrani</li> <li>4. Natho Tando Khoso</li> <li>5. Haji Jhangi Khan</li> <li>6. Goth Mayo</li> </ol>	June 13, 2015	24° 50' 27.6"	67° 26' 16.8"
Dera of Muhammad Amin (notable from Mir Khan Baloch)	<ol style="list-style-type: none"> <li>1. Humar Khan</li> <li>2. Mir Khan Baloch</li> <li>3. Pir Bux</li> </ol>	June 13, 2015	24° 51' 11.3"	67° 26' 39.8"
Residence of Makhdoom Family	Gulshan-e-Hadeed	June 13, 2015	24° 52' 10.9"	67° 21' 17.2"
Government Middle School	Morand Khan Qaiserani	June 14, 2015	24° 51' 31.9"	67° 23' 04.4"
Office of Muhammad Ilyas (local contractor and community representative)	Soomar Jokhio	June 14, 2015	24° 52' 09.4"	67° 22' 36.0"

**Exhibit 6.9: Community Consultations Locations**





**Exhibit 6.10: Photographs of the Community Consultations**



*Consultation meeting at Ibrahim Hyderi*



*Consultation with Ex-Nazim, Latt Basti*



*Consultation with fishermen of Latt Basti*



*Consultation meeting held at Rehri Goth*



*Consultation meeting held at Karam Ali Baloch*



*Females of Rehri Goth and adjacent communities*



*Consultation with resident of Ali M Brohi*



*Females of Goth Mir Behar*



*Consultation meeting held at Mir Khan Baloch*



*Consultation with residents of Morand Khan Qaiserani*



*Female consultation at Ibrahim Hyderi*



*Consultation meeting held at Haji Ibrahim*

### **6.2.2 Summary of Issues Raised by the Communities**

The consulted communities were given an opportunity to share their concerns related to the existing and proposed Developments in PQA Area. A summary of issues is provided below, with the details provided later in this section.

- ▶ Significant legacy issues persist associated with PQA's perceived mishandling of relocations between 1972 and 1982, in relation to restoration of housing and livelihood when Port Qasim was established.
- ▶ Conflicts of Fishing/Agriculture Communities with the fishermen in Fishing Communities located in west of the Study Area over their illegal fishing activities have also resulted in an incidence of loss of human life.
- ▶ The communities believe that discharge of untreated effluents results in degradation of the sea water leading to declines in fish population in creeks, which in turn affects the livelihood of the local fishermen.
- ▶ PQA disposes the dredged material in the creeks, away from their shipping lanes, resulting in increase in sea water turbidity, affecting fish population and causing reduction in the depth of the creeks making navigation through creeks difficult for the fishermen<sup>261</sup>.

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<sup>261</sup> Separate discussions with Port Qasim confirm that dumping is carried out along the sides of the navigation channel. During the socio-economic consultations.



- ▶ Port Qasim Authority has restricted their movement in the PQA main navigation channel and declared the shipping channel a formal exclusion zone where fishing is prohibited. In addition, strong waves generated by the movement of large cargo carrying vessels have resulted in incidents involving loss and damage of fishing boats and nets<sup>262</sup>.
- ▶ The key respondents from all the consulted communities identified poor educational infrastructure as the major cause of their poor socioeconomic conditions. Non-Fishing and Fishing/Agriculture Communities do not have access to pipeline gas, therefore, they mainly rely upon mesquite wood and wood from other terrestrial vegetation for fuel. In addition, approximately 80% of the Fishing/Agriculture Communities do not have access to grid electricity. Respondents from Fishing and Non-Fishing Communities reported facing power availability issues associated with unannounced and unplanned power outages and failures in poorly maintained transmission lines.

### **Legacy Issue Associated with Land acquisition for Port Qasim Development**

During the consultation meeting it was established that the current port facilities were developed by relocating 27 villages which were originally located in the PQA Area. These villages were relocated during the period of 10 years; from 1972 to 1982. Communities were assured that sufficient compensation would be paid to accommodate the loss of their livelihood, alternate employment opportunities would be provided, and locals would be preferred over others while employing work force for the development and operations of the port. In addition, the locals were assured that model villages offering basic civic amenities will be developed to relocate the communities.

The respondents from the Latt Basti located to the west of the Port Qasim, Non-Fishing Communities on the northeast and Fishing/Agriculture Communities said that they were adversely impacted by this relocation. The respondents stated that adequate compensation was not paid for the acquired land, no model villages were developed, and no alternate employment opportunities were offered.

The Non-Fishing and Fishing/Agriculture Communities were engaged in agriculture and fishing activities before forced relocation. However, their agricultural land was acquired and their access to fishing areas was restricted resulting in reduction in incomes.

The communities have filed cases against relocation in Sindh High Court since 1980's, but due to lack of political support and financial resources, they have not been able to receive any satisfactory relief from the court. Following the consultation, a review of resettlement issues and their current status was carried out. The results of this have been presented in **Section 6.7**.

### **In-migration and illegal fishing activities**

The communities located west and east of Port Qasim have traditionally been engaged in fishing activities. The area is a major attraction for the fishermen of upper Sindh and

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<sup>262</sup> A damaged fishing boat, where the outboard motor had been bent, was seen at Rehri Goth during the socioeconomic surveys.

immigrant Bengalis living in the south of Port Qasim resulting in their in-migration which has resulted in overharvesting of fish in the Korangi, Phitti and Gharo creeks.

The migrants have also introduced illegal fishing methods, including use of very small sized fishing net (commonly known as *Bullo Gujja*) that can trap the small and immature fish in the creeks. Round the year fishing has also seriously degraded the fish population in the creeks in the Port Qasim Area, particularly the Gharo creek. The fish move from Korangi and Phitti creeks to Gharo creek during their lifecycle. They breed, lay eggs and rely on the habitat of Korangi and Phitti creeks during their growth period after which they move towards the Gharo creek.

This decrease in fish catch has aggravated the socioeconomic vulnerability of the fishing communities and has also resulted in disputes between communities located west and east of the Port Qasim. The respondents in the Fishing/Agriculture Communities Zone located east of Port Qasim reported having conflicts with the fishermen in Fishing Communities Zone located in west of the Study Area over their use of illegal fishing methods. The conflict is reportedly of a very serious nature as it resulted in loss of human life.

#### **Issues related to climate change**

A significant number of households in Fishing/Agricultural Communities Zone and Goth Mir Khan Baloch located in the Non-Fishing Communities Zone rely on agriculture as their main source of livelihood. The irrigation water is mostly obtained from rain dependent *nullahs* and Gharo *nullah* flowing into the Gharo Creek. This flow of fresh water into the Gharo Creek not only regulates the salinity of the sea water near shoreline, but also serves as the major source of fresh water supporting agriculture in these communities.

However, due to a decrease in rainfall since 1992, as perceived by the key respondents from these communities, the agricultural yield of these areas has been adversely affected. The decrease in rainfall according to them has resulted in intrusion of seawater triggering erosion of shorelines, degradation of ground water quality, and increase in soil salinity.

#### **Issues related to the industries Port Qasim Authority Area**

As reported by the consulted communities, the development of PQ industrial zones has greatly affected the physical environment of the communities living around the PQA Area. The wind direction varies round the year and ambient air quality is degraded as pollutants released in the air by the industries are blown in, affecting health of the communities.

The communities also recorded concerns related to the discharge of effluents from the industries at PQA Area. These untreated effluents are perceived as degrading the sea water quality resulting in decline in fish population in creeks which in turn affects the livelihood of the local fishermen.

#### **Issues related to operation and maintenance of existing Port Qasim shipping lane**

The respondents in the Fishing Communities Zone said that the shipping lanes pass through the Korangi, Phitti, Kadiro and Chara Creeks mostly located in the southwest of the PQA Area (see **Section 4.1** for a map showing location of these creeks).

To facilitate navigation of large cargo carrying vessels through creeks in the PQA Area, periodic dredging of the Port Qasim shipping lanes is carried out. According to the respondents, the dredged material is not disposed of in deep sea at an appropriate location. To save the cost, PQA disposes the dredged material in the creeks, away from their shipping lanes, resulting in perceived increased sea water turbidity, deterioration in fish population, and reduction in the depth of the creeks making navigation through creeks difficult for the fishermen.

#### ***Access issues associated to location of Port Qasim***

According to the key respondents in the Fishing Communities Zone and Fishing/Agriculture Communities Zone, the development of Port Qasim has restricted their movement in the PQA Navigation Channel and has declared it as a formal exclusion zone where fishing is prohibited. In addition, strong waves generated by the movement of large cargo carrying vessels, has resulted in incidents involving loss and damage of fishing boats and nets. The fishermen with smaller boats are now restricted within the nearby creeks (Korangi, Phitti and Kadiro Creeks) for fishing. This in turn has increased the fishing pressure in these creeks, affecting the livelihood of the fishermen.

#### ***Issues related to ineffectiveness of FCS and PFF***

Fishermen's Cooperative Society (FCS) and Pakistan Fisherfolk Forum (PFF) were identified as two organizations actively working with the fishing communities with a mission to protect rights of the local fishermen. However, these organizations were reported as 'ineffective' in protecting rights of the fishermen and working toward their welfare and well-being. The respondents from Ibrahim Hyderi noted that FCS only works to protect the vested interests of some political groups and large fishing businesses. The respondents also stated that representatives from these organizations visit the communities, take photographs for reporting purposes, make promises to help the community to resolve their issues and stand with them to stop illegal fishing activities. But in reality, their performance in protecting fishing rights of the local fishermen is not satisfactory.

#### ***Issues related to discharge of sewage water and effluents into the creeks***

The respondents from Ibrahim Hyderi and Latt Basti shared their concerns on the discharge of untreated sewage and effluents from Karachi city and Bhains Colony. The sewage from Karachi city is discharged via Malir nullah into Korangi Creek near Ibrahim Hyderi, while the effluents and manure from Bhains colony is discharged near Latt Basti. These discharges reportedly result in deterioration in seawater quality in Korangi and Phitti Creeks, reducing the fish population and threatening livelihoods of fishermen.

#### ***Issues related to alternative sources of livelihood***

Due to limited access to education, the socioeconomic conditions of the population in Fishing, Non-Fishing and Fishing/Agriculture Communities Zones are compromised. The members of these communities rely only on agriculture, fishing, and daily wage labor to for their livelihoods and have no alternate sources of livelihood available.

The key respondents, from all the consulted communities, identified poor educational infrastructure as the major cause of their poor socioeconomic conditions. Due to lack of skill and education, these communities have no access to alternate sources of incomes

associated with the industrial development at Port Qasim or other opportunities in the area triggered by industrial development.

### **6.3 Socioeconomic Survey Methodology and Plan**

**Appendix D** section **D.4** includes the Socioeconomic Survey Plan. A summary is provided in this section. The ESR and CIA Scoping Survey and Consultation conducted from June 10 to 14, 2015 (**Section 6.2**) provided the background and information for development of the methodology and preparation of the survey plan.

For the purpose of socioeconomic survey, representative settlement clusters were demarcated in the Socioeconomic Zones. **Exhibit 6.11** provides the locations of the settlement clusters, while **Exhibit 6.12** lists the settlement clusters with communities included in each cluster. The settlement clusters were demarcated on the basis of the following:

- ▶ Population and size of settlements;
- ▶ Union council boundaries;
- ▶ Proximity of villages;
- ▶ Dependence on ecosystem services on the basis of scoping consultations; and

Socioeconomic data was collected for the selected settlement clusters.

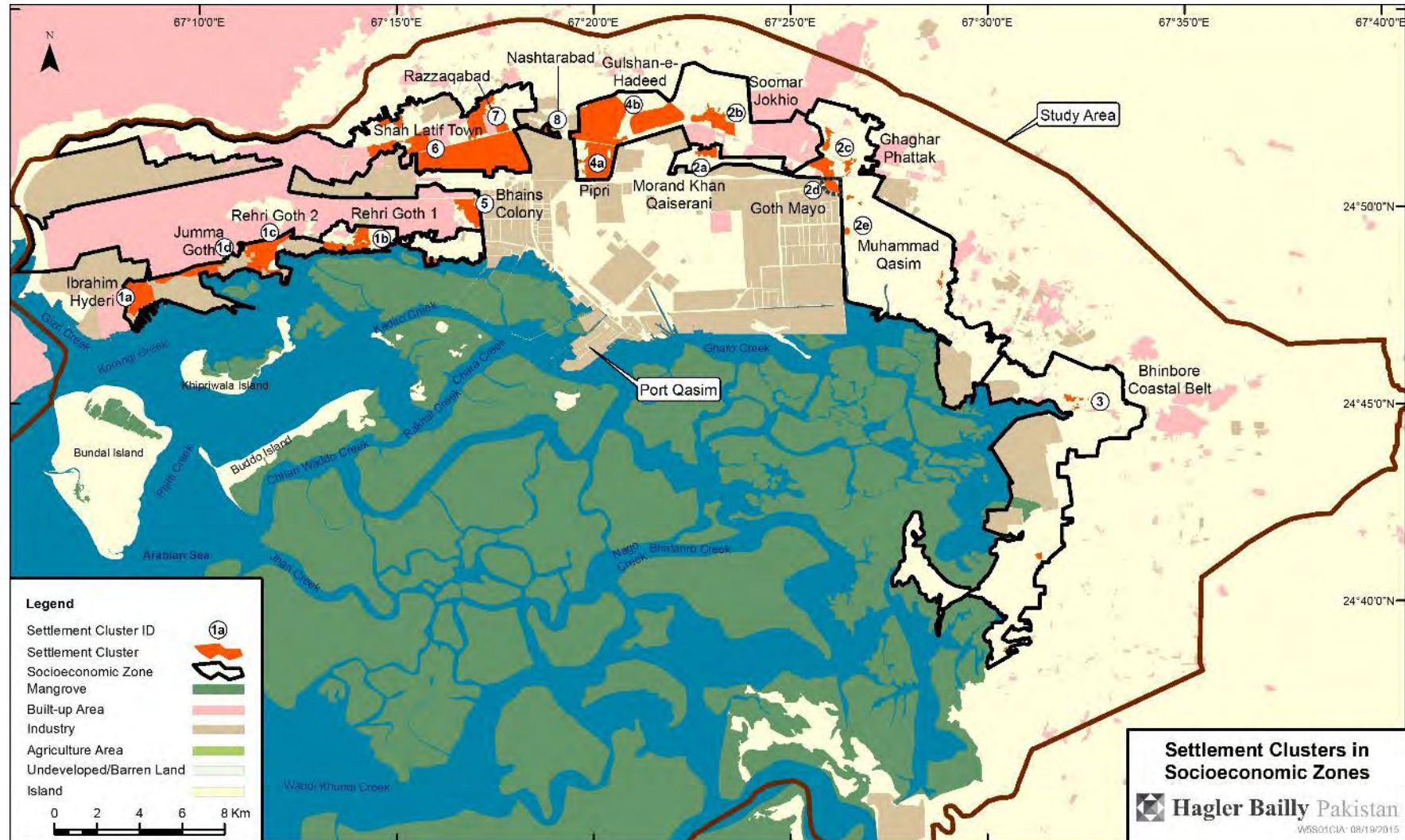
Settlement Clusters 5–8 (Urban Communities), (see **Exhibit 6.11** and **Exhibit 6.12**) and Bengalis Quarters from Cluster 1a could not be surveyed due to security issues. In addition, the residents of these clusters, during scoping consultations, reported to be dependent on Korangi and Landhi Industrial Areas, Karachi city, and Export Processing Zone for employment. They do not depend on PQA Area for employment or livelihoods from ecosystems.

Socioeconomic data of settlements Clusters 2d and 2e could also not be recorded as respondents from these clusters refused to communicate with the survey team during stakeholder consultations. These settlement clusters are shaded grey in **Exhibit 6.12**.

Surveys were conducted at household and cluster level to record the socioeconomic data. The household surveys were conducted prior to the cluster level survey. The information collected during household survey was then validated during the cluster level survey. The key respondents for cluster level data collection were requested to gather at their relevant community centers or *Autaks* (common sitting areas). A combined meeting was held with all the attendees/key informants to record the data of their respective settlement in the cluster.

Survey questionnaires for both household and settlement data collection are attached as **Appendix D** section **D.4.3** and **D.4.4** respectively.

**Exhibit 6.11: Settlement Clusters in the Socioeconomic Zones**





**Exhibit 6.12: Stratification of the Socioeconomic Zones**

<i>Zone</i>	<i>Cluster Number</i>	<i>Cluster Name</i>	<i>Settlements within Cluster</i>	<i>Union Council</i>
Fishing Communities	1a	Ibrahim Hyderi	Ibrahim Hyderi	UC 1 - Ibrahim Hyderi
			Charan Para	UC 1 - Ibrahim Hyderi
			Bangalies (SO Quarters)	UC 1 - Ibrahim Hyderi
	1b	Rehri Goth 1	Bakhtwar Goth	UC 2 - Rehri Miani
			Rehri Goth	UC 2 - Rehri Miani
			Latt Basti	UC 2 - Rehri Miani
	1c	Rehri Goth 2	Chasma Goth	UC 1 - Ibrahim Hyderi
			Ali M Brohi Goth	UC 1 - Ibrahim Hyderi
			Ali M Khaskheli Goth	UC 1 - Ibrahim Hyderi
	1d	Juma Goth	Juma Goth	UC 1 - Ibrahim Hyderi
Non-Fishing Communities	2a	Morand Khan Qaiserani	Morand Khan Qaiserani	UC 6 - Gulshan - Hadeed
	2b	Soomar Jokhio	Soomar Jokhio	UC 6 - Gulshan - Hadeed
	2c	Ghaghar Phattak	Haji Ghulam Muhammad	UC Dhabjei
			Mir Khan Baloch	UC 7 - Ghaggar
			Pir Bukhsh	UC 7 - Ghaggar
			Humar Khan	UC 7 - Ghaggar
			Haji Jhangi Khan	UC 7 - Ghaggar
			Haji Ibrahim Goth	UC 7 - Ghaggar
			Haji Khan Zohrani	UC 7 - Ghaggar
	2d	Goth Mayo	Goth Mayo	UC 7 - Ghaggar
	2e	Muhammad Qasim	Muhammad Qasim	UC Dhabjei
			Ameen Muhammad Baloch	UC Dhabjei
			Allah Dino	UC Dhabjei
Fishing/Agriculture Communities	3	Bhambore Coastal Belt (Gharo-Dhabjei Area)	Goth Karam Ali Baloch	UC Dhabjei
			Goth Ismail Katiyar	UC Dhabjei
			Goth Allah Dino Sheikh	UC Dhabjei
			Goth Haji Natho	UC Dhabjei
			Goth Mohsin Khaskheli	UC Dhabjei
			Goth Abdul Ghani Baloch	UC Dhabjei
			Hashim Mirbehar	UC Dhabjei
Planned Housing Schemes	4a	Pipri	Shahnawaz Goth	UC 6 - Gulshan - Hadeed
			New Allah Bakhsh Goth	UC 6 - Gulshan - Hadeed
			Mureed Gabol Goth	UC 6 - Gulshan - Hadeed
			Khuda Bakhsh Goth	UC 6 - Gulshan - Hadeed
			Ali Muhammad Jokhio Goth	UC 6 - Gulshan - Hadeed

<i>Zone</i>	<i>Cluster Number</i>	<i>Cluster Name</i>	<i>Settlements within Cluster</i>	<i>Union Council</i>
			Ali Bakhsh Baloch Goth	UC 6 - Gulshan - Hadeed
			Suffan Gabol Goth	UC 6 - Gulshan - Hadeed
			Dur Muhammad Goth	UC 6 - Gulshan - Hadeed
			Muhammadi Colony	UC 6 - Gulshan - Hadeed
			Pathan Goth	UC 6 - Gulshan - Hadeed
			Naseerabad	UC 6 - Gulshan - Hadeed
			Allah Bakhsh Goth	UC 6 - Gulshan - Hadeed
	4b	Gulshan-e-Hadeed	Gulshan-e-Hadeed	UC 6 - Gulshan - Hadeed
			Steel Town	UC 6 - Gulshan - Hadeed
Urban Communities	5	Bhains Colony	Bhains Colony	UC 3 - Cattle Colony
	6	Shah Latif Town	Shah Latif Town	UC 5 - Landhi
			Goth Shafi Muhammad	UC 4 - Qaidabad
			Yousaf Goth	UC 5 - Landhi
			Saleh Muhammad	UC 4 - Qaidabad
			Abdullah Goth	UC 5 - Landhi
	7	Razzaqabad	Razzaqabad	UC 5 - Landhi
	8	Nashtarabad	Nashtarabad	UC 5 - Landhi

## 6.4 Socioeconomic Profile

This section describes the socioeconomic conditions of the communities residing in Socioeconomic Zones in the Study Area, drawing on the consultations with the communities, review of secondary data, and socioeconomic surveys conducted for this study from July 30, to August 07, 2015.

### 6.4.1 Demography

#### **Population**

The population of the surveyed clusters of the Socioeconomic Zones is estimated at 396,395. **Exhibit 6.13** provides the population of surveyed settlements and the Zones in which they are located.

**Exhibit 6.13:** Estimated Population of the Surveyed Clusters in the Study Area

Zone	Cluster Number	Cluster Name	Villages Included	Estimated Population of the Cluster <sup>263</sup>	Estimated Population Surveyed Settlements in each Zone
Fishing Communities	1a	Ibrahim Hyderi	Ibrahim Hyderi	150,500	194,600
	1b	Rehri Goth 1	Bakhtwar Goth	35,100	
			Rehri Goth		
			Latt Basti		
	1c	Rehri Goth 2	Chasma Goth		
			Ali M Brohi Goth		
			Ali M Khaskheli Goth		
1d	Juma Goth	Juma Goth	9,000		
Non-Fishing Communities	2a	Morand Khan Qaiserani	Morand Khan Qaiserani	560	11,995
	2b	Soomar Jokhio	Soomar Jokhio	2,100	
	2c	Ghaghar Phattak	Haji Ghulam Muhammad	9,335	
			Mir Khan Baloch		
			Pir Bukhsh		
			Humar Khan		
			Haji Jhangi Khan		
			Haji Ibrahim Goth		
			Haji Khan Zohrani		
	2d	Goth Mayo	Goth Mayo		
	2e	Muhammad Qasim	Muhammad Qasim		
			Ameen Muhammad Baloch		
			Allah Dino		

<sup>263</sup> Population estimated for Cluster 2d and 2e are provided from HBP previous studies conducted in the PQA Area.

<i>Zone</i>	<i>Cluster Number</i>	<i>Cluster Name</i>	<i>Villages Included</i>	<i>Estimated Population of the Cluster<sup>263</sup></i>	<i>Estimated Population Surveyed Settlements in each Zone</i>
Fishing/ Agriculture Communities	3	Bhambore Coastal Belt (Gharo-Dhabeji Area)	Goth Karam Ali Baloch	14,000	14,000
			Goth Ismail Katiyar		
			Goth Khuda Dino Sheikh		
			Goth Haji Natho		
			Goth Mohsin Khaskheli		
			Goth Abdul Ghani Baloch		
			Hashim Mirbehar		
Planned Housing Schemes	4a	Pipri	Shahnawaz Goth	45,000	45,000
			New Allah Bakhsh Goth		
			Mureed Gabol Goth		
			Khuda Bakhsh Goth		
			Ali Muhammad Jokhio Goth		
			Ali Bakhsh Baloch Goth		
			Suffan Gabol Goth		
			Dur Muhammad Goth		
			Muhammadi Colony		
			Pathan Goth		
			Nasserabad		
			Allah Bakhsh Goth		
	4b	Gulshan-e-Hadeed	Gulshan-e-Hadeed	130,800	130,800
			Steel Town		
<b>Total</b>				<b>396,395</b>	<b>396,395</b>

A large concentration of population occurs in the Fishing Communities due to primary dependence of the community on fishing in the creeks in PQA Area. This is followed by the Planned Housing Schemes primarily due to better availability of health, education and other social services.

The largest proportion of population for Karachi city is between 5–9 years old which decreases with 5 years interval.<sup>264</sup> There is no secondary data available on the age ratio for the Socioeconomic Zones inclusive of UC Dhabeji of Thatta District. Sex distribution (males per 100 population) was reported at 56% for Malir District.<sup>265</sup> The sex ratio for Thatta District was reported at 53% in the 1998 Census.

### **Households and Household Size**

A household comprises of a single or more persons including members who are related or unrelated but make common provision for food and other essentials and have no place of residence elsewhere. **Exhibit 6.14** provides cluster wise household sizes. Average household size is estimated at 6.3 persons per household.

**Exhibit 6.14:** Estimated Household Size of the Surveyed Clusters in the Study Area

<i>Zone</i>	<i>Cluster Number</i>	<i>Cluster Name</i>	<i>Villages Included</i>	<i>Household Size</i>
Fishing Communities	1a	Ibrahim Hyderi	Ibrahim Hyderi	7
		Ibrahim Hyderi		
	1b	Rehri Goth 1	Bakhtwar Goth	6
			Rehri Goth	
			Latt Basti	
	1c	Rehri Goth 2	Chasma Goth	6
			Ali M Brohi Goth	
			Ali M Khaskheli Goth	
Non-Fishing Communities	1d	Juma Goth	Juma Goth	6
	2a	Morand Khan Qaiserani	Morand Khan Qaiserani	7
	2b	Soomar Jokhio	Soomar Jokhio	7
	2c	Ghaghar Phattak	Haji Ghulam Muhammad	6
			Mir Khan Baloch	
			Pir Bukhsh	
			Humar Khan	
			Haji Jhangi Khan	
			Haji Ibrahim Goth	
			Haji Khan Zohrani	
	2d	Goth Mayo	Goth Mayo	6
	2e	Muhammad	Muhammad Qasim	6

<sup>264</sup> Information Management and Mine Action Programs, Al Hasan System Private Limited and United States Agency for International Development, "Pakistan Development Perspective, Development report, City District Karachi, Sindh" Islamabad, Pakistan.

<sup>265</sup> Ibid



Zone	Cluster Number	Cluster Name	Villages Included	Household Size
Fishing/ Agriculture Communities	3	Qasim  Bhambore Coastal Belt (Gharo-Dhabeji Area)	Ameen Muhammad Baloch	7
			Allah Dino	
			Goth Karam Ali Baloch	
			Goth Ismail Katiyar	
			Goth Khuda Dino Sheikh	
			Goth Haji Natho	
			Goth Mohsin Khaskheli	
			Goth Abdul Ghani Baloch	
Planned Housing Schemes	4a	Pipri	Hashim Mirbehar	5
			Shahnawaz Goth	
			New Allah Bakhsh Goth	
			Mureed Gabol Goth	
			Khuda Bakhsh Goth	
			Ali Muhammad Jokhio Goth	
			Ali Bakhsh Baloch Goth	
			Suffan Gabol Goth	
			Dur Muhammad Goth	
			Muhammadi Colony	
			Pathan Goth	
			Nasserabad	
			Allah Bakhsh Goth	
	4b	Gulshan-e- Hadeed	Gulshan-e-Hadeed	7
			Steel Town	
Average				6.3

The estimate of 6.3 persons per household is comparable to the household sizes reported on the basis of the 1998 census.<sup>266</sup>

#### 6.4.2 Religion, Ethnicity and Culture

The religions, castes, languages and ethnicities of an area help to distinguish groups within communities that share beliefs and cultural regimes and heritage.

##### **Religion**

The majority of the population (96%–97%) residing in and around the Study Area are Muslim. A small number of Christians and Hindus also reside in the area.<sup>267</sup>

<sup>266</sup> Based on the 1998 census, there are 6.2 persons/household in District Malir and 5.1 persons/household in District Thatta.

<sup>267</sup> Hagler Bailly Pakistan, "ESIA of Coal Power Plant (CPP) Project Fauji Fertilizer Bin Qasim Complex" Fauji Fertilizer Bin Qasim Limited, Bin Qasim, Karachi, February 19, 2014.

## Castes

Castes represented within the PQA Area include Mirbehar, Jat, Khaskheli, Syed, Baloch, Brohi, Larak, Musani, Punjwani, Waryani, Qasimani, Malkani, Shah, Kalmati, Khosa and Zohrani.<sup>268,269</sup>

## Cultural Sites and Tangible Cultural Heritage

There are three shrines located around the PQA Area. The Shrine of Shah Hasan is located at a distance of about 9 km to the east of Port Qasim, and Chaukhandi Tombs are located near urban settlement of Yousaf Goth. There is another shrine located on Bundal Island in Phitti Creek. The shrine is commonly known as Bundal Shah. The history and details of Bundal Shah are unknown, however, a gathering is held every year after Eid.

In addition to the above, there are other archeological sites located in the Study Area. A map providing location of these archeological remains is provided in **Exhibit 6.15**. Among these archeological remains, Bhambore and Allah Dino hold great significance due to findings and excavations carried out at these sites. Details of the findings from the excavations at these sites are provided below:<sup>270</sup>

### Bhambore

The Bhambore archeological site is situated about 50 km east of Karachi sharing its southern boundary with the Gharo Creek (see **Exhibit 6.16**). The site is comprised of a protected settlement, measuring about two thousand by one thousand feet, and an outer un-walled area (north of the city). The site was visited earlier by Henry Cousens, N.G. Majumdar and in 1951 by Leslie Alcock who carried out preliminary diggings. A large-scale excavation at Bhambore site was launched in 1958 under the direction of Dr. F.A. Khan and lasted till 1966. Investigations at the site have revealed substantial structural remains of stone with mud-brick superstructure and a formidable protection wall with semi-circular bastions around the city. During excavations from 1958 to 1966, the diggings were done at four major areas which revealed elaborate gateway system, domestic and public architecture and a grand mosque located in the middle of city. It is the earliest known mosque in Pakistan which is dated by Arabic inscriptions found in the mosque. Excavations have also yielded a very reliable cultural sequence along with rich collection of antiquities of the early Islamic and pre-Islamic periods going back to at least 1st century BC. The grand mosque or 'Jamia Masjid' discovered during excavations at Bhambore is historically the most significant building. It is built on more or less a square-plan, measuring 120 x 122 feet (L×W).

### Allah Dino

In the Malir River basin, along the northern extent of the Study Area, a group of at least three sites of the Indus Civilization existed namely, Arnilano on the Thano Bulla Khan

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<sup>268</sup> Human Development Foundation, "General Description of the District Malir" 350 Remington Road, Suite W, Schaumburg, IL 60173, Canada, 2004.

<sup>269</sup> Hagler Bailly Pakistan, "ESIA of Engro Vopak Terminal Limited (EVTL) Expansion Project", Port Qasim, Karachi, February 22, 2007.

<sup>270</sup> The details of Bhambore and Allah Dino archeological remains are drawn from: Muhammad Rafique Mughal, "The Archeology of Sindh (Since 1930), Updated Supplement to Antiquities of Sindh" Department of Culture, Government of Sindh, 1998.

road, Hasan Ali on a sandstone outcrop near Bazar Nadi, and Allah Dino or Nel Bazar (cluster 2e).

The site is about two meters above the surrounding alluvial plain and one hundred meters in diameter. Its location in a fertile belt of intensively cultivated flood plain of the Malir River offered a great promise of yielding evidence relating to subsistence activities of ancient populations and their relationships with contemporary village sites in the region. Allah Dino is also one of the sites covers an estimated area of one hectare.

Excavations at Allah Dino were started in 1974 and continued for nearly three seasons under the general direction of Walter A. Fairservis (1973; 1976 and 1982; and Shaffer 1974). A number of building remains of mud-brick over stone foundations were exposed. Among dwelling houses, industrial activities were marked by the presence of large kilns. In general layout and construction of houses, Allah Dino is a miniature model of a large urban center of the Indus Civilization.

The excavations revealed presence of two wells and a long drain provided interesting clues to the possible irrigation technique at such a small site. As the site is located in a very fertile valley, it is very likely that in ancient times also the population at Allah Dino and around depended on the fertility of this region for agricultural purpose.

Allah Dino also participated in the trade or exchange with the surrounding regions as indicated by the presence of ninety per cent of raw materials which could have been obtained within a radius of fifty kilometers around the site. For example, the source of flint is located within 7 km of Allah Dino. Shell and fish can be obtained in the Malir basin and from the Arabian Sea. Copper, agate, jasper and carnelian are found in the Lyari hills, Porali basin, Kohistan and the Hub River valley. The discovery of 10 kg of copper artifacts at this small site during excavations is astonishing. Only the gold and silver found at Allah Dino are not locally obtainable.

In terms of antiquities, Allah Dino proved to be a very rich site. More than 300,000 pieces of pottery, 24,000 terracotta bi-cones, 2,600 terracotta triangular cakes, 1,500 bangles and 196 pieces of copper and bronze were found. In addition, a jeweler cache of five necklaces of silver, carnelian, agate, jasper, and copper beads and eleven copper finger rings of coiled wire and a gold earring were found buried at one place under the floor.

The findings of the excavations and geological studies show that the people of Allah Dino raised cattle, goat, sheep and water buffalo and possibly used donkey. Wheat and barley have been found in the plant remains. A number of seals and graffiti containing the Indus script were also found.

### **Languages**

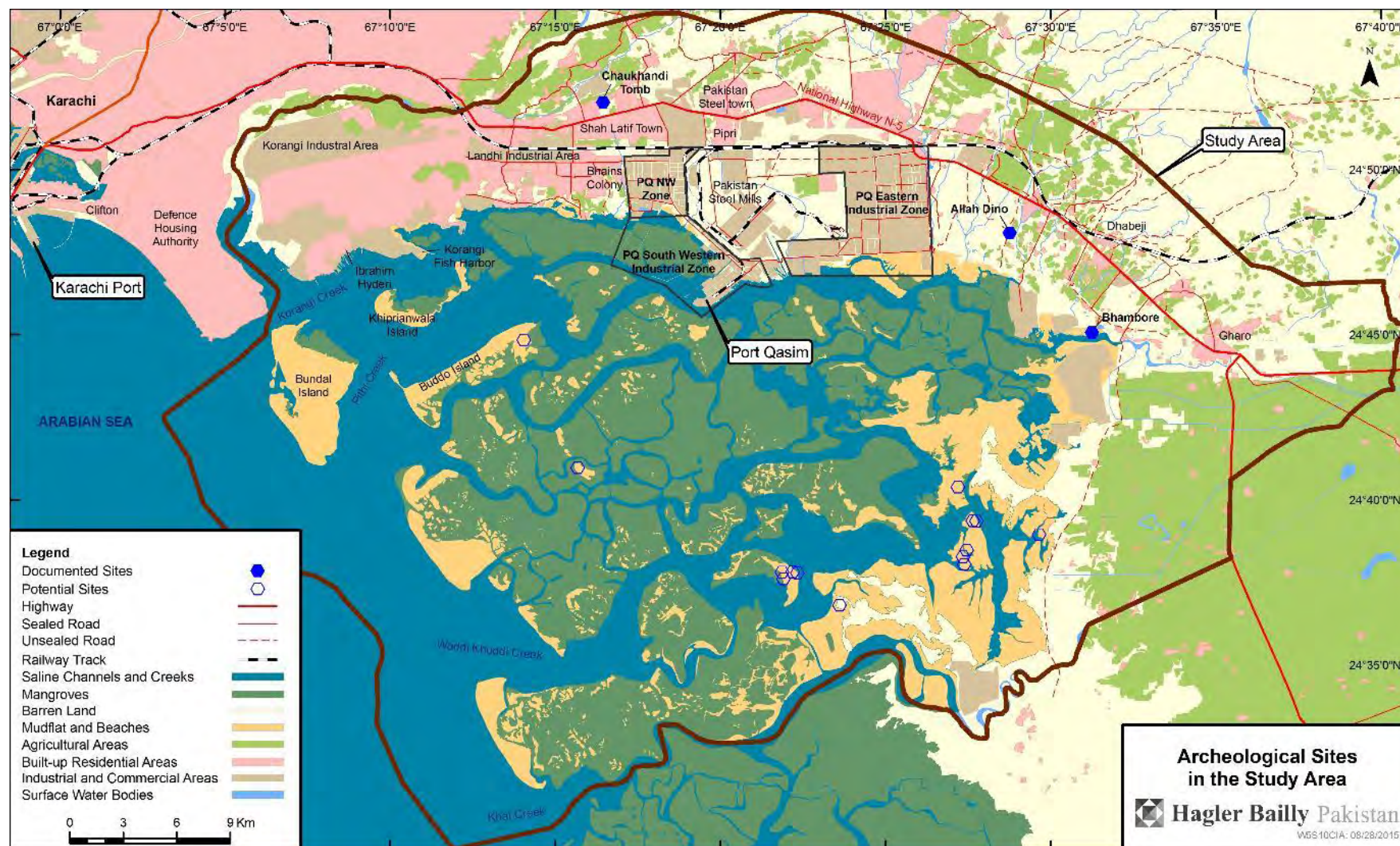
The two commonly spoken languages in the Socioeconomic Zones are Sindhi and Urdu.<sup>271</sup> Due to existence of a few Pakhtoon and Baloch settlements, a small number of people speak Pashtu and Balochi as well.<sup>272</sup>

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<sup>271</sup> Hagler Bailly Pakistan, "ESIA of Coal Power Plant (CPP) Project Fauji Fertilizer Bin Qasim Complex" Fauji Fertilizer Bin Qasim Limited, Bin Qasim, Karachi, February 19, 2014.

<sup>272</sup> The information was collected during the scoping visit to the PQA Area conducted on May 21–22, 2015.

**Exhibit 6.15: Archeological Sites in the Study Area**





**Exhibit 6.16:** Bhambore Archeological Site





### 6.4.3 Physical Infrastructure, Housing, and Services

The condition of infrastructure in Fishing, Non-Fishing and Fishing/Agriculture Communities is poorly developed. There are no police stations or check posts, and piped natural gas supply is not available.

The Planned Housing Schemes have relatively developed infrastructure. Steel Town, Gulshan-e-Hadeed and Pipri are all expanding semi-urban settlements with developed road networks and water and power supply systems. Photographs of the existing physical infrastructure of the Socioeconomic Zones are included in **Exhibit 6.3** to **Exhibit 6.6**.

#### **Housing and other Community Structures**

Most of the houses (nearly 62%) of the rural settlements in both Fishing Communities and Non-Fishing Communities, located to the west and northeast of the Port Qasim, are masonry structures, while the remaining are wood and straw huts.<sup>273</sup> The huts are in a poor condition and need repairs, especially after seasonal rains in the area. The housing in the Planned Housing Schemes comprises is of masonry construction only. Photographs of huts in the Socioeconomic Zones are provided in **Exhibit 6.17**.

Steel Town in Planned Housing Schemes has one *mandir* (temple) and one church offering prayer facility to the minorities in the area. Based on the survey conducted, the community infrastructure in the Zones and clusters is provided in **Exhibit 6.18**.

**Exhibit 6.17:** Huts in the Socioeconomic Zones



<sup>273</sup> Hagler Bailly Pakistan, "ESIA of Coal Power Plant (CPP) Project Fauji Fertilizer Bin Qasim Complex" Fauji Fertilizer Bin Qasim Limited, Bin Qasim, Karachi, February 19, 2014.

*Huts in the vicinity of Ibrahim Hyderii*



*An view of houses in Rehri Goth with Korangi Creek in the background*

**Exhibit 6.18:** Community Infrastructure

Zone	Cluster Number	Cluster Name	Community Infrastructure		
			Mosques/ Churches/Mandirs	Community Centers	Other
Fishing Communities	1a	Ibrahim Hyderi	22	8	2
	1b and 1c	Rehri Goth			
	1d	Juma Goth	4		1
<b>Total</b>			<b>26</b>	<b>8</b>	<b>3</b>
Non-Fishing Communities	2a	Morand Khan Qaiserani	1		
	2b	Soomar Jokhio	2		
	2c	Ghaghar Phattak	16		3
<b>Total</b>			<b>19</b>	<b>0</b>	<b>3</b>
Fishing/Agriculture Communities	3	Bhambore Coastal Belt (Gharo-Dhabeji Area)	18		1
<b>Total</b>			<b>18</b>	<b>0</b>	<b>1</b>
Planned Housing Schemes	4a	Pipri	25	1	2
	4b	Gulshan-e-Hadeed	20	2	4

Zone	Cluster Number	Cluster Name	Community Infrastructure		
			Mosques/ Churches/Mandirs	Community Centers	Other
			4	1	3
Total			49	4	9
Total (for all zones)			112	12	16

### **Road and Transportation**

Nearly all the settlements of the Socioeconomic Zones are connected with black top roads. However, the rural settlements of Latt Basti and Haji Mehmood Goth, categorized as Fishing Communities, connect to the black top roads through unsealed roads.<sup>274</sup> Pick-ups, private taxis and local buses and wagons provide services to the residents of the Socioeconomic Zones.<sup>275</sup>

### **Power and Natural Gas Supply**

The Planned Housing Schemes of the Socioeconomic Zones have well developed electricity and natural gas supply systems. All the households of settlements in Gulshan-e-Hadeed and Steel Town are connected with natural gas distribution network, whereas only 52% households in Pipri are connected to natural gas supply network.

In the Fishing Communities, 88% of the households reported access to natural gas, while remaining 12% of the households reported reliance on mangrove wood for cooking and heating purposes. In addition, commercial sale of mangrove wood was also reported.

The Non-Fishing and Fishing/Agriculture Communities do not have access to natural gas supply. They collect wood from mesquite forests and other vegetation in their surroundings to meet their heating and cooking requirements.

### **Water Supply**

Lack of clean drinking water is one of the major issues faced by the residents of Karachi city.<sup>276</sup> During the socioeconomic survey, it was noted that the water to the Fishing Communities, Planned Housing Schemes and the only settlement of Haji Ibrahim in Non-Fishing Communities is supplied by the Karachi Development Authority (KDA) through its supply system.

The respondents from Fishing Communities and Haji Ibrahim settlement in Non-Fishing Communities reported issues with water supply. The respondents said that their supply is sometimes cut for several days to meet the water requirements of Karachi city. During these days, the residents meet their water requirements through acquiring services of local hydrants supplying water in tankers on commercial basis.

<sup>274</sup> Hagler Bailly Pakistan, "ESIA of Coal Power Plant (CPP) Project Fauji Fertilizer Bin Qasim Complex" Fauji Fertilizer Bin Qasim Limited, Bin Qasim, Karachi, February 19, 2014.

<sup>275</sup> Hagler Bailly Pakistan, "ESIA of Coal Jetty, Shipping Lane and Ash Disposal Site for Pakistan Pot Qasim Electric Power Project 2×660 MW Coal Power Plant" Port Qasim Electric Power Company, Karachi, August 26, 2014.

<sup>276</sup> Daily Times, "Water Shortage Becomes Most Burning Issue", Thursday, June 4, 2015.

The remaining Non-Fishing Communities and Fishing/Agriculture Communities do not have access to piped water supply. They are mostly reliant upon water supply tankers for drinking water. The respondents from these communities reported water quality issues related to both available sources, namely water tankers and seasonal streams (rainfed nullahs).

The other source of water in the Socioeconomic Zones is groundwater, which is mostly brackish and not fit for drinking and mainly used for washing, bathing and cooking purposes.<sup>277</sup>

#### **6.4.4 Health and Education**

This section provides data on the existing status of health and education facilities in the Socioeconomic Zones.

##### **Education**

Education facilities in the Socioeconomic Zones consist of primary (up to 5<sup>th</sup> grade), secondary (up to 10<sup>th</sup> grade) and intermediate schools (up to 12<sup>th</sup> grade). The settlements of Ibrahim Hyderi in Fishing Communities and Steel Town in Planned Housing Schemes are the only settlements having separate government girls' and boys' colleges (up to 14<sup>th</sup> grade) providing higher education.

The two major settlements in Fishing Communities, Ibrahim Hyderi and Rehri Goth have girls' and boys' primary and secondary schools. The residents of the villages in the nearby surroundings of Rehri Goth visit colleges of either Ibrahim Hyderi or Karachi city located at an approximate distance of 5 km and 15 km from these villages.

Education facilities in the surveyed Non-Fishing Communities have primary, middle and secondary schools run by the provincial Education Department, Human Development Foundation (HDF), Fauji Fertilizer Bin Qasim Ltd. (FFBL) and Sindh Education Foundation (SEF).<sup>278</sup> The government provided educational facilities in the surveyed settlements comprise of six primary, two middle and two high schools located in Haji Ghulam Muhammad, Mir Khan Baloch, Morand Khan Qaiserani and Haji Khan Zohrani. The private educational facilities comprise of one primary school functioning under HDF. A primary school is also functioning under the SEF, located at Natho Tando Khoso settlement. FFBL has also established a girl's elementary school in Haji Jhangi Khan, where education up to class eight is provided to girls. Most of the schools are co-educational. For college level education, the residents of these communities mostly visit higher education institutions in Karachi city with the nearest institute located at a distance of 35 km from the communities.

The Planned Housing Schemes have well-developed education facilities including public and private primary, secondary and high schools. There are also separate girls' and boys' colleges operating in Steel Town offering higher education to the residents.

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<sup>277</sup> Hagler Bailly Pakistan, "ESIA of Coal Jetty, Shipping Lane and Ash Disposal Site for Pakistan Pot Qasim Electric Power Project 2×660 MW Coal Power Plant" Port Qasim Electric Power Company, Karachi, August 26, 2014.

<sup>278</sup> The Sindh Education Foundation (SEF) was established in 1992 as a semi-autonomous organization to undertake educational initiatives in the disadvantaged areas of Sindh. SEF provides communities with direct access to educational facilities by opening schools through its various endeavors.

Only two government primary schools are located in Goth Karam Ali Baloch and Goth Khuda Dino Sheikh in Fishing/Agriculture Communities. Dhabeji town, located at an approximate distance of 10 km from Goth Karam Ali Baloch and 4 km from Goth Khuda Dino Sheikh is the only developed settlement proximal to these communities. Dhabeji has both government and private primary and secondary schools. For higher education, the residents of these communities visit colleges in Mirpur Sakro located at an approximate distance of 25 km from these settlements.

Due to budgetary constraints, quantitative data on the enrollment, drop outs, teachers' strength and regularity was not recorded. The secondary data on these aspects for the Socioeconomic Zones is also not available.

For university level education, the residents UCs of the Bin Qasim Town visit universities located in Karachi city, while those of UC Dhabeji in District Thatta mostly visit universities in Hyderabad and Jamshoro.

### **Health**

Health facilities in the Socioeconomic Zones are reported to be inadequate and lack of technical medical staff and absence of doctors from duty has resulted in poor health status of the communities in the Socioeconomic Zones.

The health centers of the Fishing Communities are limited to Ibrahim Hyderi and Rehri Goth with only government and private health centers functioning in the area. The residents of these communities visit health centers including public and private hospitals located in Karachi city at a distance of about 15 km.

Of the surveyed Non-Fishing Communities, three settlements, namely Haji Ghulam Muhammad, Haji Jhangi Khan and Haji Khan Zohrani have access to community health center located at Haji Khan Zohrani settlement. The facility was established by FFBL and is operated by an HDF. In case of serious ailments, the inhabitants of the Non-Fishing Communities have access to the private clinics and hospital located in Pipri, Gulshan-e-Hadeed and Pakistan Steel Town, respectively. These facilities are, on average, located at a distance of about 7 km from these communities. In case of emergencies and serious illness, the inhabitants head to Jinnah Hospital located at an approximate distance of 40 km in Karachi city. The Fishing/Agriculture Communities do not have access to any public or private health facility in their vicinity. The closest basic health center is located at an approximate distance of 10 km from these communities.

During the socioeconomic survey, questions were asked to identify the most common diseases prevailing in the surveyed clusters. List of reported diseases along with the cluster numbers is provided in **Exhibit 6.19**. The findings show that considerable number of cases of malaria and hepatitis have occurred in the communities of the Study Area. The respondents reported lack of clean drinking water and discharge of untreated waste and sewerage as the key factors contributing to degrading health conditions of the area.



**Exhibit 6.19:** Reported Diseases and their Occurrence per Cluster in the Socioeconomic Zones

Reported Diseases	Number of Clusters Reported	Fishing Communities				Non-Fishing Communities			Fishing/ Agriculture Communities	Planned Housing Schemes	
		Cluster 1a	Cluster 1b	Cluster 1c	Cluster 1d	Cluster 2a	Cluster 2b	Cluster 2c	Cluster 3	Cluster 4a	Cluster 4b
Blood Pressure	1	✓									
Diabetes	2	✓									✓
Diarrhea	5	✓	✓	✓		✓		✓	✓		
Hepatitis B and C	6		✓	✓		✓		✓	✓		✓
Gastrointestinal Disorders	1									✓	
Kidney Disorders	2					✓				✓	
Malaria	7		✓	✓	✓		✓		✓	✓	✓
Respiratory Diseases	3						✓	✓			✓
Seasonal Fever	1							✓			
Skin Diseases	3	✓	✓			✓					
Typhoid	5		✓	✓	✓		✓		✓		

#### 6.4.5 Livelihood and Assets

A number of important industrial zones of Pakistan are located within or adjacent to the Study Area. Communities in the Socioeconomic Zones have access to employment and wage labor opportunities in the industrial areas. The sources of livelihood identified through the settlement-level socioeconomic survey are provided in **Exhibit 6.20**.

Presently, the primary sources of livelihood (shown in **Exhibit 6.20**) for the residents of communities located in the Socioeconomic Zones are as follows:

- ▶ *Fishing Communities* – Fishing is a primary source of livelihood for over 72% of the households in the Fishing Communities. Main fishing areas include the Korangi, Phitti, Khuddi, Khai, Paichiani and Dabbo Creeks. Almost all of these households provide fishing labor on boats owned by others. About 4% of the households are dependent on fishing related employment such as boat building. The remaining households (24%) engage in wage labor on daily basis for boat and net building and repair, and fish processing inside the settlements and in the industrial areas.
- ▶ *Non-Fishing Communities* – Majority of the households in these settlements are dependent on non-fishing wage labor as primary source of livelihood. About 65% of the households are engaged in wage labor in various industrial areas such as Landhi and Korangi, while 16% provide wage labor in the PQA industrial zones<sup>279</sup>. About 18% of the households are also small business owners (hotels and shops), and a small number is employed in government services.
- ▶ *Fishing/Agricultural Communities* – The livelihoods of communities in the UC Dhabeji are split between fishing labor, wage labor and farm labor. About 38% of the households provide fishing labor on boats operating in the Gharo, Dhabeji and Bhambore Creeks. Only 2% of the households fish on self-owned boats. The livelihoods of remaining households are split almost equally between non-fishing wage labor in Gharo and Dhabeji towns, and farm labor.
- ▶ *Planned Housing Schemes* – The livelihoods of these communities are equally dependent on non-fishing wage labor and employment in industrial zones of PQA, Pakistan Steel Mills, and Landhi and Korangi. All households in the Pakistan Steel Mills Town are employed in the Pakistan Steel Mills, while the households in Pipri and Gulshan-e-Hadeed engage in wage labor inside and outside the PQA industrial zones.

In addition, the household survey revealed that a small number of residents in the Fishing/Agriculture Communities (5 to 6 households approximately) are involved in salt production from seawater in operations located southeast of Gharo.

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<sup>279</sup> Reported employers include Engro Fertilizer, Fauji Fertilizer, Lotte Pakistan and local contractors providing laboring and security services to the industries in the PQA Area.

**Exhibit 6.20: Primary Sources of Livelihood (% of households)**

<i>Livelihood</i>	<i>Fishing Communities</i>	<i>Non-Fishing Communities</i>	<i>Fishing/ Agriculture Communities</i>	<i>Planned Housing Schemes</i>
Fishing (own boats)	4%	–	2%	–
Fishing (labor)	68%	–	38%	–
Boat Building/Repair	4%	–	–	–
Non-Fishing Wage Labor (employment as daily wage labor in towns of Gharo and Dhabeji and other businesses)	24%	65%	32%	54%
Employment in PQA and Pakistan Steel Mill	–	16%	–	46%
Government Employment	–	1%	–	–
Small Business (Hotel/Shop)	–	18%	–	–
Farm Labor	–	–	29%	–
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

The household survey conducted as part of this assessment shows that the average income of households engaged in fishing ranges from PKR 7,000 to PKR 20,000 per month, depending upon the size of boat, boat ownership and fish catch. As general sharing arrangement, half of the total catch goes to the boat owner while the income generated from the other half is equally divided among the fishing labor. Average crew size is 20 persons on a 24 ft boat and 45 persons on boats exceeding 32 ft. Average income of the households providing wage labor is PKR 10,000 per month (see **Appendix D** section **D.5.1**).

On the basis of the average household income of the communities residing in the Socioeconomic Zones of the Study Area, the per capita income for the communities is estimated to be PKR 2,551 per month (see **Appendix D** section **D.5.1**).

The workers at salt production facilities located in the vicinity of the Fishing/Agriculture Communities are mostly daily wage employees with an average daily wage of PKR 500.

Households in the Socioeconomic Zones are mostly dependent on a single source of income. The settlement level socioeconomic survey reveals that a small percentage of households in the Fishing Communities (around 15%) have a secondary source of income as well, shown in **Exhibit 6.21**. These include boat building, net making, fish processing, wood selling and tourism in mangroves. It is important to note that almost all of these livelihoods are fishing related; while a small number (tourism and wood selling) are dependent on the mangroves. The involvement of women in income generating activities is minimal in the Fishing Communities, with almost no involvement in other zones.

In Rehri, key informants from the local community based organization reported that almost 150 women run small food businesses out of their houses (selling tea and specific

food items), and a small number of women are also involved in shrimp peeling. However, neither of these activities are the main income sources for the households.

**Exhibit 6.21: Secondary Sources of Livelihood for Fishing Communities**

<i>Livelihood</i>	<i>% of HHs</i>
Boat-building/repair	4%
Net-making/repair	3%
Wood-cutting and selling	< 1%
Fish-processing	7%
Tourism in mangroves	< 1%
Wage Labor (other than above)	9%

The percentage division of type of livelihood in the Socioeconomic Zones (see **Exhibit 6.20**) indicates that 72% of the Fishing Communities and 40% of the households from Fishing/Agriculture Communities are involved in fishing and fishing related income generating activities (fishing labor, boat and making and repair, fish processing and tourism). Therefore, fishing is identified as one of the major source of livelihood for these communities.

To estimate the fish catch in the area and its economic value, information on number of operating boats in the Socioeconomic Zones and fishing activities with respect to the number and type of boats was determined. Following sections provide summary of the estimated fishing boats and fish catch in the Socioeconomic Zones.

**Fishing Boats**

During the survey, the respondents were asked about the size and estimated number of boats of each size in their respective clusters. The reported number of boats was then verified through Google Imagery for 2015. Reported boat size, associated net type and the cost of boats by size and net by type are provided in **Exhibit 6.22**.

**Exhibit 6.22: Commonly Found Boats and Fishing Nets in Socioeconomic Zones**

<i>Boat Size (in feet)</i>	<i>Type of Fishing Net by Boat Size</i>	<i>Estimated Cost of Boat (in PKR)<sup>280</sup></i>	<i>Estimated Cost of Fishing Net (in PKR)</i>
12 and Below	Thukri Net and Bulla Gujja (commonly used in mangrove areas to catch shrimp, trash fish and fish for food)	35,000	20,000–25,000 <sup>281</sup>
Between 12-18	Thukri Net (commonly used in mangrove areas to catch shrimp, trash fish and fish for food)	70,000	

<sup>280</sup> The prices are inclusive of engine costs.

<sup>281</sup> Thukri net is made by knitting small pieces with the help of ropes and wires. Each piece costs around 900 PKR. A commonly used net is made by knitting 20 to 25 pieces together on average. The cost is inclusive of other items used to make a Thukri net including ropes, metal weights and synthetic wires to knot the pieces. A Thukri net only lasts for one season and is replaced by a new one every year.

<i>Boat Size (in feet)</i>	<i>Type of Fishing Net by Boat Size</i>	<i>Estimated Cost of Boat (in PKR)<sup>280</sup></i>	<i>Estimated Cost of Fishing Net (in PKR)</i>
Between 18-24	Thukri Net (commonly used in mangrove areas to catch shrimp, trash fish and fish for food)	500,000	
Above 24	Katra (wire) Net and Trawl Net (commonly used in open sea to catch trash fish)	1,000,000	500,000– 1,000,000 <sup>282</sup>

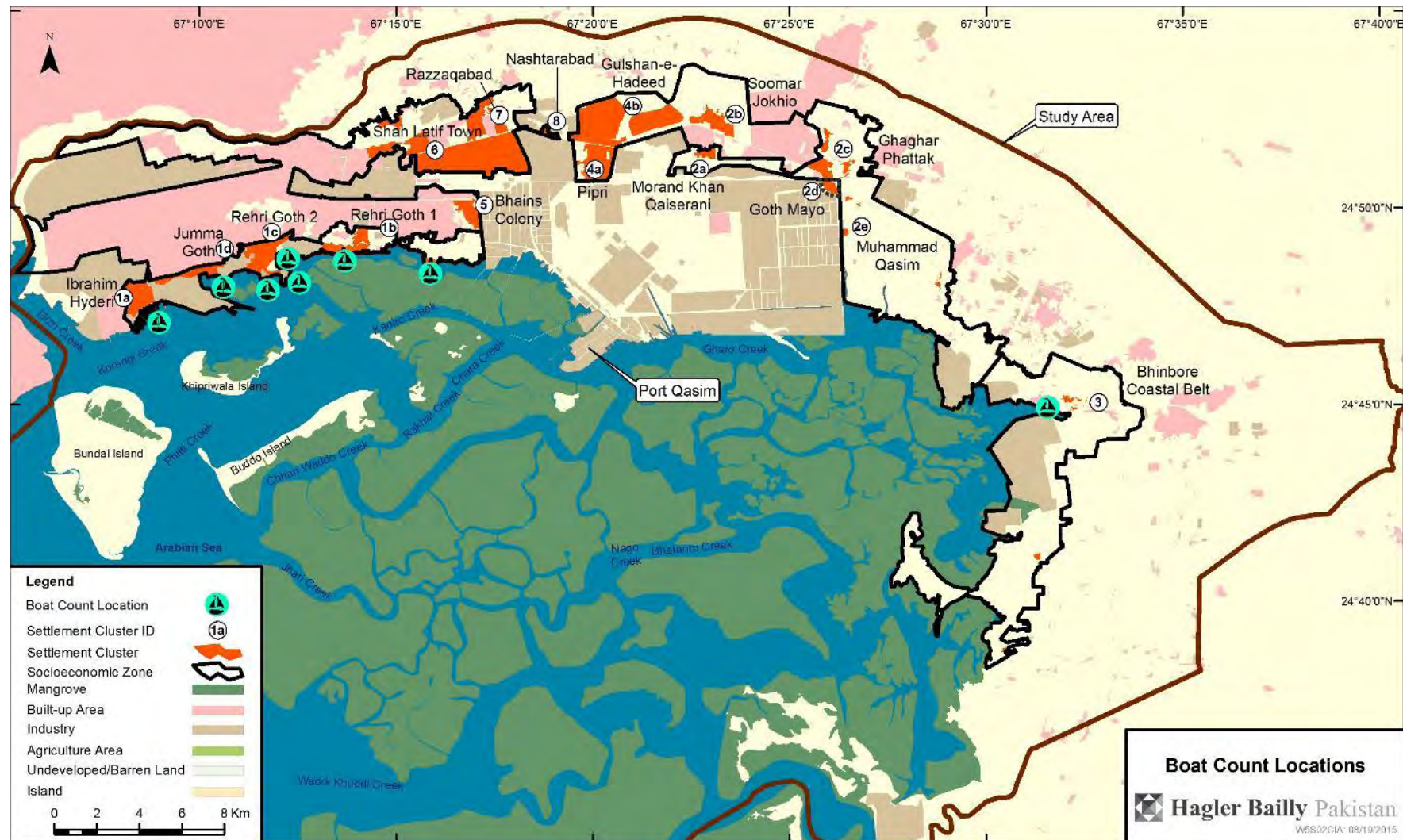
The locations for which the boat counts were recorded during the survey and then verified are shown on a map in **Exhibit 6.23**. **Exhibit 6.24** provides the estimated operating-boat count for each cluster in fishing and Fishing/Agriculture Communities of the Socioeconomic Zones, while **Exhibit 6.25** provides the percentages of boats by boat size. The photographs of the boats taken during socioeconomic survey are provided in **Exhibit 6.26**.

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<sup>282</sup> Katra or wire net and trawl nets are large size nets with sizes reaching up to 6,000 meters. These nets are also made by joining small pieces. These nets are used in open sea (approximately 12 nautical miles and beyond from land) and only requires timely repair and maintenance. Worn out and damaged pieces are replaced by new ones with an average cost of 3,000 PKR of each piece.



**Exhibit 6.23: Boat Count Locations with Respect to Clusters of the Socioeconomic Zones**



**Exhibit 6.24:** Estimated Number of Operating Boats in Relevant Clusters of the Socioeconomic Zones

<i>Zones</i>	<i>Cluster Number</i>	<i>Cluster Name</i>	<i>Count Location</i>	<i>Latest Date of count</i>	<i>12 ft and below</i>	<i>12 ft – 18 ft</i>	<i>18 ft – 24 ft</i>	<i>above 24 feet</i>	<i>Total (for the year)</i>
Fishing Communities	1a	Ibrahim Hyderi	Jetties of Ibrahim Hyderi	May 22, 2015	31	247	576	824	1,678
	1b	Rehri Goth 1	Latt Basti	June 10, 2015	0	17	41	58	116
	1b	Rehri Goth 1	Coastal Belt of Rehri Goth	June 10, 2015	0	104	242	345	690
	1b	Rehri Goth 1	Korangi Fish Harbor (west)	June 10, 2015	0	9	22	32	63
	1c	Rehri Goth 2	Chashma Goth	April 17, 2015	0	14	34	48	96
	1c	Rehri Goth 2	Boats Yard	April 20, 2015	0	6	13	19	37
	1c	Rehri Goth 2	Ali M Brohi	April 17, 2015	0	5	12	17	33
	1d	Juma Goth	Jetty to the south of Juma Goth	June 5, 2015	0	29	68	97	194
Fishing/Agriculture Communities	3	Bhambore Coastal Belt	Bhambore Landing Point	October 22, 2014	0	4	40	0	44
<b>Total (for clusters)</b>					<b>31</b>	<b>435</b>	<b>1,047</b>	<b>1,438</b>	<b>2,951</b>

**Exhibit 6.25: Percentage of Boats by Boat Size**

Zones	Cluster Number	Cluster Name	%age of Boats from size 12 ft and below	%age of Boats from size 12 ft – 18 ft	%age of Boats from size 18 ft-- 24 ft	% of boats above 24 Feet	Total
Fishing Communities	1a	Ibrahim Hyderi	2%	15%	34%	49%	100%
	1b	Rehri Goth 1	0%	15%	35%	50%	100%
	1b	Rehri Goth 1	0%	15%	35%	50%	100%
	1b	Rehri Goth 1	0%	14%	35%	51%	100%
	1c	Rehri Goth 2	0%	15%	35%	50%	100%
	1c	Rehri Goth 2	0%	16%	35%	51%	100%
	1c	Rehri Goth 2	0%	15%	36%	52%	100%
	1d	Juma Goth	0%	15%	35%	50%	100%
Fishing/ Agriculture Communities	3	Bhambore Coastal Belt	0%	9%	91%	0%	100%



**Exhibit 6.26: Photographs of Boats from the Socioeconomic Zones**



*A Typical 24 feet boat at Ibrahim Hyderi*



*A view of the main jetty at Ibrahim Hyderi*



*Fishermen preparing to leave for fishing on a typical 24 feet boat*



*18 feet boats near Rehri Goth*



### **Fishing in the Socioeconomic Zones**

Fishing is the major source of income for communities residing along the shoreline of Korangi Creek (Fishing Communities located in the northwest of the Study Area), and among the major sources of income for Fishing/Agriculture Communities to the south of Gharo Creek. The fishermen from the Fishing Communities make most of their trips in the Korangi, Phitti, Khuddi, Khai, Paichiani and Dabbo Creeks as well as in the open sea to catch fish and shrimp, while fishermen residing in Fishing/Agriculture Communities rely upon Bhambore and Gharo Creeks for fishing. Almost all the fishermen in the Socioeconomic Zones are working as fishing labor, with only a small number of fishermen owning boats (4% in Fishing Communities and 2% in Fishing/Agriculture Communities). As a result, the fishermen have low income levels; the boat owners keep the major share of the catch proceeds, with the remaining being divided amongst the fishermen providing labor on the boats.

Findings of the socioeconomic survey and discussions with key informants in the Fishing and Fishing/Agriculture Communities indicate that there are three major launching and landing sites in the Socioeconomic Zones. These include:

- ▶ **Ibrahim Hyderi** – fishing trips are made by fishermen from Ibrahim Hyderi and small fishing villages in its vicinity in the Fishing Communities. It is the largest of the three landing sites with an estimated 12 jetties operating in the settlement. Fishing trips from Ibrahim Hyderi are made by small boats into the creeks and mangrove areas, as well as in the open sea by large boats.
- ▶ **Rehri** – fishing trips are made by fishermen from Rehri Goth, Bakhtawar Goth, Chashma Goth, Ali M Brohi Goth, Ali M Khaskheli Goth and Latt Basti in the Fishing Communities. Fishing trips from Rehri are made by small boats in the creeks and mangrove areas, as well as in the open sea by large boats. Rehri Goth and its neighboring villages have approximately 9 operating jetties facilitating fishing in the area.
- ▶ **Bhambore** – fishing trips made by fishermen from the Fishing/Agriculture Communities. Fishermen from this area only fish on smaller boats in the creeks and mangrove areas, and a small number of fishermen also wade in shallow creeks to catch shrimp.

Depending on the catch, the landing sites are either the jetties from where the fishing trips originate, or the Korangi and Karachi Fish Harbors if the catch is bigger.

**Exhibit 6.27** shows the marine fish catch in Sindh province since 1947, along with a break-down between shell fish and finfish since 1993.<sup>283</sup> Total fish catch increased from 1947 onwards. However, a general decreasing trend in catch is observed after 1993. The decrease is attributed a reduction in the quantity of fin fish caught.

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<sup>283</sup> The data for the analysis of fishing the Socioeconomic Zones is obtained from Marine Fishery Department, MFD, Government of Sindh, Pakistan.

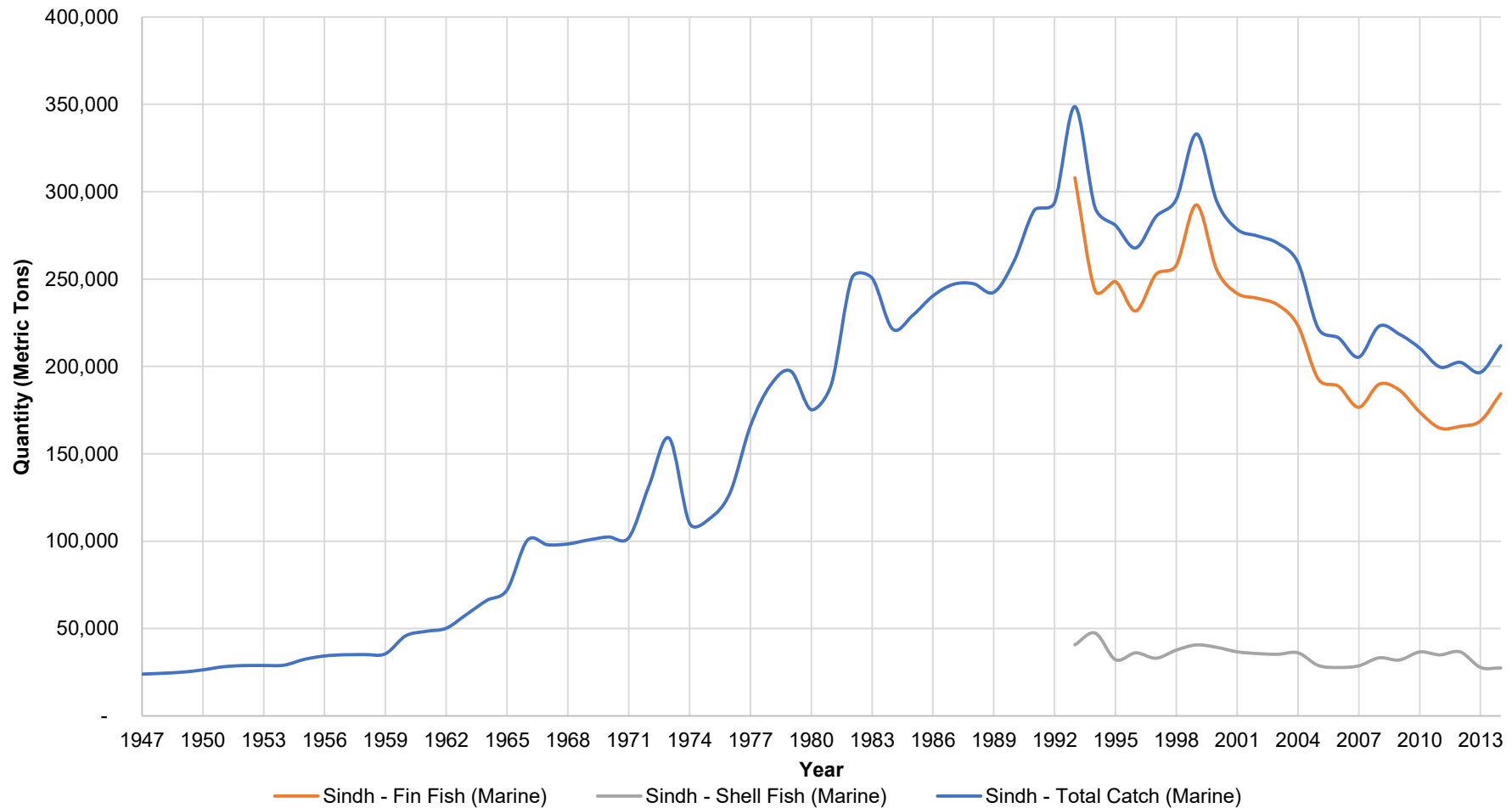
**Exhibit 6.28** shows the number of operating boats in Sindh province. A comparison of the number of operating boats in 2014 in Sindh with data from **Exhibit 6.24** indicates that roughly 33% of operating boats in Sindh have trips originating in the Socioeconomic Zones.<sup>284,285</sup> The percentage of marine species by catch in Sindh province is provided in

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<sup>284</sup> To verify the boat counts in whole Sindh province and reconcile it with the MFD data, Google Imagery was used to calculate the boats for all the key fishing locations in Sindh including fish harbor at Karachi Port Terminal, Keti Bandar, Shah Bandar, Mubarak Village and Shams Peer. The total boat count for the whole province estimates to 8,594 boats. Due to negligible difference between estimated boat count and boat count provided by MFD (8,920 boats), the value of 33% is calculated using the boat count from MFD data.

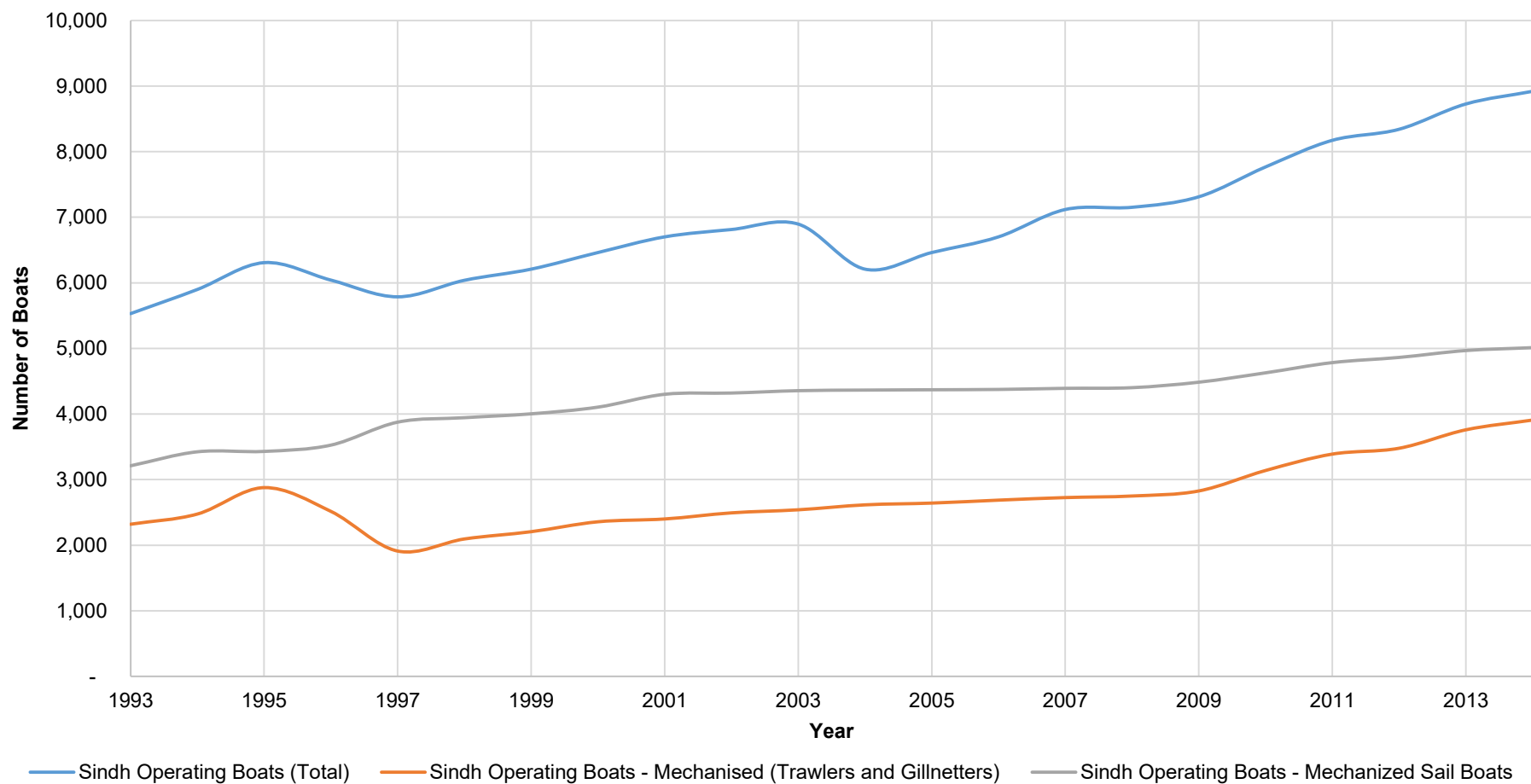
<sup>285</sup> 2951/8920

**Exhibit 6.27: Marine Fish Catch in Sindh**



Source: Marine Fisheries Department

**Exhibit 6.28: Boats Operating in Sindh**



Source: Marine Fisheries Department

**Exhibit 6.29: Percentage of Marine Species by Catch in Sindh**

<i>Species</i>	<i>Percent of Total Catch (2011)</i>	<i>Percent of Total Catch (2012)</i>	<i>Percent of Total Catch (2013)</i>	<i>Percent of Total Catch (2014)</i>
<b><i>Small Pelagics</i></b>	<b>19.5%</b>	<b>20.0%</b>	<b>21.8%</b>	<b>23.6%</b>
Shads	0.1%	0.1%	0.2%	0.2%
Sardinellas	5.9%	6.0%	5.6%	5.6%
Misc. Clupeoids	5.6%	5.6%	5.0%	5.7%
Thryssa	2.3%	2.3%	3.1%	3.0%
Scads	0.6%	0.7%	0.6%	0.6%
Indian Mackerel	5.0%	5.3%	7.2%	8.3%
<b><i>Demersals</i></b>	<b>44.4%</b>	<b>44.1%</b>	<b>44.2%</b>	<b>44.2%</b>
Sharks	1.1%	1.1%	1.1%	1.0%
Guitarfishes	0.1%	0.1%	0.1%	0.1%
Rays	2.0%	2.0%	1.9%	1.7%
Wolf Herrings	0.3%	0.3%	0.2%	0.2%
Bombay Duck	0.0%	0.0%	0.0%	0.0%
Catfish	6.9%	7.2%	5.7%	5.7%
Eels	0.8%	0.9%	0.8%	0.8%
Threadfin Breems	1.4%	1.5%	2.2%	2.8%
Barracudas	1.9%	2.0%	1.6%	1.4%
Mulletts	3.5%	3.0%	3.2%	2.7%
Groupers	3.3%	3.4%	3.3%	3.0%
Croakers	3.8%	3.5%	3.3%	3.0%
Silver Whittings	0.2%	0.2%	0.2%	0.2%
Cobia	0.5%	0.5%	0.6%	0.5%
Queenfish	2.2%	1.7%	2.6%	2.5%
Travellies	0.8%	0.8%	0.6%	0.6%
Snappers	0.7%	0.8%	0.6%	0.5%
Grunts	0.2%	0.2%	0.3%	0.4%
Emperors	0.1%	0.1%	0.1%	0.1%
Threadfin	0.1%	0.1%	0.1%	0.1%
Misc. Sea Breems	0.9%	0.9%	0.9%	0.9%
King Soldier bream	0.7%	0.7%	0.6%	0.5%
Ribbonfish	3.5%	3.5%	3.6%	3.5%
White Pomferts	0.8%	0.9%	0.8%	0.7%



<i>Species</i>	<i>Percent of Total Catch (2011)</i>	<i>Percent of Total Catch (2012)</i>	<i>Percent of Total Catch (2013)</i>	<i>Percent of Total Catch (2014)</i>
Soles	1.1%	1.1%	1.1%	0.9%
Black Pomfrets	1.1%	1.1%	1.1%	1.0%
Others	6.5%	6.5%	7.8%	9.4%
<b>Large Pelagics</b>	<b>18.6%</b>	<b>18.6%</b>	<b>19.8%</b>	<b>19.3%</b>
Dolphin fish	0.4%	0.4%	0.4%	0.5%
Spanish Mackerels	2.0%	2.0%	2.1%	2.3%
Tunas	15.5%	15.4%	16.4%	15.7%
Sailfish	0.7%	0.8%	0.9%	0.9%
<b>Shellfish</b>	<b>17.5%</b>	<b>17.3%</b>	<b>14.1%</b>	<b>13.0%</b>
White Shrimps	1.4%	1.4%	1.2%	1.1%
Pink/Brown Shrimps	3.2%	3.2%	2.5%	2.3%
Kiddy Shrimps	4.0%	4.0%	3.2%	2.9%
Lobsters	0.1%	0.1%	0.2%	0.1%
Crabs	4.1%	4.1%	1.8%	1.8%
Ivory Shells	0.2%	0.2%	0.2%	0.2%
Cephalopods	3.7%	3.6%	4.2%	3.9%
Jellyfish	0.5%	0.5%	0.5%	0.3%
Razor clam	0.1%	0.1%	0.1%	0.1%
Clams	0.2%	0.2%	0.2%	0.3%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>

To estimate the catch by boats originating in the Socioeconomic Zones using the data of Marine Fishery Department (MFD), the total fish catch of the whole Sindh province was multiplied with the percentage of boats in the Socioeconomic Zones (33%). Estimated fish catch from the fishing trips originating from the Socioeconomic Zones of the Study Area is provided in **Exhibit 6.30**.

**Exhibit 6.30:** Estimated Fish Catch from Trips Originating in Socioeconomic Zones, Metric Tons

<i>Species</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>2014</i>
<b>Small Pelagics</b>	<b>12,851</b>	<b>13,397</b>	<b>14,202</b>	<b>16,521</b>
Shads	84	88	155	170
Sardinellas	3,884	4,022	3,643	3,928
Misc. Clupeoids	3,676	3,754	3,279	4,004
Thryssa	1,522	1,571	2,022	2,128

<i>Species</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>2014</i>
Scads	411	438	401	440
Indian Mackerel	3,274	3,525	4,701	5,852
<b><i>Demersals</i></b>	<b><i>29,329</i></b>	<b><i>29,503</i></b>	<b><i>28,774</i></b>	<b><i>30,984</i></b>
Sharks	718	765	691	712
Guitarfishes	73	84	70	99
Rays	1,296	1,327	1,228	1,171
Wolf Herrings	169	186	154	152
Bombay Duck	13	15	14	13
Catfish	4,550	4,818	3,679	4,008
Eels	552	580	546	529
Threadfin Breems	929	996	1,430	1,942
Barracudas	1,261	1,328	1,051	963
Mullets	2,312	1,990	2,065	1,922
Groupers	2,195	2,276	2,131	2,117
Croakers	2,533	2,356	2,167	2,123
Silver Whittings	125	133	149	140
Cobia	330	331	377	333
Queenfish	1,431	1,135	1,667	1,725
Travellies	517	537	372	397
Snappers	474	507	403	382
Grunts	140	149	172	253
Emperors	66	67	66	90
Threadfin	63	67	97	88
Misc. Sea Breems	589	614	579	603
King Soldier bream	437	447	363	346
Ribbonfish	2,283	2,337	2,310	2,422
White Pomferts	548	574	553	520
Soles	698	738	687	621
Black Pomfrets	731	764	692	724
Others	4,294	4,382	5,062	6,589
<b><i>Large Pelagics</i></b>	<b><i>12,311</i></b>	<b><i>12,444</i></b>	<b><i>12,882</i></b>	<b><i>13,521</i></b>
Dolphinfish	252	266	268	322
Spanish Mackerels	1,319	1,346	1,386	1,613
Tunas	10,248	10,326	10,638	10,980

<i>Species</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>2014</i>
Sailfish	493	507	589	606
<b>Shellfish</b>	<b>11,562</b>	<b>11,604</b>	<b>9,181</b>	<b>9,085</b>
White Shrimps	923	940	812	775
Pink/Brown Shrimps	2,114	2,128	1,654	1,613
Kiddy Shrimps	2,624	2,651	2,088	2,025
Lobsters	98	100	103	92
Crabs	2,689	2,723	1,148	1,235
Ivory Shells	132	133	136	172
Cephalopods	2,459	2,383	2,716	2,711
Jellyfish	323	333	327	222
Razor clam	58	66	55	62
Clams	143	149	142	176
<b>TOTAL</b>	<b>66,054</b>	<b>66,948</b>	<b>65,038</b>	<b>70,110</b>

On the basis of the estimated number of boats at the landing sites, the total catch for the year 2014 (70,110 metric tons) was allocated to landing sites in the Socioeconomic Zones. The estimated catch by landing site is provided in **Exhibit 6.31**.

**Exhibit 6.31: Estimated Fish Catch per Landing Site**

<i>Landing Site</i>	<i>Estimated Catch per Landing Site (Metric tons)</i>	<i>Percentage of Catch per Landing site (%)</i>
Ibrahim Hyderi	39,866	57
Rehri	29,199	42
Bhambore	1,045	1
<b>Total</b>	<b>70,110</b>	<b>100</b>

The respondents reported that the boat size exceeding 24 ft make trips to the open sea for fishing. The rest of the boats (size below 24 ft) focus on the creeks/mangroves for fishing (see **Section 6.4.5** for details on operational boats in the Socioeconomic Zones). On the basis of this information and division of boat count by size provided in **Exhibit 6.24** and **Exhibit 6.25**, the fish catch with respect to the fishing locations (creeks/mangroves and open sea) was estimated. The results are provided in **Exhibit 6.32** and **Exhibit 6.33**.

**Exhibit 6.32:** Estimated Fish Catch by Fishing Locations

<i>Landing Site</i>	<i>Fishing Location</i>	<i>Fish Catch (in metric tons)</i>	<i>% of Fish Catch</i>
Ibrahim Hyderi	Mangrove	20,301	28.96
	Open Sea	19,565	27.91
Rehri	Mangrove	14,599	20.82
	Open Sea	14,599	20.82
Bhambore	Mangrove	1,045	1.49
	Open Sea	0	
<b>Total</b>		<b>70,110</b>	<b>100</b>

**Exhibit 6.33:** Estimated Distribution of Fish Caught by Communities Living  
in Study Area

<i>Fishing Location</i>	<i>% age of Catch</i>
Mangroves	51
Open Sea	49

The results show that mangrove areas account for about half of the fish caught by the communities living in the Study Area, and are therefore providing an important ecosystem service. The Fishing and Fishing/Agriculture Communities are dominated by small fishermen with limited resources who cannot afford large fishing boats and more costly fishing trips to open sea. On the other hand, the large fishing boats manage to catch greater quantity of fish in the open sea as compared to small boats operating in mangrove area.

The majority of the fish catch at all three landing sites is sold immediately on landing to fish brokers who are present at the jetties. A small number of fishermen at Ibrahim Hyderi also sell to hotels and processing factories within the settlement and take their catch to markets outside the settlement. Similarly a small number of fishermen at Rehri take their catch to markets in Karachi, and those in Bhambore sell some of their catch in markets in Gharo and Dhabeji towns. The fish catch is transported to the market or hotels using donkey carts, Suzuki pickups or two-axle mini trucks. Commonly used carriers to transport fish to the market are shown in **Exhibit 6.34**.

**Exhibit 6.34: Commonly used Carriers for Transportation of Fish Catch**



*Commonly used Suzuki Pick-Ups for transportation of fish catch*



*Donkey carts used for transportation of fish catch to nearby markets*





Two-axle mini trucks used for transporting fish catch to Karachi Fishery

### **Estimated Value of Catch of Fish, Shrimp, and Crab from Mangroves**

The information on the value of catch for fish, shrimp and crab has been estimated on the basis of the following:

- ▶ interviews with key respondents, which mostly included seasoned fishermen of the Fishing and Fishing/Agriculture Communities,
- ▶ the total number of operating boats at their respective jetties, sizes of boats, average catch by specie for each size of boat,
- ▶ fishing areas with respect to the boat size (boats with length 24 feet and below operate in mangroves, while boats exceeding size of 24 feet make fishing trips to open sea),
- ▶ Data supplied by the Marine Fisheries Department (see **Exhibit 6.30**)

#### **Fish**

The total fish catch from the Socioeconomic Zones, including fish for food and trash fish (fish used in manufacturing process of dairy and poultry feed), is estimated to be 61,026<sup>286</sup> metric tons in 2014. It was difficult to connect the common English names used by MFD for data compilation with the local names used in the market. An independent estimate for fish catch using socioeconomic data including catch per boat and number of

<sup>286</sup> Estimated on basis of MFD Data; see **Exhibit 6.30** with shellfish excluded.

boat trips in a year from different landing areas is presented in **Appendix D** section **D.5.2**. The estimate for fish catch arrived at in this manner is 86,172 metric tons in 2014.

Fish catch can be divided into two main groups in terms of its market value, food fish and trash fish. Average market value of food fish is estimated at Rs 787/kg, on the basis of weighted average price of fish in the market as listed in **Appendix D** section **D.5.2**. The corresponding price of trash fish is Rs 16/kg, which is dried and milled for use as poultry feed. Total fish catch of 61,026 metric tons, as derived from the MFD data, was apportioned into food fish and trash fish on the basis of data collected through socioeconomic survey. Fish catch was estimated at 14,107 metric tons for food fish and 46,919 metric tons for trash fish. Applying the market rates for these categories of fish, the annual market value of the fish caught in the Study Area is estimated at PKR 7,332 million.

### Shrimp

Reliable data could not be collected for shrimp catch through the socioeconomic survey. Applying an average market rate of PKR 787/kg<sup>287</sup> for the total of 4,413 metric tons of shrimp estimated on the basis of MFD data for three types of shrimp reported (**Exhibit 6.30**), the annual market value of shrimp catch is estimated at PKR 3,473 million.

### Crabs

The MFD does not provide data for crab catch. From the surveyed Fishing and Non-Fishing Communities, a small number of fishermen reported catching crabs. Fishermen who catch crabs are concentrated in Ali Muhammad Brohi, Ali M Khaskheli and Chashma Goth in Fishing Communities and Goth Hashim Mirbehar in Fishing/Agriculture Communities. The fishermen identified mangroves as the major sites for catching crabs. Crab catch is estimated at 34,131 kg as calculated from the data recorded during the socioeconomic survey. The annual market value of crab catch is estimated at PKR 7.8 million.

### **Reported Reasons for Change in Fishing Locations and Fish Catch**

All settlements in the Fishing Communities and Fishing/Agriculture Communities reported a change in their fishing locations (creeks) in the past 5 years. The main reason given for this was a decrease in population of fish (**Exhibit 6.35**) as reported by 71% of the settlements. About 29% of the settlements have had to change their fishing locations as they no longer have access due to the development of PQA jetties and shipping lanes. The movement of large cargo carrying vessels has forced the fishermen to fish in deep seas, increasing their fishing cost and reducing their profit margins.

The reasons for decreased catch of fish over the past 5 years include unsustainable fishing practices (the use of illegal nets), increase in number of fishermen, and discharge of sewage and industrial pollutants in the creeks (**Exhibit 6.36**).

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<sup>287</sup> Market rate varies from PKR 300 to PKR 1,200 per kg depending on the size and quality of shrimp.

**Exhibit 6.35: Reasons for Change in Fishing Locations (Creeks)**

<i>Reasons</i>	<i>% Settlements</i>
Decrease in Number of Fish	71%
Development of PQA	29%
Both	14%

**Exhibit 6.36: Reasons for Decreasing Catch of Fish**

<i>Reasons</i>	<i>% Settlements</i>
Discharge of Sewage in Creeks and Pollution	29%
Increased number of fishermen	43%
Unsustainable fishing practices (illegal nets)	71%

***Wage Labor, Fishing and other Businesses***

Eleven percent of the non-fishing households in the coastal communities are also dependent on fishing related activities such as fish processing, net making and boat making. Almost 90% of the businesses in the Fishing Communities are related to fishing (boat owners, fish brokering, net making, boat making) as shown in **Exhibit 6.37**. The photographs showing boat and net making in the Socioeconomic Zones are provided in **Exhibit 6.38**.

Settlement level surveys indicate that there are around 2,600 businesses/enterprises in the Study Area. The nature of these businesses varies across the different zones of the Study Area as shown in **Exhibit 6.37**. Half of these businesses are located in the Fishing Communities of which 65% are boat owners who hire crews for fishing, and 25% are shops and hotels. The remaining are split almost evenly between fish brokering, tourism, boat making, net making, money lending and wood selling. Almost all of the businesses in the Non-Fishing Communities are shops and hotels. The majority of businesses in the Fishing/Agriculture Communities are agriculture related. In Planned Housing Schemes, 67% of the businesses are shops and hotels, and 25% sell fuel wood mainly collect from mesquite and other terrestrial vegetation adjacent to these communities.

**Exhibit 6.37: Businesses in the Study Area**

<i>Type of Business</i>	<i>Proportion of Total Number of Businesses</i>			
	<i>Fishing Communities</i>	<i>Non-Fishing Communities</i>	<i>Fishing/ Agriculture Communities</i>	<i>Planned Housing Schemes</i>
Fishing (boat owners hiring labor)	65%	-	9%	-
Fish Brokering	1%	-	1%	-
Hotel	7%	6%	2%	24%
Shop	18%	90%	5%	43%
Tourism/ Recreational Fishing	2%	-	-	-
Boat Making	<1%	-	-	-
Net Making	2%	-	-	-
Wood Selling	2%	1%	3%	25%
Money Lending	3%	-	-	-
Other Businesses	-	2%	81%	8%
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

**Exhibit 6.38: Boat and Net Making/Repair in the Socioeconomic Zones**



*Net Making at Ibrahim Hyderi*





*Net making at Rehri Goth*



*A distant view of boat building yard at Ibrahim Hyderi*





*Boat building yard at Rehri Goth*

Korangi and Landhi Industrial Areas are home to Pakistan's' largest textiles, pharmaceutical, cosmetic, steel, chemical, automobile and flour mill industries. These industries provide multifaceted job opportunities to the residents of the communities located in their immediate vicinity.<sup>288,289,290</sup> The residents of the urban communities located to the west of Port Qasim are employed in industries within the Korangi and Landhi industrial areas. While residents of urban and Non-Fishing Communities located to the north of the Port Qasim are employed as both permanent and daily wage labor in the industries of PQA area.<sup>291</sup>

**Exhibit 6.39** shows the proportion of households in each zone that are involved in wage labor, and where they provide this labor. Wage labor by Fishing Communities is mostly provided within the settlements, with the exception of Juma Goth where 10% of the households provide wage labor in the PQA industrial zones and 80% in other areas of Karachi such as Landhi and Korangi.

Non-Fishing Communities have a high dependence on wage labor, with 100% households in Morand Khan Qaiserani and Ghaghar Phattak working as wage labor.

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<sup>288</sup> Environmental Management Consultants "ESIA of Proposed LNG Import Terminal Project" Elengy Terminal Pakistan Limited, Port Qasim, Karachi, January 2014.

<sup>289</sup> Landhi Association of Trade and Industry. Source: [www.landhi.org](http://www.landhi.org). Accessed on June 03, 2015.

<sup>290</sup> Korangi Association of Trade and Industry, Source: [www.kati.pk](http://www.kati.pk). Accessed on June 03, 2015

<sup>291</sup> Environmental Management Consultants "ESIA of Proposed LNG Import Terminal Project" Elengy Terminal Pakistan Limited, Port Qasim, Karachi, January 2014.

Majority of these households are working as labor in the industrial areas of Landhi and Korangi, with a small number working in the PQA industrial zones.

Wage labor in Fishing/Agricultural Communities differs as a large proportion of the households involved are providing agricultural labor within the settlement. A smaller number of households also work as wage labor in industrial areas of Karachi.

Planned Housing Schemes of Pipri and Gulshan-e-Hadeed have a high dependence on wage labor, almost 30% of which is provided in the PQA industrial area. The other 70% is provided in the industrial areas of Landhi and Korangi.

**Exhibit 6.39: Proportion of Households Dependent on Wage Labor**

Cluster	% HH Providing Wage Labor	Location		
		Inside Settlement	Inside PQA	Other Areas in Karachi
Fishing Communities				
Ibrahim Hyderi (1a)	15%	15%		
Rehri Goth (1) (1b)	38%	38%		
Rehri Goth (2) (1c)	35%	35%		
Juma Goth (1d)	90%		10%	80%
Non-Fishing Communities				
Morand Khan Qaiserani (2a)	100%		6%	94%
Soomar Jhokio (2b)	90%		10%	80%
Ghaghar Phattak (2c)	85%		15%	70%
Fishing/Agriculture Communities				
Goth Karam Ali Baloch (3)	100%	90%		10%
Hashim Mirbehar (3)	50%			50%
Planned Housing Schemes				
Pipri (4a)	100%		30%	70%
Gulshan-e-Hadeed (4b)	100%		35%	65%

#### 6.4.6 Livestock

The respondents were asked about their dependence on livestock farming for both subsistence and commercial purposes. Questions were asked about the estimated number of livestock in each cluster, average cost of existing livestock, and their grazing practices.

The fodder in nearly all the clusters is either purchased for market or collected from mesquite forests and other terrestrial vegetation in the Socioeconomic Zones. A portion of fodder is also purchased from market. Only the residents of Rehri Goth identified mangroves of Korangi Creek as a fodder source. The reported number of livestock in

each cluster is provided in **Exhibit 6.40**, while the average cost of each livestock item (in PKR) is given below:

- ▶ Camel: 180,000
- ▶ Bullock/Buffalo: 125,000
- ▶ Cow: 80,000
- ▶ Goat: 10,000
- ▶ Sheep: 8,000
- ▶ Donkey: 25,000
- ▶ Horse: 80,000

**Exhibit 6.40: Reported Number of Livestock in Socioeconomic Zones**

Zone	Cluster Number	Cluster Name	Livestock						
			Camel	Bullock/ Buffalo	Cow	Goat	Sheep	Donkey	Horse
Fishing Communities	1a	Ibrahim Hyderi	4	375		280		65	2
	1b and 1c	Rehri Goth		230	410	500		68	
	1d	Juma Goth		100	25	150		15	5
<b>Total</b>			<b>4</b>	<b>705</b>	<b>435</b>	<b>930</b>	<b>0</b>	<b>148</b>	<b>7</b>
Non-Fishing Communities	2a	Morand Khan Qaiserani			3		35		
	2b	Soomar Jokhio				35			
	2c	Ghaghar Phattak		120	105	245			
<b>Total</b>			<b>0</b>	<b>120</b>	<b>108</b>	<b>280</b>	<b>35</b>	<b>0</b>	<b>0</b>
Fishing/Agriculture Communities	3	Binbore Coastal Belt (Gharo-Dhabeji Area)		100	350	500	200	20	
<b>Total</b>			<b>0</b>	<b>100</b>	<b>350</b>	<b>500</b>	<b>200</b>	<b>20</b>	<b>0</b>
Planned Housing Schemes	4a	Pipri		1,200	1,500	1,000		100	
	4b	Gulshan-e-Hadeed							
<b>Total</b>			<b>0</b>	<b>1,200</b>	<b>1,500</b>	<b>1,000</b>	<b>0</b>	<b>100</b>	<b>0</b>
<b>Total (for all zones)</b>			<b>4</b>	<b>2,125</b>	<b>2,393</b>	<b>2,710</b>	<b>235</b>	<b>268</b>	<b>7</b>

#### 6.4.7 Law and Order

The overall law and order situation of Karachi is poor. A targeted operation is currently being conducted by Rangers and Pakistan Police in different areas of Karachi to deal with the militant groups causing chaos and terror in the city.<sup>292</sup>

The Planned Housing Schemes and Non-Fishing Communities, due to their considerable distance from the Karachi city, are relatively peaceful. Very few incidents of snatching and robbery are reported in these areas.<sup>293</sup> However, the security in, communities of the Socioeconomic Zones located in the immediate vicinity of Korangi and Landhi industrial areas including Razzaqabad, Nashtarabad and Shah Latif Town (see **Exhibit 6.2**), is poor. The Korangi area is home of militant group ‘Harkat ul-Jihad al-Islami (HuJI), Arakan’ that is reportedly engaged in special trainings of Jihadis and their activists are also involved in sectarian violence and terrorism.<sup>294</sup> Another terrorist group ‘Jundullah’ is reported to be operating in Landhi area. The youth of the militant group is reported to be involved in bank robberies, ransom, car snatching and target killing.<sup>295</sup>

#### 6.5 Overview of Community Dependence on Ecological Resources

The mangrove forest in Pakistan provide important ecosystem services including habitat and breeding ground for economically important marine life and migratory birds; protecting coastline and sea ports from erosion and siltation; meet fuel wood and fodder requirements of local communities, act as natural physical barrier to cyclones and typhoons and provide livelihood to a coastal population of more than 100,000 people.<sup>296</sup>

Communities in the Socioeconomic Zones are dependent on the ecological resources, specifically mangroves in a number of different ways. The settlement level socioeconomic survey shows that this includes livelihoods as discussed in **Section 6.5** (fishing in mangroves), fodder, fuel, recreation and protection from hazards.

The livelihoods of the Fishing Communities are almost entirely dependent (75% of households) on fishing and fishing related activities, with little diversification of income sources **Exhibit 6.20**). 51% of the fish catch in these communities comes from the creeks and mangrove areas (**Exhibit 6.33**). In the Fishing/Agriculture Communities, 40% of the households are dependent entirely on fishing in the creeks and mangrove areas (**Exhibit 6.20**).

In the Fishing Communities, a small number of households in Rehri Goth collect fodder from the mangroves for their livestock and 12% of the households are dependent on wood collected from the mangroves for fuel use. These households cannot afford to pay for a piped gas connection. A small number of households (less than 1%) in Ibrahim

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<sup>292</sup> Saqib Nisar, The Express Tribune, “Karachi Law and Order Situation Heading Towards Chaos: Chaudhry Nisar” Karachi, February 13, 2014.

<sup>293</sup> Hagler Bailly Pakistan, “ESIA of Coal Power Plant (CPP) Project Fauji Fertilizer Bin Qasim Complex” Fauji Fertilizer Bin Qasim Limited, Bin Qasim, Karachi, February 19, 2014.

<sup>294</sup> Pakistan Institute of Peace Studies, “Report: Profiling the Violence in Karachi” July–September, 2009.

<sup>295</sup> Pakistan Institute of Peace Studies, “Report: Profiling the Violence in Karachi” July–September, 2009.

<sup>296</sup> Sawaid Abbas et al, “An assessment of status and distribution of mangrove forest cover in Pakistan” Journal of Biodiversity and Environmental Sciences (JBES), ISSN: 2222-3045 (online), Vol. 3, No. 6, 2013. P64–78.

Hyderi are also dependent on wood from the mangroves for fuel. All settlements in the Non-Fishing Communities and Fishing/Agriculture Communities use wood from Mesquite for fuel (either collected or bought from the market). Photographs of the fuel wood collected from mangroves in the Socioeconomic Zones are provided in **Exhibit 6.41.**

The mangroves also provide a place for recreation and relaxation for the communities in the Study Area. All settlements in the Fishing Communities, Planned Housing Schemes and half of the settlements in the Non-Fishing Communities report that they visit the creeks occasionally to carry out recreational activities in the mangroves and other islands. Recreation activities include the festival of Shah Hasan, picnics, fishing and hunting.

**Exhibit 6.41: Mangroves cut as Fuel Wood**



*Mangroves cut at as Fuel Wood (left of the photograph)*





*A pile of mangrove wood for sale at Ibrahim Hyderi Main Jetty*

All settlements in the Fishing and Fishing/Agriculture Communities, as well as a few from the Non-Fishing Communities and Planned Housing Schemes (Pipri mostly) have suffered losses from rains, flooding, ocean storms and cyclones. As shown in **Exhibit 6.42**, the occurrence of flooding due to rains is more frequent, with 43% of the settlements experiencing this every year. The occurrence of ocean storms and cyclones is less frequent. Interviews with key informants and the settlement survey indicate that the communities strongly believe the mangroves provide some protection from natural hazards by reducing the intensity of ocean storms and cyclones.

**Exhibit 6.42:** Reported Proportion of Settlements Affected by Natural Hazards

<i>Natural Hazard</i>	<i>% of Settlements Experiencing Once Every Year</i>	<i>% of Settlements Experiencing Once Every 2 - 4 Years</i>
Rainfall/Floods	43%	21%
Cyclones/Ocean Storms	21%	43%

**Exhibit 6.43** lists the identified ecosystem services, and the degree dependence of the community groups on ecosystem services. Prioritized ecosystem services based on community dependence and magnitude of impact of Developments are provided in the associated Ecosystem Service Review report (HBP Ref: D5E01CIA).

**Exhibit 6.43:** Dependence of Communities on Ecosystem Services

High  Medium  Low  Very Low/None

<i>Ecosystem Service Area</i>	<i>Impacted Ecosystem</i>	<i>Ecosystem Service Potentially Impacted by PQA Development</i>	<i>Dependence of Fishing Communities</i>	<i>Dependence of Non-Fishing Communities</i>	<i>Dependence of Fishing/Agriculture Communities</i>	<i>Dependence of Planned Housing Schemes</i>
Food from crops, livestock, capture, fisheries, aquaculture, and wild foods.	Mangrove	Food from fish	High	None	High	None
Food from crops, livestock, capture, fisheries, aquaculture, and wild foods.	Mangrove	Food from shrimp	High	None	High	None
Erosion control	Mangrove	Mangrove swamps prevent erosion by locking in soils.	High	None	High	None
Water purification and waste treatment	Mangrove	Mangroves absorb heavy metals and utilize nutrients in wastewaters.	High	None	High	None
Regulation of natural hazards	Mangrove	Mangroves prevent damage from oceanic storms and cyclones	High	None	High	None
Habitat	Mangrove	Habitats as a supporting service, supports other services such as food (fish, shrimp, etc.) from the mangrove ecosystem.	High	None	High	None
Regulation of soil quality	Mangrove	Mangrove swamps prevent movement of and lock contaminated soils.	Medium	None	High	None
Pollination	Mangrove	Insects from mangroves may provide pollination for crops.	None	None	High	None
Biomass fuel	Terrestrial	Mesquites used as fuel wood	None	Medium	Medium	Low
Food from crops, livestock, capture, fisheries, aquaculture, and wild foods.	Mangrove	Food from crab	Medium	None	Medium	None

<i>Ecosystem Service Area</i>	<i>Impacted Ecosystem</i>	<i>Ecosystem Service Potentially Impacted by PQA Development</i>	<i>Dependence of Fishing Communities</i>	<i>Dependence of Non-Fishing Communities</i>	<i>Dependence of Fishing/Agriculture Communities</i>	<i>Dependence of Planned Housing Schemes</i>
Regulation of estuarine flows and dynamics	Mangrove	Mangroves regulate the flow of water through the estuary and control sedimentation and erosion rates	High	None	None	None
Ethical and spiritual values	Mangrove	The mangrove areas provide aesthetic values.	High	None	None	None
Nutrient cycling	Mangrove	Nutrient cycling as a supporting service supports other services such as water purification and waste treatment within the mangrove ecosystem.	High	None	None	None
Primary production	Mangrove	Primary production is a supporting service, supports other services such as food (fish, shrimp, etc) from the mangrove ecosystem.	High	None	None	None
Food from crops, livestock, capture, fisheries, aquaculture, and wild foods.	Terrestrial	Mesquites and other terrestrial vegetation used as source of fodder	Very Low	None	Medium	Low
Biomass fuel	Mangrove	Wood for burning extracted by local communities	Low	None	Very Low	None
Recreation and ecotourism	Mangrove	Mangrove areas are used for recreational fishing, and tourists visit Buddo and Bundal Islands.	Low	None	Very Low	None
Food from crops, livestock, capture, fisheries, aquaculture, and wild foods.	Mangrove	Fodder for animals is extracted by some local communities, and camels graze in the area.	Very Low	None	Very Low	None
Food from crops, livestock, capture, fisheries, aquaculture, and wild foods.	Mangrove	Food from honey	Very Low	None	None	None
Educational and inspirational values	Mangrove	There are some school field trips on Buddo and Bundal Island.	Very Low	None	None	None

<i>Ecosystem Service Area</i>	<i>Impacted Ecosystem</i>	<i>Ecosystem Service Potentially Impacted by PQA Development</i>	<i>Dependence of Fishing Communities</i>	<i>Dependence of Non-Fishing Communities</i>	<i>Dependence of Fishing/Agriculture Communities</i>	<i>Dependence of Planned Housing Schemes</i>
Biological raw materials from timber and other wood products, fibers and resins, animal skins, sand, and ornamental resources.	Mangrove	Dredging sand and clays are utilized by Developments for land reclamation along shore.	None	None	None	None
Freshwater	Terrestrial	Groundwater utilized by local communities and companies in the area.	None	None	None	None
Regulation of local, regional, and/ or global climate	Mangrove	Mangroves regulate climate locally, regionally and globally.	None	None	None	None

Based on the above, the most significant ecosystem services with respect to communities which clearly stand out are:

#### Fishing and Fishing/Agriculture Communities

- ▶ Food from crops, livestock, capture fisheries, aquaculture, and wild foods – fish and shrimps, supporting livelihood of the local fishermen.
- ▶ **Erosion control** – as mangrove swamps prevent erosion by locking in soils, preventing increased sea water turbidity triggered by erosion which can possibly affect the marine fishery resources.
- ▶ **Water purification and waste treatment** – as mangroves absorb heavy metals and utilize nutrients in wastewaters, providing suitable habitat to marine fishery resources of the creeks of PQA Area.
- ▶ **Regulation of natural hazards** – as mangrove prevent damage from oceanic storms and clones, preventing damage to fishing boats playing a positive role in supporting livelihood of the local fishermen, and protection to the communities against string oceanic currents.
- ▶ **Habitat** – habitats are critical in providing food and support other ecosystem services. Mangroves, in this case provides suitable habitat t marine fishery resources of the Study Area.
- ▶ **Regulation of estuarine flows and dynamics** – mangroves regulate the flow of water through the estuary and control sedimentation and erosion rates.
- ▶ **Ethical and spiritual values** – as mangroves supports fish breeding and maturity providing positive aesthetic value to the marine fishery resources of the creeks of PQA Area.
- ▶ **Nutrient cycling** – providing support services such as water purification and waste treatment within the mangrove ecosystem supporting fish population.
- ▶ **Primary production as a supporting service supports services likes food from fish, shrimps and crabs** – mangroves provide habitat and essential nutrients to juvenile fish and shrimp during their growth period.
- ▶ **Regulation of soil quality** – especially along the shoreline, preventing cutting and erosion of shoreline by saline sea water, supporting the agriculture practices of the Fishing/Agriculture Communities.

#### Non-Fishing Communities and Planned Housing Schemes

- ▶ **Biomass fuel**, collected form terrestrial ecosystem, mainly from mesquite forests and other terrestrial vegetation including thorny bushes in the surroundings of these communities.

As mentioned previously, the prioritized ecosystem services, based on impact of PQA Developments as well as dependence of communities are provided in the associated Ecosystem Service Review report (HBP Ref: D5E02CIA).



## 6.6 Absolute Vulnerability

To ascertain the absolute vulnerability status of the communities, a vulnerability matrix (included in **Appendix D** section **D.5.3**) was filled in discussion with key informants at each settlement as a part the settlement level socioeconomic survey. Each settlement was ranked from Level 1 to Level 6 based on their current status for the following aspects of vulnerability:

- ▶ Access to social services – health and education facilities
- ▶ Out migration – as an indicator of inability to cope with vulnerability
- ▶ Economic opportunities – availability of fishing activities and dependence on wage labor
- ▶ Assets – boats and livestock
- ▶ Mobility – ownership of means of transportation by households
- ▶ Disaster preparedness and response

Level 1 indicates critically vulnerable, while Level 6 indicates resilient. The Levels are defined in **Exhibit 6.44** below. Definition of level of vulnerability for each aspect of vulnerability is provided in Item 11, ‘Vulnerability’, of the Settlement Level Questionnaire included in **Appendix D** section **D.4.4**.

**Exhibit 6.44: Levels of Vulnerability**

<i>Level</i>	<i>Vulnerability Level</i>
Level 1	Critically Vulnerable
Level 2	Highly Vulnerable
Level 3	Vulnerable
Level 4	Moderately Vulnerable
Level 5	Moderately Resilient
Level 6	Resilient

**Exhibit 6.45** shows the levels of vulnerability in the Socioeconomic Zones. The highest levels of vulnerability were observed in the Non-Fishing Communities, followed by the Fishing Communities and Fishing/Agriculture Communities. The Planned Housing Schemes have relatively lower level of vulnerability in comparison to populations in other Socioeconomic Zones studied. **Appendix D** Section **D.5.3** provides settlement wise vulnerability ranking with respect to the Vulnerability Matrix.

**Exhibit 6.45: Vulnerability Levels in Study Area**

Zone	Vulnerability Level							
	Access to Social Services	Out Migration	Economic Opportunities	Access to Credit	Assets	Mobility	Disaster Preparedness and Response	Overall Vulnerability Level
Fishing Communities	Moderately Resilient	Resilient	Moderately Vulnerable	Moderately Vulnerable	Highly Vulnerable	Vulnerable	Critically Vulnerable	Vulnerable
Non Fishing Communities	Highly Vulnerable	Moderately Resilient	Critically Vulnerable	Moderately Vulnerable	Highly Vulnerable	Critically Vulnerable	Critically Vulnerable	Highly Vulnerable
Fishing/ Agriculture Communities	Highly Vulnerable	Moderately Resilient	Vulnerable	Moderately Vulnerable	Vulnerable	Critically Vulnerable	Highly Vulnerable	Vulnerable
Planned Housing Schemes	Moderately Resilient	Moderately Vulnerable	Critically Vulnerable	Resilient	Vulnerable	Moderately Resilient	Moderately Vulnerable	Moderately Vulnerable

Color Coding: Red – Critically Vulnerable, Brown – Highly Vulnerable, Yellow - Vulnerable

### **Access to Social Services**

Vulnerability with respect to access to Education and Health Services in the Fishing Communities and Planned Housing Schemes is ranked as ‘Moderately Resilient’. Details on the types of health and facilities available are presented in **Section 6.4.4**. A ‘Moderately Resilient’ categorization can be attributed to a large population size of these settlements, allowing for more attention by the Government to establish basic health and education facilities. Their proximity to Karachi also allows them to have easier access to hospitals and higher education facilities. Private and NGO run schools are also present in Ibrahim Hyderi and Rehri. However, discussions with key informants and information collected in the household survey show that majority of the adults in these settlements are not educated. Only 20% of the adults (18 years and above) in the surveyed households reported that they had received some level of education (mostly primary). The importance of education and sending children to school is a recent phenomenon with 50% of the children (5-18 years) in surveyed households enrolled in schools.

Non-Fishing and Fishing/Agriculture Communities are made up of smaller scattered settlements and are located at some distance from Karachi. Due to their size and remoteness, they are ‘Highly Vulnerable’ in accessing education and health facilities. Whereas as basic primary education facilities were found to be within access of settlements in Non-Fishing Communities, settlements in Fishing/Agriculture Communities do not have government primary schools within easy access. All the settlements in these communities (with the exception of Haji Ghulam Muhammad) do not have any basic health facility. As there are no government hospitals close-by, the communities often have to pay large sums for private health care, adding pressure on their already stressed financial situation. According to the household survey, households in the Socioeconomic Zones spend an average of PKR 3,000 per month on household expenses. This is almost 50% of the income of households dependent on fishing, and 30% of the income of households dependent on wage labor (see **Appendix D** section **D.5.1**).

### **Out Migration**

Migration patterns during the last 10 years have not had an impact on the vulnerability of the communities in the Socioeconomic Zones. As shown in **Exhibit 6.46**, there has been very little in-migration in Fishing Communities and Fishing/Agriculture Communities. A small number of households that have migrated in the last 10 years have done so to pursue fishing, and employment in salt production factories in UC Dhabeji.

A higher number of households have migrated out to the Non-Fishing and Planned Housing Schemes in the last 10 years. In the Non-Fishing Communities, the reason is their proximity to Gulshan-e-Hadeed, which has some health and education facilities. Households migrating to the Planned Housing Schemes Communities have done so to mainly pursue employment at the industrial zones of PQA and Pakistan Steel Mills.

**Exhibit 6.46:** Migration Patterns for Last 10 Years

Zone	% of Households	
	In-Migration	Out-Migration
Fishing Communities	6%	1%
Non-Fishing Communities	20%	9%
Fishing/Agriculture Communities	10%	21%
Planned Housing Schemes	29%	20%

### ***Economic Opportunities***

Economic Opportunities include the availability of fishing activities and dependence on wage labor in the Socioeconomic Zones. As discussed in the section on Livelihoods, most households in the Fishing Communities and Fishing/Agriculture Communities are able to secure work as labor on fishing boats, thus making them Moderately Vulnerable and Vulnerable respectively. The household survey reveals that only 14% of the surveyed households in the Fishing Communities and 30% in the Fishing/Agriculture Communities are earning an income from more than one type of occupation (see **Appendix D** section **D.5.1**). The Non-Fishing and communities residing in Pipri settlement in Planned Housing Schemes are mostly dependent on wage labor making them Critically Vulnerable.

### ***Access to Credit***

All Zones rank Moderately Vulnerable in accessing credit. The Planned Housing Schemes Communities in the Socioeconomic Zones have easy access to credit and when needed, residents are able to secure loans from lending institutions such as commercial banks. The level of borrowing in the settlement of Pipri is high, but moderate in other settlements. In the other zones, there is very high level of borrowing, especially in Fishing Communities (93% of the households according to the household survey) and Non-Fishing Communities that are dependent on wage labor (75% of the households according to the household survey). Households dependent on fishing labor and wage labor have constant debt, mostly from friends and family or from local shopkeepers who sell them groceries on credit. If needed, larger loans are available from money lenders who charge high interest rates. According to the household survey, the average debt of a household in the Fishing Communities is PKR 570,000 and in the Non-Fishing Communities is PKR 130,000. About 60% of the households surveyed in the Fishing/Agriculture Communities have an average debt of PKR 84,000 (see **Appendix D** section **D.5.1**)

### ***Assets***

Assets considered were boats and livestock for Fishing and Fishing/Agriculture Communities, and only livestock for Non-Fishing and Planned Housing Schemes. Though a large number of boats are present at the landing sites in the Socioeconomic Zones, they are owned by a small number of individuals. Almost all of the fishermen provide labor on fishing boats owned by others (as discussed in the section on Livelihoods). Very few households in the Fishing Communities own livestock, therefore

ranking Highly Vulnerable on the Vulnerability Matrix. The Fishing/Agriculture Communities, with a similar situation of boat ownership, have a higher proportion of households owning some livestock (mostly a goat), making them Vulnerable.

Non-Fishing Communities are ranked Highly Vulnerable as they have minimal ownership of livestock. Planned Housing Schemes Communities rank Vulnerable as there is high ownership of livestock by households in Pipri, but none in other settlements such as Gulshan-e- Hadeed.

### **Mobility**

Mobility was assessed in terms of ownership of a means of transportation by household. In Non-Fishing and Fishing/Agriculture Communities, less than 10% of the households own a means of transportation (at least one motorbike). This is higher in Fishing Communities who rank Vulnerable, and significantly higher in Planned Housing Schemes who rank Moderately Resilient.

### **Disaster Preparedness and Response**

Almost half of the settlements in the Socioeconomic Zones suffer from flooding due to rainfall every year, and ocean storms/cyclones every 2-4 years (please see **Exhibit 6.42**). All settlements that have suffered from flooding and rainfall in the past 5 years have suffered some damage to structures (houses, walls etc.), while a third reported some loss of livestock. Almost 90% of the settlements that have suffered from cyclones/ocean storms in the past 5 years reported some damage to structures and 44% reported that their boats were damaged as well. 67% also suffered a loss of fishing time due to cyclones and ocean storms. Percentage of households reported damage from natural hazards are provided in **Exhibit 6.47**.

**Exhibit 6.47: Damage from Natural Hazards**

<i>Natural Hazard</i>	<i>Proportion of Settlements Reporting</i>			
	<i>Damage to Structures</i>	<i>Loss of Livestock</i>	<i>Damage to Boats</i>	<i>Loss of Fishing Time</i>
Rainfall/Floods	100%	33%	0%	22%
Cyclones/ Ocean Storms	89%	33%	44%	67%

Despite frequent occurrence of natural disasters that cause damage, the Fishing and Non-Fishing Communities rank as Critically Vulnerable on Disaster Preparedness and Response, which was assessed by contingency planning at various levels. In these settlements, it was found that no community, government or NGO contingency planning for any type of disaster exists. In Fishing/Agriculture Communities, there is a community level contingency plan for major disasters such as cyclones and floods prepared by the UC level local support organization for UC Dhabeji. Though this plan is present a disaster management committee comprising of community members has been established, the plan does not have government support. Of the surveyed Planned Housing Schemes, only Steel Mill is reported to have a disaster preparedness and emergency response plan which is designed in collaboration with and support of Pakistan Steel Mills. Pipri and Gulshan-e-Hadeed have no such preparedness and response plan in place.



## **6.7 Legacy Resettlement Issues**

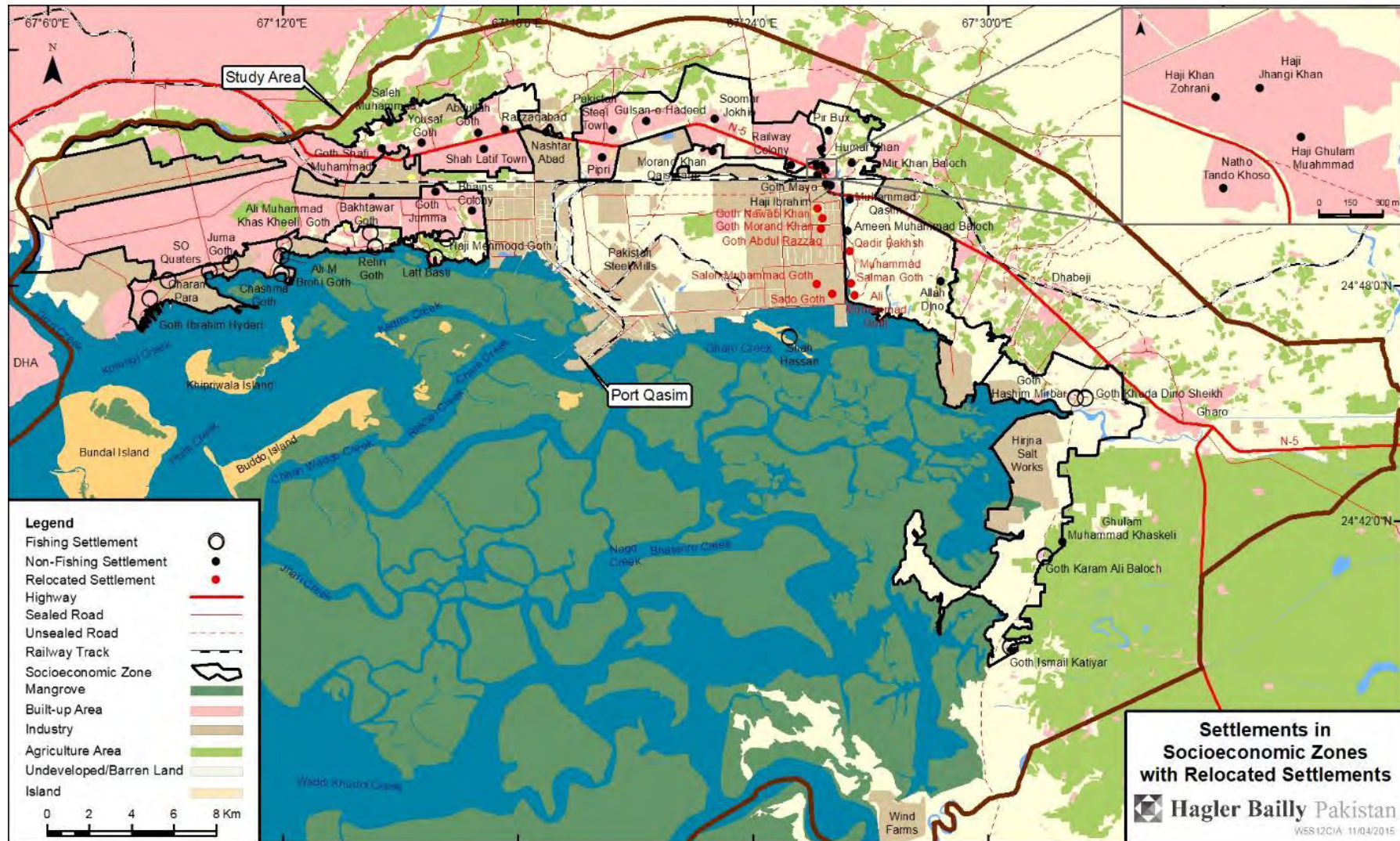
During the socioeconomic survey of PQA, one of the key issues raised by the communities was grievance regarding compensation and loss of livelihood due to land acquisition conducted by the Government of Sindh and Port Qasim Authority (see **Section 6.2.2**). A review of legacy resettlement issues and determination of the current status of resettlement, was carried out as part of the socioeconomic baseline. This section summarizes findings of short resettlement investigation survey conducted at Port Qasim Area (PQA).

### **6.7.1 Methodology**

Information from socioeconomic baseline surveys and consultations was used to initially identify few communities that were affected by resettlement due to development of PQA. The relocated settlements initially identified are shown in **Exhibit 6.48**. Also, during earlier surveys it was identified that most of the affected communities had settled in Haji Ibrahim, Pipri and Razzaqabad. These settlements were surveyed to identify individuals affected by land acquisition by Port Qasim Authority and resettlement related information was collected from them through interviews. A Resettlement Investigation Questionnaire was designed to collect relevant data from the affected individuals. The questionnaire used is included in **Appendix D.6.1**.

It was ensured that all the interviewees had experienced the land acquisition themselves, therefore the age criterion was set to minimum 50 years for all the interviewees. The survey was conducted from November 4-5, 2015.

**Exhibit 6.48: Settlements in Socioeconomic Zones with Relocated Settlements**



### 6.7.2 Details of the Survey

The results of the survey are provided in **Appendix D.6.2**. During the survey it was identified that land was acquired for three major developments in the surveyed area:

- ▶ Pakistan Steel Mill
- ▶ Pakistan Steel Town
- ▶ Port Qasim Area
  - ▷ East Industrial Zone
  - ▷ North Western Industrial Zone

It was identified that total 30 settlements were affected out of which 11 were affected due to Pakistan Steel Mill, 6 were affected due to Pakistan Steel Town and 13 were affected due to Port Qasim Area. Out of 13 affected due to PQA, 8 were part of the region which is now Eastern Industrial Zone (EIZ) and 5 were part of the region which is North Western Zone (NWZ). Most of the affected communities moved to Razzaqabad, Pipri and Haji Ibrahim communities. The list of relocated settlements and the area they moved to is provided in **Exhibit 6.49**. All the relocated settlements are shown on a map in **Exhibit 6.50**.

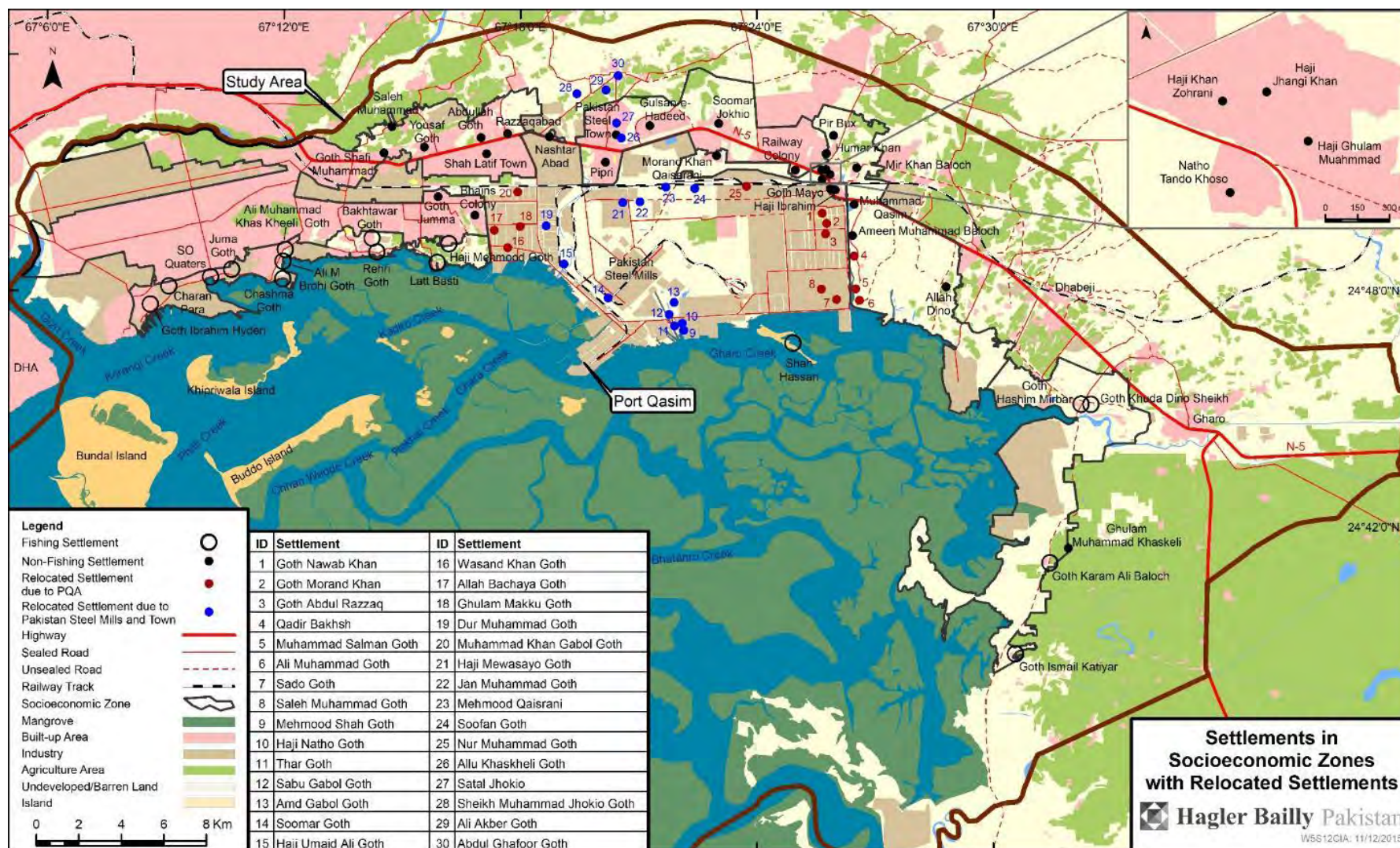
**Exhibit 6.49:** List of Relocated Settlements

<i>Relocated Settlement</i>	<i>Relocated to</i>	<i>Affected by</i>
Mehmood Shah Goth	Razzaqabad	Pakistan Steel Mill
Haji Natho Goth	Razzaqabad	
Thar Goth	Pipri	
Amd Gabol Goth	Razzaqabad	
Sabu Gabol Goth	Pipri	
Haji Umaid Ali Goth	Razzaqabad	
Soomar Goth	Pipri	
Dur Muhammad Goth	Pipri	
Haji Mewasayo Goth	Pipri	
Jan Muhammad Goth	Pipri	
Soofan Goth	Pipri	
Allu Khaskheli Goth	Razzaqabad	Pakistan Steel Town
Satal Jhokio	Razzaqabad	
Ali Akber Goth	Razzaqabad	
Sheikh Muhammad Jhokio Goth	Razzaqabad	
Abdul Ghafoor Goth	Razzaqabad	
Mehmood Qaisrani	Razzaqabad	

<i>Relocated Settlement</i>	<i>Relocated to</i>	<i>Affected by</i>
Nur Muhammad Goth	Gagar	Port Qasim Area – East Industrial Zone
Wasand Khan Goth	Port Qasim Colony	
Allah Bachaya Goth	Peeranu Goth	
Ghulam Makku Goth	Razzaqabad	
Muhammad Khan Gabol Goth	Razzaqabad	
Goth Morand Chakkar/Khan	Morand Khan Qaisrani/Thatta	Port Qasim Area – South Western Zone
Goth Nawab Khan/Goth Ali Khan	Khan Muhammad Goth/Nawab Goth	
Goth Abdul Razzaq	Mehmood Qaisrani	
Saleh Muhammad Goth	Haji Ibrahim	
Sodo Goth	Haji Ibrahim	
Qadir Buksh	Haji Ibrahim	
Muhammad Suleman Goth	Haji Ibrahim	
Ali Muhammad Goth	Haji Ibrahim Goth	



**Exhibit 6.50: Settlements in Socioeconomic Zones with Relocated Settlements**





Out of 9 affected individuals who were interviewed, 6 belonged to communities from EIZ, 2 belonged to communities from NWZ and 1 was from Pakistan Steel Town. The list of surveyed settlements is provided in **Exhibit 6.51**. The photographs of the survey are provided in **Exhibit 6.52**. Due to the scope of the survey, focus was limited to collection of information from communities that were affected by land acquisition for the development of Port Qasim Area.

**Exhibit 6.51: List of Surveyed Settlements**

<i>Settlement Name</i>	<i>Location within PQA</i>	<i>Settled to</i>	<i>Estimated no. of Households</i>	<i>Resettled in</i>
Ali Khan Goth	East Industrial Zone	Khan Muhammad Goth	60	1974
Muhammad Suleman Goth	East Industrial Zone	Peeranu Goth/Haji Ibrahim	40	1975
Saleh Muhammad Goth	East Industrial Zone	Haji Ibrahim	50	1976
Qadir Baksh Goth	East Industrial Zone	Haji Ibrahim	60	1978
Goth Morand Chakkar	East Industrial Zone	Morand Khan Qaisrani	50	1974
Abdul Razzaq Goth	East Industrial Zone	Mehmood Qaisrani	30	1977
Wasand Khan Goth	North Western Zone	Port Qasim Goth	40	1985
Muhammad Khan Gabol Goth	North Western Zone	Razzaqabad	70	1975
Mehmood Qaisrani	Pakistan Steel Town	Razzaqabad	40	1975

**Exhibit 6.52: Photographs of the Resettlement Survey**



*Data collection from affected individuals at Razzaqabad*



*Data collection from affected individuals at Haji Ibrahim*



*Data collection from affected individuals at Latt Basti*



*View of a cemetery protected by locals from acquisition*

### **Eastern Industrial Zone**

According to the local leaders, 8 communities were affected due to the development of EIZ. Six individuals from different settlements in this area were interviewed who were affected by land acquisition.

The interviewees reported that in 1972, Zulfikar Ali Bhutto as the President, and Port Qasim Authority announced the development of Port Qasim Area and informed the local communities about the resettlement plan. According to locals, they were promised alternate land, monetary compensation against their houses, alternate means of employment due to loss of livelihood and other basic utilities after relocation. However, the locals were reluctant to relocate due to sentimental attachment with their land and means of livelihood, which were mainly agriculture and livestock.

To build pressure and to forcefully evacuate the local population, their access to water and travel was cut off in 1972. As no alternate land to relocate was provided, the locals migrated to other settlements where they had relatives and friends in 1974 and onwards. Some locals reported that the Government of Sindh paid Rs 19,000/acre for surveyed land only. As most of the inhabitants were living on un-surveyed land, they did not receive any monetary compensation. No compensation was provided for loss of livelihood and jobs that were promised at Port Qasim were not provided. Most of the monetary compensation went to the landlords who had proper documentation of their land. Furthermore, some locals also reported that Rs 1500 was paid for loss of each masonry house and Rs 1000 was paid for loss of each adobe house. The affected people moved to adjoining settlements and no further support from PQA or the Government was provided.

After the downfall of Zulfikar Ali Bhutto's government, the pending issues of resettlement and compensation were neglected during Zia ul Haq's government. When Benazir Bhutto came into power, she ordered formation of a commission in 1989, called the Congo Commission. This Commission was headed by the Chief Minister of Sindh and included Chief Secretary, Secretary Information, Secretary Culture, and other important bureaucrats. This Commission was responsible for reviewing the pending resettlement related issues and propose a solution acceptable to all stakeholders. The Commission proposed the following:

- ▶ Allotment of 50 acres of land by PQA to be provided to affected households.
- ▶ PQA to form and fund Sindh Town Planning Department to prepare and execute the Masterplan for the development of those 50 acres and provide houses and basic utilities to all the affected households.
- ▶ Payment of Rs.100,000 to each affected household.

Out of the above three points, only the first proposal was implemented and 50 acres of land was acquired by PQA from the Revenue Department to resettle affected households. Most of the affected people who were shelter-less settled in this area, now known as Haji Ibrahim. However, no housing or utilities were provided by PQA and people had to arrange for funds themselves to settle there. It was also reported that no paperwork was provided to anyone against the land they settled on. Currently the ownership of the area is with Port Qasim which has led to serious issues of encroachment and land grabbing by land mafias. Locals also complain that they do not have any legal right over the land they live on and whenever they try to develop their homes, authorities demand paperwork which they are unable to produce. Locals also complained about regular harassment incidents by police and other municipal authorities as they do not have any legal ownership of the land they live on.

Primary means of livelihood of affected households of this area were agriculture and livestock. No alternate means of livelihood or compensation for loss of livelihood was provided to the locals. Many affected individuals reported that they had filed cases in the court of law against PQA for fair monetary compensation and provision of jobs.

### **North Western Zone**

According to the local leaders, 5 communities were affected due to the development of NWZ. Two individuals from different settlements in this area were interviewed who were affected by land acquisition.

It was reported that this region was sparsely populated due to unavailability of water. Most of the affected households moved to Pipri or Razzaqabad after land acquisition. The resettlement and compensation issues were similar to EIZ. However, the key differences were related to their past means of livelihood. The locals reported that their primary means of livelihood involved fishing, agriculture and livestock in the past before 1972. In 1972, as in EIZ, the Government announced development of PQA and the residents of these 5 communities were asked to relocate. No monetary compensation against their land, houses or loss of livelihood was provided to the locals. They had to relocate to other settlements where relatives and friends accommodated them. Now their current means of livelihood involved labour work which did not pay well and was seasonal. No regular jobs at PQA were provided which were promised during the time of land acquisition. It was also reported that many cases are pending in the court of law against PQA which have been filed by the locals but no verdict has ever been announced.

Local leaders reported that a committee was formed in 2004 by Chief Secretary of Sindh to investigate resettlement related disputes between PQA and affected communities. However, after the first meeting PQA authorities backed out and never attended the following meetings.

### **6.7.3 Summary of Key Issues and Solutions Proposed by Community**

Three key issues were highlighted by communities regarding resettlement in the order of decreasing priority:

- ▶ Non provision of alternate means of livelihood and jobs at PQA which were promised
- ▶ Non provision of basic facilities and utilities that were promised such as water, electricity, hospitals and schools which were promised.
- ▶ Non-payment of monetary compensation against land that was acquired which is a legal right.

The community proposed that the PQA sets up an independent committee to investigate pending issues regarding resettlement, as well as own and accept the recommendations of this committee for effective implementation of solutions. The communities proposed the following responsibilities for the committee:

- ▶ Implement the recommendations of the Congo Commission.
- ▶ Investigate the commitments that were made regarding provision of alternate means of employment to the locals.
- ▶ Conduct a socioeconomic survey of the area to collect data of education and skills available among the local population.
- ▶ Explore job opportunities available at PQA and advise the authorities to hire skills from local population.
- ▶ Liaise with the local communities and leaders to provide a grievance redressal mechanism.
- ▶ Implement the re-development plans that were promised by PQA.
- ▶ Conduct an independent review of all the legal claims made by locals regarding monetary compensation against loss of land and settle them on case by case basis.

## 7. Valued Environmental Components and Baseline Status

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Valued Environmental Components (VECs) are defined as “*fundamental elements of the physical, biological or socio-economic environment that are likely to be the most sensitive receptors to the impacts of a proposed project or the cumulative impacts of several projects*”.<sup>297</sup> They may include:

- ▶ physical features, habitats, wildlife populations (e.g., biodiversity),
- ▶ ecosystem services (e.g., fishing, timber, food, aesthetic values),
- ▶ natural processes (e.g., water and nutrient cycles, microclimate),
- ▶ social conditions (e.g., health, economics), or
- ▶ cultural aspects (e.g., traditional spiritual ceremonies)<sup>298</sup>.

While VECs may be directly or indirectly affected by a specific development, they often are also affected by the cumulative effects of several developments. VECs are the ultimate recipient of impacts because they tend to be at the end of ecological pathways<sup>299</sup>.

### 7.1 Methodology for Identification and Prioritization

The approach adopted for identification and prioritization of VECs is as follows:

- ▶ Use of baseline studies, institutional and community stakeholder consultations, prioritized ecosystem services (based on an Ecosystem Service Review) to determine possible VECs.
- ▶ Prioritization of VECs particularly on the basis of degree of potential impact that PQA could have on the VECs and leverage of PQA over managing the VECs.

In addition to a list of prioritized VECs, identification of indicators and thresholds for VECs was carried out. The following provides further detail on the adopted methodology.

#### 7.1.1 Baseline Studies

Baseline studies were conducted to understand the physical, ecological and socioeconomic conditions in the Study Area (see **Section 3**), the pathways through which the Developments at Port Qasim and other economic activities in the vicinity of Port Qasim may affect the sensitive receptors in the environment, and the extent to which the sensitive receptors and the local livelihoods will be affected. The baseline studies drew on the available literature, ESIA reports prepared for development projects in the PQA

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<sup>297</sup> Cadinale, Pablo, and Lorne Greig. "Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets." In *Good Practice Handbook*: International Finance Corporation and ESSA Technologies Ltd, 2013.

<sup>298</sup> Ibid

<sup>299</sup> Ibid



area, and results of field surveys and sampling conducted as a part of this study to address the gaps in the literature and ESIA reports.

### **7.1.2 Identification of VECs and Ecosystem Services by Stakeholders**

Community, institutional, and industry stakeholders were consulted to identify aspects of environment that they considered important with respect to their livelihoods and well-being, businesses, and institutional mandates. A list of VECs and ecosystem services that the stakeholders considered important was also developed in consultation with the stakeholders.

### **7.1.3 Ecosystem Services**

The ESR Report prioritized ecosystem services (**Section 5** of the ESR Report) on the basis of the socioeconomic profile of the communities (**Section 3** of the ESR Report), and application of criteria which included:

- ▶ magnitude of impact by the Developments on potentially impacted ecosystem services,
- ▶ extent of dependence of the Developments (project owners and developers) on impacted ecosystem services
- ▶ magnitude of impact on communities, taking into account their income dependence on impacted ecosystem services and their vulnerability; and
- ▶ extent to which PQA can leverage the impact on the ecosystem services considered important by the stakeholders.

### **7.1.4 Prioritization of VECs**

The VECs identified by the communities as important and over which PQA has leverage, and the ecosystem services considered important by the owners of industries and developers in PQA were combined to develop a list of prioritized VECs for the purpose of this study. This list was kept limited to focus management and mitigation on VECs that are important for protection of biodiversity in the Study Area and important for the stakeholders in the context of ecosystem services being availed by them as concluded in the ESR study.

### **7.1.5 Identification of Indicators for the VECs**

A Pressure-State-Response (PSR) framework is used for impact assessment and monitoring of VECs<sup>300</sup>. The PSR framework lays out the basic relationships amongst:

- ▶ the pressures human society puts on the environment
- ▶ the resulting state or condition of the environment, and
- ▶ the response of society to these conditions to ease or prevent negative impacts resulting from the pressures

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<sup>300</sup> Pressure-State-Response Framework and Environmental Indicators,  
<http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/refer/envindi.htm>

For the purpose of this CIA, and consistent with the framework adopted for the study:

- ▶ the pressures on environment are those exerted by PQA and others on the VECs in the Study Area, and
- ▶ the response is the institutional response of PQA to manage and mitigate the impacts on the VECs.

#### **7.1.6 Thresholds for the Indicators**

For the indicators of state identified above, where possible thresholds and limits for the VECs were provided as specified in the law (prescribed environmental quality standards) or as required to protect the livelihoods of the stakeholders, particularly those who are vulnerable (e.g. abundance levels of fish to support sustainable livelihoods).

### **7.2 Justification for VECs Identified**

Applying the methodology described in **Section 5.1**, the following is a discussion on selection of the VECs.

#### **7.2.1 Identification of VECs by Stakeholders**

Consultations were conducted with communities in the Study Area and with institutional stakeholders including major conservation organizations such as the WWF-P and IUCN to record their views and concerns on the ecosystem services and impacts of Developments in Port Qasim Area on the ecosystem services. VECs identified as important were also recorded in these consultations. Records of consultations appear in **Appendix D.2 and Appendix D.3**, while a summary of concerns expressed and issues raised by community stakeholders are summarized in **Section 6.2 and Section 3.3 of Appendix D.1** (ESR Report). VECs identified by the stakeholders as important for their livelihoods, well-being, and businesses are listed below.

##### **Local Communities**

**Marine ecosystem:** The large boats go to deep sea to catch fish, which is an important source of livelihood for the communities.

**Mangrove ecosystem:** A large population depends on catching fish in the creeks in the mangrove areas, and on associated livelihoods such as boat and net repairs. Poor fishermen mostly rely on catching fish in the creeks near the mainland. The fish from the deep sea breed in the creeks, and the mangroves provide shelter and protection for the fish to mature before they can swim back to open sea. The mangrove ecosystem provides essential food for the fish to grow.

**Mangroves:** Wood from mangroves is used both as fuel and for construction of huts, and leaves are used as fodder for camels and other livestock. Honey is also produced in mangroves.

**Intertidal mudflats:** The intertidal mudflats are the ideal habitat for the crabs. Crabs serve as a source of livelihood for the local fishermen community.

**Fresh water flows into creeks:** Fresh water flows into creeks holds major significance in determining the health of marine and mangrove ecosystems. Flow of fresh water into the

Indus Delta through the Indus River and rainfall to lesser extent maintains ecological balance of the marine ecosystem and provides freshwater to the local farmers for irrigation.

**Water quality in creeks:** The quality and quantity of fish available in creeks depends greatly upon the water quality of the creeks.

**Sea breeze:** With limited access to electricity, sea breeze helps in coping with hot and humid weather.

**Terrestrial vegetation:** With limited or no access to pipeline gas, mesquite bushes are the only source of fuel for both cooking and heating purposes, particularly for communities located towards northwest and east of Port Qasim Area.

**Surface (fresh) water quality:** Quality of water in open streams is important as communities located towards east of Port Qasim Area use the stream water for washing clothes, as drinking water for livestock, and for irrigation.

**Public health:** Facilities provided by the government for health are very limited. Water borne diseases including skin infections are prevalent as quality of water available is not good.

#### ***Institutional Stakeholders***

**Water quality in creeks:** For the same reasons as local communities.

**Fresh water flows into creeks:** For the same reasons as local communities.

**Mangroves:** Provide habitat for biodiversity, and protection against flooding, storm surges, and sedimentation and erosion of shipping channels.

**Mangrove ecosystem:** In addition to a large population depending on fish in the creeks for livelihoods, mangrove ecosystem supports diversity of marine life including fish, turtles and marine mammals (including dolphins), and migratory birds.

**Public health:** Health of population in vicinity of industries in Port Qasim Area can be affected by air emissions from industries.

#### ***VECs Identified by Stakeholders but not considered as Priority for this Study***

The PQA has a varying degree of leverage on the VECs listed above, ranging from high for the mangroves in the notified area, to somewhat low for the rest in view of the impacts caused by economic activities by others not in control of PQA. The following ecosystem services were not prioritized for these reasons.

**Marine ecosystem:** The Developments at Port Qasim Area do not directly impact the larger marine ecosystem of which only a small part falls in the Study Area. PQA also has no control over the fishing activities within the larger marine ecosystem as only a small portion of the marine ecosystem is within PQA jurisdiction.

**Freshwater flows into creeks:** Only a small quantity of low salinity effluent water is released by industries and terminals in Port Qasim into the creeks. PQA has not control over inflows of fresh water from River Indus or from other streams draining into the sea such as the Malir and Korangi Rivers.

**Sea breeze:** This is weather related.

**Terrestrial vegetation:** Other than areas included in the Notified PQA Area, PQA has not control over the terrestrial vegetation outside the PQA Area where the communities obtain the fuel wood.

**Surface (fresh) water quality:** Only a small quantity of low salinity effluent water is released by industries and terminals in Port Qasim into the open drains that flow into the sea. Bults of the contaminated effluents originate from the industrial and residential areas such as Korangi and Landhi over which PQA has not control or jurisdiction. In addition, the PQA does not discharge wastewaters in areas, or upstream of areas, where the local communities utilize fresh surface water resources.

**Public health facilities:** PQA has no leverage over the provision of health facilities to local communities by the government, or over the quality of water supplied to the communities. However, PQA does have leverage over air quality as it is impacted by the industries located within PQA Area, and air quality was included as a VEC for this study (see **Section 7.2.3**).

***VECs not identified by Stakeholders and also not considered as Priority for this Study***

Supply of freshwater, given the scarcity of freshwater in Pakistan and in Sindh, was not identified as a VEC by the stakeholders. Requirement of Port Qasim industries and Pakistan Steel Mills is about 3% of freshwater demand of Karachi, which is coming from Keenjhar and Haleji lakes. The upcoming power plants at Port Qasim Area, which are a major consumer of water, will utilize seawater for cooling purposes. Groundwater in the Study Area is saline and is not utilized by the community, but is in some cases utilized by industry. Degradation of land due to disposal of solid waste and contamination of soil from disposal of contaminated waste from industries were not identified as issues by the stakeholders.

## **7.2.2 Ecosystem Services**

Prioritized ecosystem services were assessed independently for Developments (**Section 5.2** of ESR Report) reflecting impacts on the country economy associated with port and industry activities, and for communities (**Section 5.3** of ESR Report) reflecting the local socioeconomic costs and benefits. An important point to consider in this context is that the communities are more at risk from changes in ecosystem services due to their inherent vulnerability, compared to the owners of projects in Developments, who can invest in mitigation to protect their assets and incomes.

**Local Communities:** Based on the magnitude of impact of Development on ecosystem services and community dependence and vulnerability on ecosystem services, the priority ecosystem services with respect to communities as identified in the ESR Report are:

- ▶ **Food from crops, livestock, capture fisheries, aquaculture, and wild foods** – fish as food and for income is relied upon by local communities
- ▶ **Food from crops, livestock, capture fisheries, aquaculture, and wild foods** – shrimp as food and for income is relied upon by local communities
- ▶ **Habitat** – habitats are critical in providing food and support other ecosystem services.

- ▶ **Regulation of natural hazards** - mangroves prevent damage from oceanic storms and cyclones.

**Project Owners and Developers:** Based on the magnitude of impact of Developments on ecosystem services and extent of dependence of Developments on impacted ecosystem services, the priority ecosystem services are:

- ▶ **Regulation of estuarine flows and dynamics** - mangroves regulate the flow of water through the estuary and control sedimentation and erosion rates.
- ▶ **Erosion control** - as mangrove swamps prevent erosion by locking in soils.
- ▶ **Regulation of natural hazards** - mangroves prevent damage from oceanic storms and cyclones.

### ***Ecosystem Services Identified but not considered as Priority for this Study***

The following ecosystem services were not prioritized for reasons outlined below.

#### ***Local Communities***

**Fodder:** Only a small number of households in the communities located mainly in the eastern part of the Study Area are engaged in harvesting mangrove leaves for use as fodder for livestock.

**Groundwater:** Groundwater, where present, is largely saline and is therefore not used by the local communities. PQA does not extract any groundwater, and contamination at PQA is unlikely to reach the areas where groundwater is utilized.

**Fuel wood:** While the communities rely on mangroves and mesquite trees inland for fuel wood, the Developments do not have any significant impact on availability of fuel wood for the communities.

**Recreation and tourism in mangrove areas:** The level of this activity and community dependence on it for livelihood is low.

**Honey extracted from mangrove areas:** This is a seasonal activity. The level of this activity and community dependence on it for livelihood is low.

#### ***Project Owners and Developers***

**Provision of dredging sand and clays:** Dredging sand and clays are utilized by Developments for land reclamation along the shore. While the dependence for the Developments is high on dredged sediment and clays for reclamation, there is negligible impact of the Developments on availability of sands and clays.

**Groundwater:** The industries and terminals do not depend on groundwater for their freshwater requirements as ground water is saline, and the Developments can draw saline water from the mangroves area (e.g. it is utilized by K Electric power plants as well as Pakistan Steel Mills) for cooling after desalination.

**Water purification and nutrient cycling by mangroves:** Mangroves absorb heavy metals and utilize nutrients in wastewaters. It is expected that flushing and mixing within the estuary is a greater control, compared to localized uptake by mangroves. Additionally, relatively low cost water treatment alternatives are available to the industries and port terminals to treat water before it is discharged.



### 7.2.3 Prioritization of VECs

**Exhibit 7.1** summarizes the selection of the VECs for this study, including principal VEC groups, pressures from developments in PQA on the VECs, the leverage PQA has over the VECs, and the shortlisted VECs for this study. The number of VECs was kept limited to maintain the focus of the study on VECs that are likely to account for bulk of the impacts of Developments on the environment and ecosystem services, and for the impacts that the changes in VECs may have on the Developments themselves.

The VECs identified by the stakeholders as important (**Section 7.2.1**) and over which PQA has leverage, and the prioritized ecosystem services associated with the VECs (**Section 7.2.2**) were combined to develop a list of VECs for the purpose of this study.

The selected VECs can be placed into the following three broad principal VEC groups:

#### ***Mangrove Ecosystem and Biodiversity***

Mangrove habitats are important breeding and producing areas for fish and coastal invertebrate fauna, support populations of marine mammals, and are refuge areas for both migratory and resident avifauna. The mangrove plants have a high biological productivity and are important for the nutrient budget of coastal waters. They export organic matter, mainly in detritus form (i.e. leaf litter) to the marine environment, thus providing a highly nutritious food source for marine fauna. Mangroves act as a natural barrier to shoreline erosion. A large population depends on catching fish in the creeks in the mangrove areas. The fish from the deep sea breed in the creeks, and the mangroves provide shelter and protection for the fish to mature before they can swim back to open sea.

#### ***Livelihoods Related to Mangrove Ecosystem Services***

The fishing communities located in the Study Area rely heavily on the mangrove ecosystem for their livelihoods. In addition to supporting offshore fishery, the fish, shrimp and crab catch in the mangrove areas and the local economy that supports fishing activities such as building, repair, and maintenance of fishing boats depends on the mangrove ecosystem. Mangroves also supplement fuel wood and fodder requirements of the local communities. PQA has a degree of leverage over this income.

#### ***Public Health***

Various ESIA studies conducted for projects in Port Qasim indicate an emerging threat to air quality, mainly due to emissions from coal fired power plants being installed and planned in the PQA industrial zone. With low incomes, poor health, and poor access to health services, a large population living in the Study Area is vulnerable to air quality.

#### ***Pressure from Developments and Leverage of PQA***

The VECs were screened for the degree of impact that Developments in Port Qasim Area have on VECs, and the degree of control PQA has on management of the VEC. Pressure from Developments and leverage of PQA was defined in the following manner:

**Pressure from Developments in PQA:** The extent to which PQA directly or indirectly impacts the VEC; e.g. clearance of mangroves for port development.

**PQA Leverage:** The extent to which PQA has leverage to manage or mitigate the impacts on VEC, irrespective of whether or not it is causing the impact, e.g. allowing

clearance of mangroves is an aspect over which PQA has a high degree of leverage through policies, planning, and regulation in the PQA area.

Developments in PQA will impact the VECs in all the three prioritized VEC groups i.e. mangrove ecosystem and biodiversity, livelihoods related to mangrove ecosystem services, and public health. Activities and action that will negatively impact the mangrove ecosystem in the Study Area and the associated livelihoods include:

- ▶ Clearing of mangrove for construction of port facilities,
- ▶ Industrial discharges into the mangrove areas,
- ▶ Dumping of dredged material in mangrove areas,
- ▶ Changing hydrodynamics and consequently sedimentation and erosion due to jetties and land reclamation, and
- ▶ Erosion due to movement of ships in the navigation channels.

Air quality will be impacted mainly by coal fired power plants.

PQA, through application of its own environmental guidelines and through supporting the Sindh Environmental Protection Agency (SEPA) in enforcement of NEQS for air quality can improve the air quality in the Study Area. PQA has limited control over non-sustainable fishing methods being used by the local communities that lead to depletion of fish stocks. However, PQA has leverage over access of fishermen to the Notified PQA Area through which it can work with other agencies to introduce sustainable harvesting practices.

#### **7.2.4 Shortlisted VECs**

Following the discussion above, the VECs prioritized and shortlisted for this study are summarized in **Exhibit 7.1**, and outlined below.

##### ***Mangrove Ecosystem and Biodiversity***

- ▶ **Fish, Shrimp, Crabs, and Marine Mammals:** Fish, shrimp, crabs, and marine mammals are important components of the mangrove biodiversity. Fish, shrimp, and crabs are harvested for self-consumption and income.
- ▶ **Mangroves:** Mangroves regulate the flow of water through the estuary and control sedimentation and erosion rates, and prevent damage from oceanic storms and cyclones. Wood from mangroves is used both as fuel and for construction of huts, and leaves are used as fodder for camels and other livestock.
- ▶ **Intertidal Mudflats:** The intertidal mudflats are the habitat for the crabs that are a source of livelihood for the local fishermen community.

The VECs listed above are a part of mangrove ecosystem and biodiversity identified as important by the community and institutional stakeholders particularly in relation to the ecosystem services they provide.

##### ***Livelihoods Related to Mangrove Ecosystem Services***

- ▶ **Income from harvesting of fish, shrimp and crab:** Income from harvesting of fish, shrimp and crab was selected as a VEC for the study. As discussed in

**Section 7.2.2**, the fishing communities located in the Study Area rely heavily on the mangrove ecosystem for their livelihoods. The fish catch and the local economy that is induced by the fishing activities such as boat building, and repair and maintenance of boats depends on the mangrove ecosystem.

### **Public Health**

- **Air Quality:** Health of population in vicinity of industries in Port Qasim Area can be affected by air emissions from industries.

### **7.3 Indicators for VECs and Threshold, Targets and Limits**

Following the Pressure-State-Response framework, the framework for monitoring of changes in VECs is described in this. Details of the indicator description, method of data collection and analysis, as well as frequency and timing will be provided in the Framework Monitoring and Evaluation Plan that will be prepared under this study.

**Exhibit 7.2** summarizes the monitoring requirements for indicators of pressure on VECs due to Developments at Port Qasim. **Exhibit 7.3** summarizes the monitoring requirements for indicators of external pressures on VECs, such as industrial and residential areas in the vicinity of Port Qasim.

**Exhibit 7.4** summarizes a preliminary framework for the monitoring requirements for indicators of response.

**Exhibit 7.1: VECs Prioritized and Shortlisted for the Study**

<i>Principal VEC Group</i>	<i>VECs</i>	<i>Pressure from Developments in PQA</i>	<i>PQA Leverage</i>
Mangrove Ecosystem and Biodiversity	<ul style="list-style-type: none"> <li>► Fish</li> <li>► Shrimp</li> <li>► Crab</li> <li>► Marine Mammals</li> <li>► Mangroves</li> <li>► Intertidal Mudflats</li> </ul>	The Development will be associated with removal of mangroves, discharge of wastewater into the ecosystem, and extraction of water from this system. The marine mammals (cetaceans) will be affected by shipping traffic where collisions with ships are of concern.	<p>PQA has leverage to address mangrove ecosystem VEC in the Notified PQA area and also because it is mandated to protect environment in PQA notified area.</p> <p>Nonetheless, PQA has limited leverage on external pressures related to fishing by communities, and discharge of wastewater by other industrial areas and municipalities.</p> <p>PQA could advise ships to watch for the presence of dolphins and porpoises and take measures to avoid collisions.</p>
Livelihoods Related to Mangroves	<ul style="list-style-type: none"> <li>► Income from fish, shrimp, and crab</li> </ul>	The Development will have associated direct impacts on the mangrove ecosystem. These will be addressed under the "mangrove ecosystem VEC"	PQA has leverage to address livelihood (related to ecosystem services) as it directly impacts some ecosystem services, and also because it has leverage to manage mangrove ecosystem in the Notified PQA Area. PQA has some leverage over access of fishermen to this area, through which it may be able influence use of illegal and non-sustainable fishing methods used by local fishermen.
Public Health	<ul style="list-style-type: none"> <li>► Air Quality</li> </ul>	The Development will be associated with increased emissions that will impact Public Health, mainly stack emissions from coal fired power plants that will impact air quality.	PQA has limited leverage to address Public Health in the area, through management measures directly relating to public health, but can address stack emissions from coal fired plants located in PQA area.

## Exhibit 7.2: Framework for Indicators for Pressure from PQA Developments on VECs

VEC	Description of Pressure	Indicators	Comments
<b>Mangrove Ecosystem and Biodiversity</b>			
<ul style="list-style-type: none"> <li>▶ Fish</li> <li>▶ Shrimp</li> <li>▶ Crabs</li> </ul>	No direct pressure	Not applicable	Pressure will be through reduction in quality and extent of mangrove habitat which is covered separately under this VEC
▶ Marine mammals	The marine mammals (cetaceans) will be affected by shipping traffic where collisions with ships are of concern.	Collisions and fatalities of species of concern	
Mangroves	Clearing of mangroves for construction of port facilities; ship traffic and port development related erosion; operational dredging related erosion and sedimentation; erosion and sedimentation related to new channel dredging and ship traffic in the new channel.	<ul style="list-style-type: none"> <li>▶ Extent of mangroves cleared</li> <li>▶ Length of new shipping channels created</li> <li>▶ Quantity of material dredged</li> </ul>	Measurement of clearing of mangroves and widening of channels due to erosion can be best done through use of time series high resolution satellite images or aerial photos. Clearing of mangroves should be minimized and credible offsets should be created if clearing is unavoidable
	Wastewater flows from Developments affecting the water quality in creeks	<ul style="list-style-type: none"> <li>▶ Quantity of wastewater discharged into estuary by Developments</li> <li>▶ Quantity of key pollutants mainly nutrients and heavy metals discharged</li> </ul>	Reporting systems along the lines of SMART <sup>301</sup> will have to be introduced to track quantity and quality of wastewater discharged by individual installations. Measurements can be made at key discharge points where effluents are drained into the estuary
	Heavy metals from wastewater contaminating the sediments in the estuary	Same as above for water quality	
Intertidal Mudflats	Use of mudflats for construction of port facilities; ship traffic and port development related erosion; operational dredging related erosion and sedimentation; erosion and sedimentation related to new channel dredging and ship traffic in the new channel.	<ul style="list-style-type: none"> <li>▶ Extent of mudflats cleared</li> <li>▶ Length of new shipping channels created</li> <li>▶ Quantity of material dredged</li> </ul>	Measurement of clearing of mangroves and widening of channels due to erosion can be best done through use of time series high resolution satellite images or aerial photos.
<b>Livelihoods Related to Mangroves</b>			
Income from Fish, Shrimp, and Crabs	No direct pressure	Not applicable	Pressure will be through reduction in quality and extent of mangrove habitat which is covered separately under this VEC
<b>Public Health</b>			
Air Quality	Air quality impacts are mainly associated with operation of coal fired plants in PQA area.	Installed capacity of coal fired power plants in PQA area.	Pressure will correspond to the installed capacity

<sup>301</sup> The Self-Monitoring and Reporting Tool managed by the Sindh Environmental Protection Agency under which the industries can report compliance with NEQS at specified intervals.

### Exhibit 7.3: Framework for Indicators of External Pressures on VECs

VEC	Description of Pressure	Indicators	Comments
<b>Mangrove Ecosystem and Biodiversity</b>			
<ul style="list-style-type: none"> <li>▶ Fish</li> <li>▶ Shrimp</li> <li>▶ Crab</li> </ul>	Non-sustainable harvesting practices by local communities impact the diversity and abundance of the species	▶ Landings of fish, shrimp, and crab from trips originating in Study Area.	Landing statistics will be best organized through Marine Fisheries Department.
Mangroves	Clearing of mangroves for construction of residential and commercial areas outside PQA Notified Area	▶ Extent of mangroves cleared.	Measurement of clearing of mangroves can be best done through use of time series high resolution satellite images or aerial photos. Clearing of mangroves should be minimized and credible offsets should be created if clearing is unavoidable
Intertidal Mudflats	Use of mudflats for construction of residential and commercial areas outside PQA Notified Area	▶ Extent of mangroves cleared.	Measurement of clearing can be best done through use of time series high resolution satellite images or aerial photos.
Water Quality	Wastewater flows from industrial and residential areas	<ul style="list-style-type: none"> <li>▶ Quantity of wastewater discharged into estuary others.</li> <li>▶ Quantity of key pollutants mainly nutrients and heavy metals discharged by others.</li> </ul>	PQA does not have leverage to introduce SMART in industrial areas in which it does not have jurisdiction. Measurements can be made at key discharge points where effluents are drained into the estuary.
Sediment Quality	Heavy metals from wastewater contaminating the sediments in the estuary	▶ Same as above for Water Quality.	
<b>Livelihoods Related to Mangroves</b>			
Income from Fish, Shrimp, and Crabs	Given the vulnerability of the dependent population, use of illegal and capital intensive methods which they may not be able to afford will reduce their ability to catch	<ul style="list-style-type: none"> <li>▶ Percent of catch by illegal fishing methods such as fine mesh drag nets locally known as <i>Bullo Gujja</i>.</li> <li>▶ Percent of catch by commercial fishing outfits as opposed to subsistence harvesting if data is available.</li> </ul>	Periodic field surveys will be required to determine the extent to which illegal and capital intensive fishing methods are used.
<b>Public Health</b>			
Air Quality	Air quality impacts will mainly be associated with operation of coal fired plants outside PQA area	▶ Installed capacity of coal fired power plants outside PQA area.	Pressure will correspond to the installed capacity.



### Exhibit 7.4: Framework for Indicators of State of VECs

VEC	Indicators	Thresholds, limits, and/or targets	Comments
<b>Mangrove Ecosystem and Biodiversity</b>			
<ul style="list-style-type: none"> <li>▶ Fish</li> <li>▶ Shrimp</li> <li>▶ Crabs</li> <li>▶ Marine Mammals</li> </ul>	<ul style="list-style-type: none"> <li>▶ Species diversity</li> <li>▶ Species abundance</li> </ul>	<ul style="list-style-type: none"> <li>▶ No loss of species</li> <li>▶ No decrease in abundance of indicator species or abundance levels adequate to support sustainable harvesting.</li> </ul>	<p>Diversity will be presented for species as a whole and for major groups</p> <p>Abundance will be measured under a defined sampling protocol for a limited number of key species, up to 5 for fish, and 2-3 for shrimp, crabs, and marine mammals each. Key species will be selected in view of income value, representation of main classes and families, and conservation status.</p>
Mangroves	<ul style="list-style-type: none"> <li>▶ Health of mangroves.</li> <li>▶ Extent of widening of shipping channels in mangrove areas due to erosion.</li> </ul>	<ul style="list-style-type: none"> <li>▶ No deterioration in health of mangroves</li> <li>▶ No further widening of channels</li> </ul>	<p>Tracking of spatial changes in health of mangroves on the basis of defined classification system (see Ecological Baseline) that accounts for cover, height, type of growth (normal or epicormic<sup>302</sup>) and disease exposure (yellow or curled leaves, insect attacks)</p> <p>Measurement of widening of channels due to erosion can be best done through use of time series high resolution satellite images or aerial photos.</p>
	<ul style="list-style-type: none"> <li>▶ Concentration of key pollutants in estuary water, mainly nutrients and heavy metals.</li> </ul>	<ul style="list-style-type: none"> <li>▶ Limits on the basis of reference site or sites</li> </ul>	<p>Periodic sampling in the estuary following a specified protocol</p>
	<ul style="list-style-type: none"> <li>▶ Concentration of key pollutants in estuary sediments, mainly heavy metals.</li> <li>▶ Silt and clay content.</li> </ul>	<ul style="list-style-type: none"> <li>▶ Limits for heavy metals on the basis of crustal abundance</li> <li>▶ No change in silt and clay content</li> </ul>	<p>Periodic sampling in the estuary following a specified protocol</p>
Intertidal Mudflats	None relevant to pressure applicable.	None relevant to pressure applicable.	Concentration of key pollutants in estuary sediments, mainly heavy metals and silt content within mangrove areas is already considered above.
<b>Livelihoods Related to Mangroves</b>			
Income from Fish, Shrimp, and Crabs	<ul style="list-style-type: none"> <li>▶ Market value of fish, shrimp, crab catch</li> <li>▶ Market value of catch using illegal and non-sustainable fishing practices</li> <li>▶ Market value of catch using capital intensive methods such as large boats</li> </ul>	<ul style="list-style-type: none"> <li>▶ No decrease in market value in real terms provided harvesting remains within sustainable limits</li> <li>▶ Annual decrease of 5% in catch by illegal means</li> <li>▶ No further increase in catch using larger boats.</li> <li>▶ Elimination of catch using larger boats</li> </ul>	<p>The quantities available from pressure indicators can be multiplied by prices to estimate market value.</p>

<sup>302</sup> The height of the mangrove tree does not increase and the growth is in the form of branches that shoot off the trunk closer to the ground.

VEC	Indicators	Thresholds, limits, and/or targets	Comments
		over time.	
<b>Public Health</b>			
Air Quality	Concentration of key parameters such as SO <sub>x</sub> , NO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub>	Limits as defined in NEQS or SEQS <sup>303</sup> for air quality. Threshold on total generation capacity for coal-fired power plants within Port Qasim.	Periodic sampling at location of sensitive receptors following a defined sampling protocol. The threshold for total capacity at Port Qasim (based on air quality modelling) will be provided as part of the impact assessment.

### **Exhibit 7.5: Framework for Indicators of Response or Actions Taken by Stakeholders to Maintain or Enhance the VECs**

VEC	Response Indicator
<b>Mangrove Ecosystem and Biodiversity</b>	
<ul style="list-style-type: none"> <li>▶ Fish</li> <li>▶ Shrimp</li> <li>▶ Crab</li> <li>▶ Marine mammals</li> </ul>	<ul style="list-style-type: none"> <li>▶ Preparation and enforcement of guidelines for regulation of fishing and harvesting in PQA Notified Area to maintain harvesting at sustainable levels.</li> <li>▶ Preparation and enforcement of guidelines for avoidance of ship collisions with marine mammals</li> </ul>
Mangroves	<ul style="list-style-type: none"> <li>▶ Zoning to control extent of conversion of mangroves and mudflats to other uses.</li> <li>▶ Setting limits on extent of conversion of mangroves and mudflats to other uses.</li> <li>▶ Enforcement of NEQS for waste water in collaboration with Bin Qasim Association of Trade and Industry and Sindh EPA.</li> <li>▶ Guidelines for control of erosion and sedimentation.</li> </ul>
Mudflats	Addressed above through zoning.
<b>Livelihoods Related to Mangroves</b>	
Income from Fish, Shrimp, and Crabs	No direct response suggested with respect to income, control through enforcement of guidelines for regulation of fishing and harvesting in PQA area to maintain harvesting at sustainable levels as described under Mangrove Ecosystem and Biodiversity.
<b>Public Health</b>	
Air Quality	<ul style="list-style-type: none"> <li>▶ Limits on total capacity of significant emitters in PQA such as coal-fired power generation.</li> <li>▶ Zoning of significant emitters to locate them away from receptors if assessed to be beneficial.</li> </ul>

## **7.4 Baseline Status of VECs – Indicator of State**

This section presents the baseline VECs through associated indicators of state identified. The VECs and indicators of state were presented in **Exhibit 7.4**.

The baseline status of the VECs is summarized in **Exhibit 7.6**. The information is presented in detail in the baselines (**Section 4** Physical Baseline, **Section 5** Ecological Baseline and **Section 6** Socioeconomic Baseline) for the Study Area defined in **Section 3**.

<sup>303</sup> National Environmental Quality Standards or Sindh Environmental Quality Standards

**Exhibit 7.6: Summary of Baseline Status (Indicator of State) of VECs**

VEC	Indicator	Baseline Status (Indicator of State)	Comments
Fish	Species Diversity	<p>128 species are reported from a sampling exercise carried out at Ketī Bandar (a reference site outside the Study Area) of which 126 species were marine species while two are brackish water species (see <b>Section 5.5.1</b>). All 126 marine species that occur in the Ketī Bandar area are assumed to occur in the Study Area at Port Qasim.</p> <p>The two species that occur in brackish water at Ketī Bandar are unlikely to occur in the Study Area as the brackish water zone has been much reduced in the Study Area due to reduction in inflows of fresh water, and a high level of pollution in the low salinity waste water that flows into the Study Area from residential and industrial areas (see <b>Section 5.5.1</b>). The fresh water species that occur in the Ketī Bandar area are not likely to occur in Study Area.</p> <p>The sampling exercise carried out during September 2015 resulted in observation of 66 species. Limited time availability resulted in inability to achieve saturation in sampling. Therefore, an estimate for the total number of species could not be obtained. However, the trend of reduced species diversity closer to polluting anthropogenic activity and increased species diversity at locations distal to polluting anthropogenic activity, was observed.</p>	<p>Additional was requested from the Marine Fisheries Department on species abundance and diversity; however information was not provided.</p> <p>The MFD has carried out extensive fish and shrimp sampling in Issaro Creek within the Study Area. In addition, they have carried out fish and shrimp sampling in the at least 13 other locations in the Indus Delta including creeks near Ketī Bandar. This information may be used at a later stage, when available, for comparison against monitoring information.</p>
	Species Abundance	Species abundances for the fish species observed during sampling in September 2015 showed a trend of higher species abundance at points distal from the coastline and a lower species abundance at points proximal to the coastline. Abundances for the species observed are given in <b>Exhibit 5.40</b> (see <b>Section 5.5.2</b> )	See comment above.
Shrimp	Species Diversity	Shrimp of <i>Parapenaeopsis</i> spp and <i>Metapenaeus</i> spp were observed during sampling carried out in June 2015 (see <b>Section 5.5.3</b> ). During Sampling carried out in September 2015 four shrimp species were observed, all belonging to the Penaeidae family, of which two were <i>Parapenaeopsis</i> spp. These included <i>Parapenaeopsis sculptilis</i> and <i>Parapenaeopsis stylifera</i> . <i>Penaeus indicus</i> and <i>Penaeus japonicus</i> were also observed.	<p>Additional data was requested from the Marine Fisheries Department on species abundance and diversity; however information was not provided.</p> <p>The MFD has carried out extensive fish and shrimp sampling in Issaro Creek within the Study Area. In addition, they have carried out fish and shrimp sampling in the at least 13 other locations in the Indus Delta including creeks near Ketī Bandar. This information may be used at a later stage, when available, for comparison against further monitoring information.</p>
	Species Abundance	To be established.	See comment above.
Crab	Species Diversity	Brachyuran crabs form the major component of crabs present. They fall into the families Grapsidae, Ocypodiidae, Xanthidae and Portunidae. The two species of crabs reported from the Study Area include <i>Scylla serrata</i> and <i>Portunus pelagicus</i> . The locals are engaged in	

VEC	Indicator	Baseline Status (Indicator of State)	Comments
		catching the species <i>Portunus pelagicus</i> (see <b>Section 5.5.3</b> ). During sampling in September 2015 three additional crab species were observed, <i>Charybdis feriatus</i> , <i>Portunus segnis</i> and <i>Portunus sanguinolentus</i> .	
	Species Abundance	During the mangrove sampling exercise carried out in September 2015, crab holes were observed at all four Study Sites and in each of the quadrats in which sampling was carried out. Highest number of crab holes were observed at the Study Site closest to the effluent release, from the nearby coastline. During fish sampling carried out in the same period, three species of crabs were observed (named above) at two of the six sampling locations.	
Marine Mammals	Species Diversity	Three cetacean species (Indian Ocean Humpback Dolphin <i>Sousa plumbea</i> , Bottle-nosed Dolphin <i>Tursiops truncatus</i> , and Finless Porpoise <i>Neophocaena asiaeorientalis</i> ) have been reported from the Indus Delta. Indian Ocean Humpback Dolphin has been sighted in the Study Area.	
	Species Abundance	There were no sightings during the surveys conducted as a part of this study. Systematic data on abundance is not available.	
Mangroves	Health of mangroves	The health of mangroves was assessed using three categories as defined in the mangrove characterization scheme used in the Ecology Baseline (see <b>Section 5.3.4</b> ). The categories include 'Healthy Mangroves', 'Unhealthy Mangroves' and 'Mangroves with Dieback'. The results of the analysis carried out using Google Earth™ Satellite imagery and demarcation for each study site are shown in <b>Exhibit 5.14 to Exhibit 5.18</b> (see <b>Section 5.3.5</b> ). The results of the ground verification and mangrove sampling carried out in September 2015 are shown in <b>Exhibit 5.19</b> and <b>Exhibit 5.20</b> (see <b>Section 5.3.6</b> ).	Sites proximal to the coast line at Port Qasim (where anthropogenic activity such as release of effluents from industries and human settlements is present) Healthy Mangroves covered a larger percentage area relative to sites distal from the coast line. In contrast the proportion of Unhealthy Mangroves is higher at study sites distal from Port Qasim. Mangroves with Dieback are mainly on thin strips of land along shorelines.
	Extent of widening of shipping channels in mangrove areas due to erosion and/or dredging.	Erosion along the current navigation channel and anticipated extension is presented in <b>Section 4.2.5</b> . The results of the analysis show that the net erosion per unit channel is: <ul style="list-style-type: none"> <li>▶ 48.6 m<sup>2</sup>/m-channel along Kadiro Creek</li> <li>▶ 15.0 m<sup>2</sup>/m-channel in front of the main Port Qasim bulk terminal</li> <li>▶ 15.5 m<sup>2</sup>/m-channel along Gharo Creek where the proposed extension to the current navigation channel is.</li> </ul> The high erosion along Kadiro creek is due to ship wake. This is indicated by the lower amount of erosion along wider sections of the channel (i.e. along port Qasim bulk terminals and along the proposed extension within Gharo Creek); ship wake has greater impact in narrow channels. In addition to this, dredging within Kadiro Creek may also be a factor.	In addition to mangrove erosion along the banks, the amount of dredging material removed from the channel each year by Port Qasim is an indicator of erosion and sedimentation within the channel, particularly since sediment may be carried in from the ocean into the estuary as well as the eroded mangrove area. Trends in this would indicate any requirements for increased dredging. This information may be used by PQA when carrying out any further monitoring and evaluation.
	Concentration of key pollutants in estuary water, mainly nutrients and heavy metals	The concentrations of key pollutants within the estuary are provided in <b>Exhibit 4.33</b> (Seawater Quality Results) in <b>Section 4.6.3</b> . The heavy metals concentration indicate that	The results indicate that the estuary is tide-dominated estuary, and is well-flushed or the flow of wastewater is very low compared to the tidal

VEC	Indicator	Baseline Status (Indicator of State)	Comments
		there is little contamination in the Study Area. Nutrients enter the Study Area largely from municipal drains east of Port Qasim e.g. Bhains Colony and drains along the Malir River. Nonetheless, there is long-term bioaccumulation of heavy metals in the fish tissue (see <b>Section 5.5.4</b> )	prism, particularly in the Port Qasim area, but higher in areas such as Bhains Colony and Malir River.
	Concentration of key pollutants in estuary sediments, mainly heavy metals.	Concentration of key pollutants in sediments within the Study Area are provided in <b>Section 4.7.6</b> . The results do not indicate a major contamination; however Manganese and Strontium are present in concentrates higher than average crustal abundance.	
	Silt and clay content	The particle size distribution is provided in <b>Section 4.7.6</b> . However this is for areas within the channel.	
Income from fish, shrimp and crab	<ul style="list-style-type: none"> <li>▶ Market value of fish, shrimp, crab catch</li> <li>▶ Market value of catch using illegal and non-sustainable fishing practices</li> <li>▶ Market value of catch using capital intensive methods such as large boats</li> </ul>	<p>With reference to <b>Section 6.4.5</b>:</p> <ul style="list-style-type: none"> <li>▶ Total annual fish catch of 70,110 metric tons as derived from the MFD data, with annual market value of the fish caught in the Study Area is estimated at PKR 7,332 million.</li> <li>▶ Annual shrimp catch estimated at 4,413 metric tons estimated on the basis of MFD data for three types of shrimp. Annual market value of shrimp catch in the Study Area is estimated at PKR 3,473 million.</li> <li>▶ Annual crab catch estimated at 34,131 kg as calculated from the survey data. Annual market value of crab catch is estimated at PKR 8 million.</li> </ul> <p>A reported 71% of fishing trips originating on small to medium boats that go into the mangroves, have been reported to use illegal or non-sustainable fishing practices.</p>	
Air Quality	<ul style="list-style-type: none"> <li>▶ Concentration of key parameters including SO<sub>x</sub>, NO<sub>x</sub>, TSP, PM<sub>2.5</sub> and PM<sub>10</sub></li> </ul>	The baseline status of the air quality in three zones within and proximal to the Port Qasim Industrial areas are provided in <b>Section 4.5</b> .	



## 8. Impact Assessment

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**Section 7** of this report identified and prioritized Valued Environmental Components (VECs) in the following manner:

- ▶ Possible VECs were determined using information in baseline studies (**Section 4**, **Section 5**, and **Section 6**), and prioritized ecosystem services based on an Ecosystem Service Review<sup>304</sup> which included consultations with community and institutional stakeholders (**Section 6.2**).
- ▶ VECs were prioritized and shortlisted on the basis of degree of potential impact that PQA could have on the VECs and leverage of PQA over managing the VECs (**Exhibit 7.1** in **Section 7**).

In addition to prioritization of VECs, identification of indicators and thresholds for VECs was also carried out in **Section 7**. The impact assessment in this section focuses on the indicators and is conducted in the perspective of thresholds recommended in **Section 7** for indicators of state (**Exhibit 7.4**).

**Section 2** describes the under construction, anticipated, and reasonably foreseeable ‘Developments’ in PQA. The time horizon for the impact assessment in this section is therefore the same as that for the Developments, i.e., of the order of 35 years until 2050.

A ‘Business as Usual’ management scenario was considered for assessing the impacts in this section. This management scenario assumes that current policies, and regulatory and management practices being applied in the Study Area will continue until 2050.

This section addresses impacts on the following shortlisted VECs:

- ▶ **Physical Environment:** Air quality as it impacts public health
- ▶ **Ecological Environment:** Mangrove ecosystem and biodiversity including diversity and abundance of fish, shrimp, and crab species, mangrove habitats, and intertidal mudflat habitats
- ▶ **Socioeconomic Environment:** Income from harvesting of fish, shrimp, and crab

### 8.1 Air Quality

This section covers an assessment of the impacts of past and proposed infrastructure developments by PQA and other Developments on air quality. The impact of PQA on the ambient air quality is currently not substantial (see **Section 4.5.3** and **Appendix E**). However, this is expected to change in future as more industrial units are installed in the industrial zones. This development together similar developments outside PQA are likely to affect the communities in the Study Area as well as workers of industrial units and port. The objective of the air quality impact analysis is to predict the likely ambient air

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<sup>304</sup> Ecosystem Service Review for Industrial and Port Developments at Port Qasim’, Hagler Bailly Pakistan, June 2015, prepared as a part of this study.

quality in future in areas affected by PQA activities. The methodology of assessment is summarized in **Exhibit 8.1**.

**Exhibit 8.1: Ambient Air Quality Assessment Methodology**

<i>Step</i>	<i>Description</i>	<i>Explanation of Scope and Methodology</i>
1	Identify all PQA activities carried out in 2015 and their air quality impacts	<p>The PQA activities that have been considered include:</p> <ul style="list-style-type: none"> <li>▶ Shipping (1,372 ship visits annually) in the shipping channel from the outer sea to Port Qasim and ships at berth;</li> <li>▶ Industrial activities in the PQA Industrial Zones (currently covering 18% of the area of the zones);</li> <li>▶ Road traffic on the internal PQA road;</li> <li>▶ Road traffic on the National Highway N-5 (within the Study Area) due to PQA related traffic;</li> <li>▶ Railway traffic on the railway track within PQA (carrying 2,445,000 tonnes of cargo annually); and</li> <li>▶ Railway traffic on Main Pakistan railway Track (within the Study Area) due to PQA activities.</li> </ul>
2	Identify receptors of PQA Activities	<p>The identified receptors included:</p> <ul style="list-style-type: none"> <li>▶ Railway Colony;</li> <li>▶ Haji Jhanghi Khan and surrounding villages;</li> <li>▶ Pipri;</li> <li>▶ Shah Latif Town; and</li> <li>▶ New Malir Housing Society.</li> </ul>
3	Identify other developments that are likely to affect the receptors identified in Step 1; model their impact; and combine the results with that of PQA	<p>The following developments, outside PQA, were identified and modeled:</p> <ul style="list-style-type: none"> <li>▶ Trains on main railway line (46 trains per day);</li> <li>▶ Traffic on N-5 (40,100 vehicles per day);</li> <li>▶ The K-Electric Bin Qasim thermal power station;</li> <li>▶ Pakistan Steel Mills (currently estimated to be operating at 10% of its 1.1 million tonne capacity);</li> <li>▶ Aisha Steel Mills (production capacity – 220,000 tonnes per year)</li> <li>▶ Tuwairqi Steel Mills (production capacity – 1.28 million tonnes per year but currently not operational)</li> <li>▶ Landhi Industrial Area; and</li> <li>▶ Residential areas and colonies on the north and northwest of PQA.</li> </ul>

<i>Step</i>	<i>Description</i>	<i>Explanation of Scope and Methodology</i>
4	Based on the development scenarios ( <b>Appendix E</b> ) identify the likely nature and magnitude of activities due to PQA in 2050	<p>The projection for 2050 for PQA activities are as follows:</p> <ul style="list-style-type: none"> <li>▶ Based on the Strategic Planning Study for Port Qasim (SPSPQ), the volume of shipping activity was estimated to be 3,008 ships per year;</li> <li>▶ The volume of cargo transported by railways was estimated to be 5,56 million tonnes;</li> <li>▶ Volume of traffic on the PQ access roads was estimated to be 77,370;</li> <li>▶ All power plants currently planned or under construction are expected to be fully operational; and</li> <li>▶ All industrial plots in the PQA industrial zones that are currently vacant are projected to be fully occupied and active.</li> </ul>
5	Based on the development scenarios identify the likely nature and magnitude of activities due to other developments in 2050	<p>The project for 2050 for other developments are as follows:</p> <ul style="list-style-type: none"> <li>▶ Privatization and subsequent upgrade of Pakistan Steel Mills to 3.5 million tonne capacity and operation at 100% capacity;</li> <li>▶ Tuwairqi Steel Mills will be in operation;</li> <li>▶ Lucky Electric Power Company Limited (660 MW Coal fired power plant);</li> <li>▶ Conversion of K-Electric HFSO stacks to coal;</li> <li>▶ Increase in traffic on N5 to 2.5 times current flows due to lane doubling and increased use;</li> <li>▶ Volume of traffic on main railway track was estimated to be 90 trains per day; and</li> <li>▶ All residential plots currently empty are occupied.</li> </ul>
6	Model the ambient air quality for 2050 due to PQA activities and other developments, separately	

The United States Environmental Protection Agency (USEPA) approved regulatory air quality model AERMOD was used for this assessment. The details of the modeling and assessment are provided in **Appendix E**.

The pollutants that were modeled included oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), coarse inhalable particulate matter (PM<sub>10</sub>) and fine inhalable particulate matter (PM<sub>2.5</sub>). All significant emission sources were included with one exception. Wind-blown dust is a major source of PM<sub>10</sub> in the ambient air. However, the emission depends on several factors such as vegetation on the land, whether it is disturbed or stable, particle size distribution, amount of moisture, and wind speed. As reliable information on these factors and relationship of these factors with the air-borne dust are not available, PM<sub>10</sub> model only covers anthropogenic sources.

Given the long-term nature of the study, only annual average concentrations are modeled. The results are evaluated against the Sindh Environmental Quality Standards (SEQS) for Ambient Air and IFC Environment, Health and Safety (EHS) Guidelines for Ambient Air Quality Guidelines. The *target limits*, defined as more stringent of the two criteria, are provided in **Exhibit 8.2**.

**Exhibit 8.2:** Target for Air Quality Evaluation – Annual Average Limits ( $\mu\text{g}/\text{m}^3$ )

	$\text{NO}_x$	$\text{SO}_2$	$\text{PM}_{10}$	$\text{PM}_{2.5}$
SEQS	100 <sup>a</sup>	80	120	40
IFC EHS	40 <sup>a</sup>	— <sup>b</sup>	70	35
Target Limit	40	80	70	35

Notes: a. IFC EHS Guidelines are for  $\text{NO}_x$  expressed as  $\text{NO}_2$ ; whereas SEQS has separate standards for  $\text{NO}_2$  and  $\text{NO}$  ( $40 \mu\text{g}/\text{m}^3$  for each pollutant separately). The  $\text{NO}$  limit is converted to  $\text{NO}_2$  limit by assuming that all  $\text{NO}$  oxidizes to  $\text{NO}_2$  and hence a combined  $\text{NO}_x$  limit is obtained ( $40 + 61.3 = 101.3 \mu\text{g}/\text{m}^3$ ). b. IFC EHS does not prescribe any annual limit for  $\text{SO}_2$ .

### 8.1.1 Cumulative Impact of Current Anthropogenic Activities on Air Quality

The detailed results are provided in **Appendix E**. Summary results are presented in **Exhibit 8.3**. Following observations are made on the results:

- ▶ The average concentration of  $\text{NO}_x$  in the Study Area is 5.13 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ). This is well below the target limit. The contribution of PQA activities to the  $\text{NO}_x$  concentration in the Study Area is about 33%. The largest source of  $\text{NO}_x$  in the Study Area is the K-Electric Thermal Power Station. Due to this source,  $\text{NO}_x$  concentrations exceed target limits in a small area, about 27 hectares (ha) around the Engro Polymer plant. The other area where the annual average concentration of  $\text{NO}_x$  is relatively high is to the west of PQA, however, the maximum concentration is less than the target limits. The primary source of  $\text{NO}_x$  in this area is the Landhi Industrial Area.
- ▶ The average concentration of  $\text{SO}_2$  in the Study Area is  $13.66 \mu\text{g}/\text{m}^3$ —well below the target limit. The contribution of PQA activities to the  $\text{SO}_2$  concentration in the Study Area is about 15%. The largest source of  $\text{SO}_2$  in the Study Area is the K-Electric Thermal Power Station which contributes about 85% of the  $\text{SO}_2$ . Due to this source,  $\text{SO}_2$  concentrations exceed target limits in an area of about 770 ha near the K-Electric Power Plant. It may be noted that this high value of  $\text{SO}_2$  is a result of the assumption that Units 1 and 2 of K-Electric Thermal Power Station operated on high sulfur fuel oil (HSFO) throughout the year. In reality the operation of the plant on HSFO has been on the decline and which, in turn, reduces the concentration of  $\text{SO}_2$  and also  $\text{NO}_x$  in the ambient air.
- ▶ The incremental contribution of PQA activities as well as that of other developments on the  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$  concentrations in the ambient air are very low.

### **8.1.2 Cumulative Impact of Anthropogenic Activities on Air Quality for 2050**

The results of modeled emissions in 2050 (due to PQA and due to other developments) to air quality standards are given in **Exhibit 8.4**. This modeling assumes a ‘business-as-usual’ scenario which means that other than reduction in unit emissions due to improved technology or international requirements there is no change in the unit emission rate. The reduction is assumed in the ship emission as more stringent standards of MARPOL kicks in. Similarly, the railway and road unit emission rates are assumed to decline due to availability of better engines. Comparison of the 2015 and 2050 impact of NO<sub>x</sub> and SO<sub>2</sub> emissions are shown in **Exhibit 8.5** and impact of PM<sub>10</sub> and PM<sub>2.5</sub> emissions are shown in **Exhibit 8.6**.

The observations on the results are as follows:

- ▶ The intensity and the area of non-compliance with target limits of NO<sub>x</sub> are predicted to increase significantly. The area will cover almost 9,000 ha and will be affecting some of the communities on the northeastern side of the PQA. This is not due to any single factor but is a result of cumulative emission increase in industries in PQ, production at PSM, and the emission from coal fired power plants. Contribution of PQA activities in the ambient air concentration of NO<sub>x</sub> will be 60%, most of which will come from industrial units and power plants. The significant non-PQ contributor will be the Pakistan Steel Mills (which is also assumed to have increased its production capacity to three times its present capacity).
- ▶ The intensity and the area of non-compliance with target limits of SO<sub>2</sub> are predicted to increase significantly. The area will cover almost 6,000 ha and will be affecting the entire Eastern Industrial Zone as well as the communities on the northeastern side of the PQA. Contribution of PQ activities in the ambient air concentration of SO<sub>2</sub> will be almost 88%, most of which will come from incineration and coal fired power plants. Incineration plants, although fewer in number, can have significant emission. Other significant sources of SO<sub>2</sub> emission are the K-Electric thermal power station and the PSM.
- ▶ The incremental concentration of PM<sub>10</sub> and PM<sub>2.5</sub> due to the PQA activities and other developments in 2015 is 0.85 µg/m<sup>3</sup> and 0.34 µg/m<sup>3</sup>, respectively. This is predicted to increase to 5.99 µg/m<sup>3</sup> and 0.92 µg/m<sup>3</sup>, respectively in 2050. The total incremental concentrations will still be significantly below the target limits.



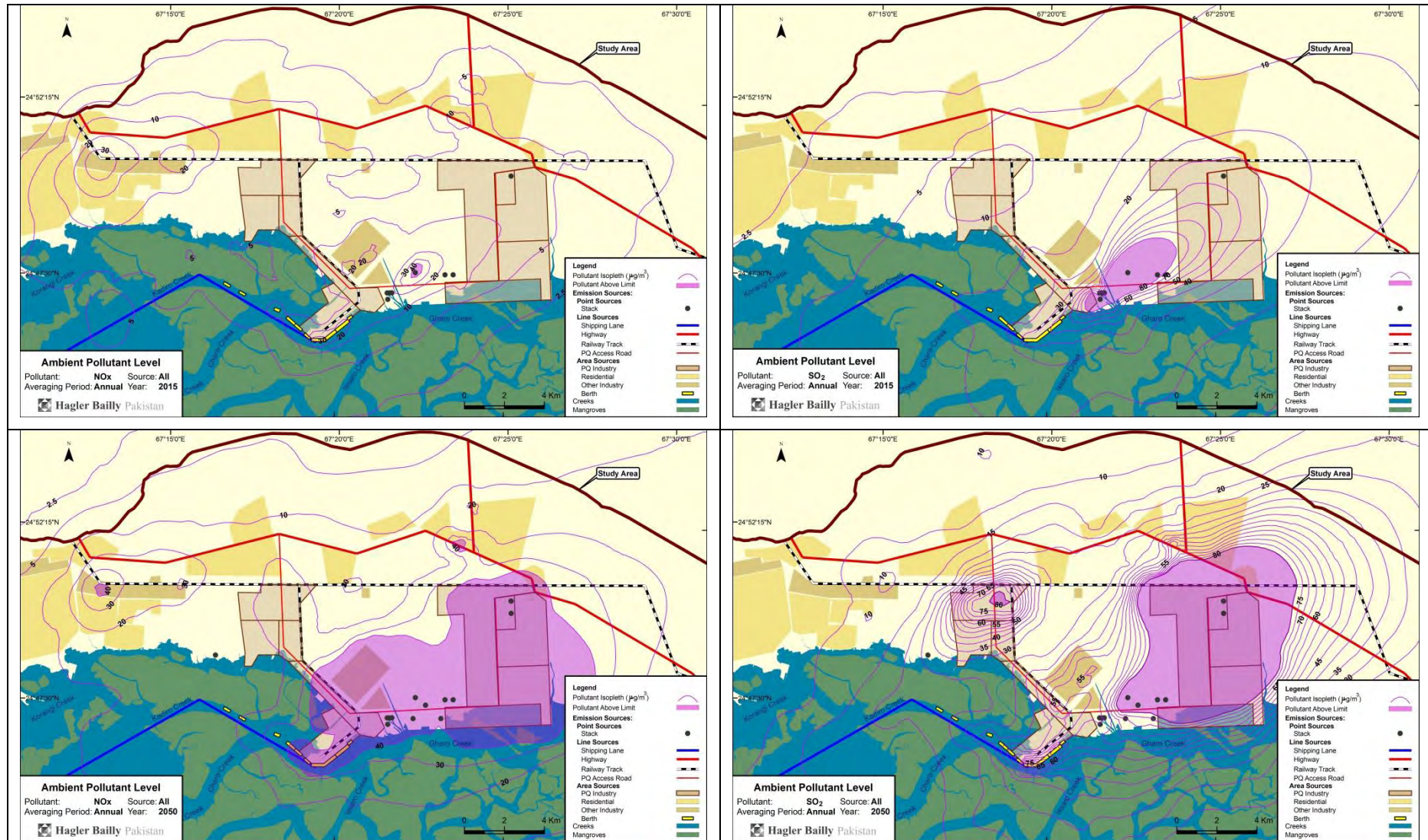
**Exhibit 8.3: Status of Ambient Air Quality in 2015 ( $\mu\text{g}/\text{m}^3$ )**

Pollutant		PQA Activities				Other Developments							Cumulative		Target
		Ships	Industrial Units	Roads and Rail Traffic	Total	Residential	Power Plants	Landhi Industrial Area	Pakistan Steel Mills	Aisha Steel Mill	Roads and Rail Traffic	Total	Total	Max	
NO <sub>x</sub>	Ave.	0.71	0.61	0.37	<b>1.69</b>	0.01	1.45	1.04	0.70	0.02	0.23	<b>3.44</b>	5.13	53.86	40
	Contrib	14%	12%	7%	<b>33%</b>	0%	28%	20%	14%	0%	5%	<b>67%</b>	100%		
SO <sub>2</sub>	Ave.	0.50	1.66	0.22	<b>2.38</b>	0.00	13.63	0.00	0.02	0.01	0.12	<b>13.79</b>	16.17	245.17	80
	Contrib	3%	10%	1%	<b>15%</b>	0%	84%	0%	0%	0%	1%	<b>85%</b>	100%		
PM <sub>10</sub>	Ave.	0.05	0.46	0.01	<b>0.52</b>	0.08	0.21	0.00	0.03	0.00	0.01	<b>0.33</b>	0.85	34.19	70
	Contrib	6%	54%	1%	<b>61%</b>	10%	24%	0%	4%	0%	1%	<b>39%</b>	100%		
PM <sub>2.5</sub>	Ave.	0.05	0.00	0.03	<b>0.07</b>	0.08	0.15	0.00	0.00	0.00	0.03	<b>0.27</b>	0.34	3.32	35
	Contrib	13%	0%	9%	<b>22%</b>	24%	44%	0%	0%	0%	10%	<b>78%</b>	100%		

**Exhibit 8.4: Status of Ambient Air Quality in 2050 ( $\mu\text{g}/\text{m}^3$ )**

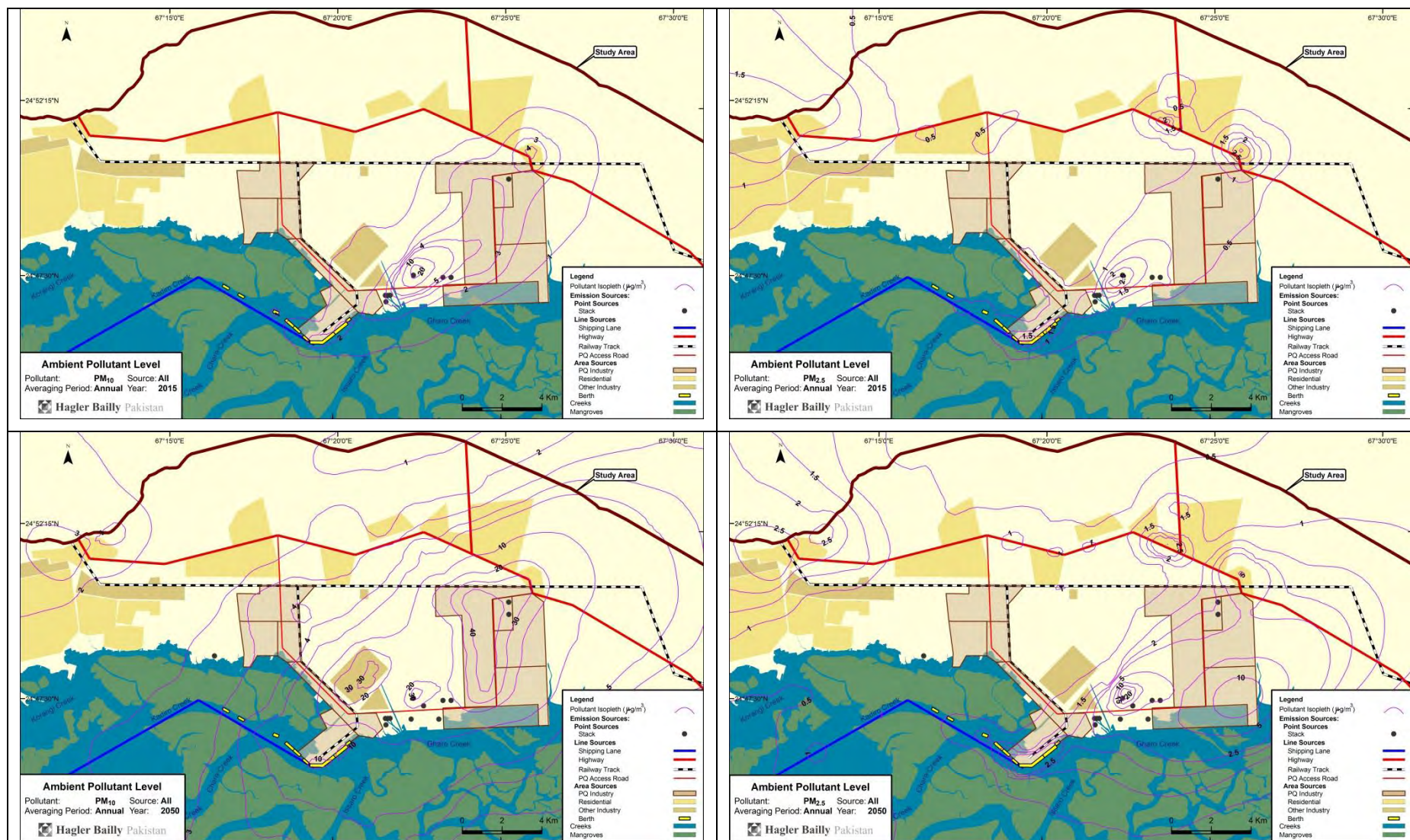
Pollutant		PQA Activities				Other Developments							Cumulative		Target
		Ships	Industrial Units	Roads and Rail Traffic	Total	Residential	Power Plants	Landhi Industrial Area	Pakistan Steel Mills	Aisha and Tuwairqi Steel Mills	Roads and Rail Traffic	Total	Total	Max	
NO <sub>x</sub>	Ave.	1.54	11.69	1.19	<b>14.41</b>	0.01	1.92	1.04	6.03	0.02	0.56	<b>9.57</b>	23.98	226.96	40
	Contrib	6%	49%	5%	<b>60%</b>	0%	8%	4%	25%	0%	2%	<b>40%</b>	100%		
SO <sub>2</sub>	Ave.	1.11	29.37	0.73	<b>31.20</b>	0.00	3.08	0.00	0.77	0.01	0.30	<b>4.16</b>	35.36	289.44	80
	Contrib	3%	83%	2%	<b>88%</b>	0%	9%	0%	2%	0%	1%	<b>12%</b>	100%		
PM <sub>10</sub>	Ave.	0.12	4.52	0.01	<b>4.65</b>	0.12	0.12	0.00	1.10	0.00	0.01	<b>1.34</b>	5.99	48.12	70
	Contrib	2%	75%	0%	<b>78%</b>	2%	2%	0%	18%	0%	0%	<b>22%</b>	100%		
PM <sub>2.5</sub>	Ave.	0.11	0.17	0.38	<b>0.65</b>	0.12	0.06	0.00	0.00	0.00	0.09	<b>0.26</b>	0.92	32.57	35
	Contrib	12%	18%	41%	<b>71%</b>	13%	6%	0%	0%	0%	9%	<b>29%</b>	100%		

**Exhibit 8.5: Concentrations of NO<sub>x</sub> and SO<sub>2</sub> in 2015 and 2050**





**Exhibit 8.6: Concentrations of PM<sub>10</sub> and PM<sub>2.5</sub> in 2015 and 2050**



### 8.1.3 Particulate Matter Concentration from Natural Sources

Windblown dust is the major source of particulate matter in the ambient air. The analysis shows that anthropogenic sources have negligible emissions as compared to natural sources. To estimate the concentration of dust in the ambient air due to natural sources, the Study Area was divided into 12 blocks on the basis of dominant land use. Land use in each block was categorized as follows: active agriculture, inactive agriculture, barren, and constructed land. The detailed results are provided in **Appendix E**. Summary results are presented in **Exhibit 8.7** and shown in **Exhibit 8.8**. Following observations are made on the results:

- ▶ For 2015, the predicted annual average PM<sub>10</sub> concentration from natural sources is significantly above the target limit. In almost the entire area of PQA and the areas to east, the target is exceeded. This exceedance can be linked to the large area in the PQA and east of PQA which is barren or under construction and is, therefore, results in significant PM<sub>10</sub> emissions. It may be noted that the apparent lower concentration of PM<sub>10</sub> near the fringes of the Study Area is mainly due to the fact that only areas within the Study Area are considered as source. The fringe areas also receive dust from areas outside the Study Area. If a larger area was modelled, chances are that the apparent tapering off would not have been seen.
- ▶ For 2015, the predicted PM<sub>2.5</sub> concentrations from natural sources comply with the target limit for annual average concentration.

For 2050, it was assumed that the large open area with PQA will get industrial units and the area north of PQA will see new housing developments, thus the land use will change to constructed from open thereby lowering the emission of dust by wind.

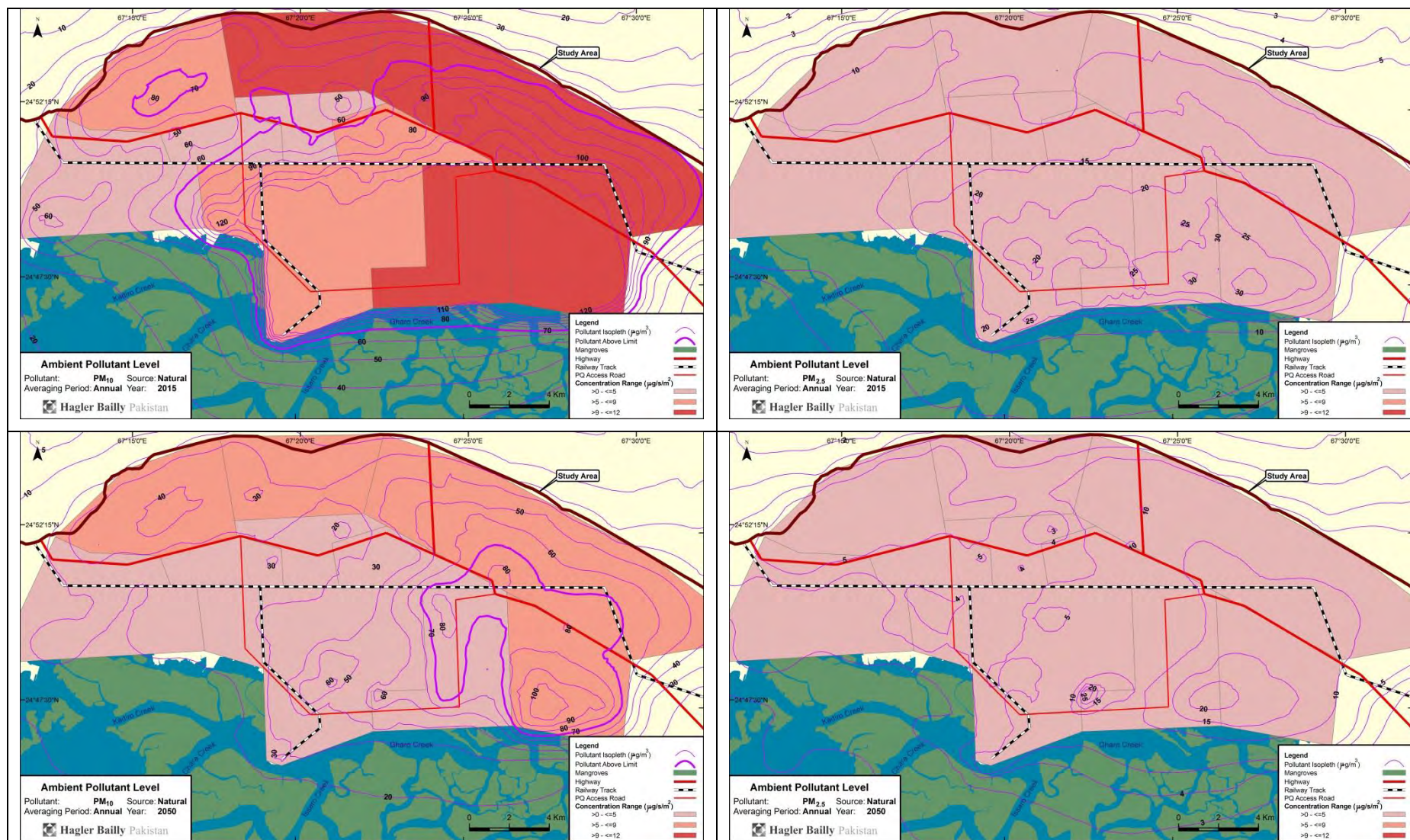
- ▶ For 2050, the predicted annual average PM<sub>10</sub> concentrations from natural sources exceeds the target limit. This is despite the fact that in 2050 the concentration of PM<sub>10</sub> due to natural sources is expected to reduce to half to that in 2015. However, the area exceeding the target limit due to the natural sources is reduced to about one-fifth.
- ▶ For 2050, the predicted PM<sub>2.5</sub> concentrations from natural sources comply with the target limit for annual average concentration.

**Exhibit 8.7:** Status of Ambient Air Quality in 2015 and 2050 (µg/m<sup>3</sup>)

<i>Pollutant</i>		<i>2015</i>	<i>2050</i>	<i>Target Limit</i>
PM <sub>10</sub>	Max	218	105	70
PM <sub>2.5</sub>	Max	32	15	35



**Exhibit 8.8: Concentrations of PM<sub>10</sub> and PM<sub>2.5</sub> in 2015 and 2050**





## 8.2 Mangrove Ecosystem and Biodiversity

This section covers an assessment of the impacts of past and proposed infrastructure developments by PQA and others on the mangrove habitats in the Study Area, on the fish, shrimp, and crabs in the creeks supported by the mangrove habitat, and on the intertidal mudflats in the Study Area.

Port Qasim is located on the northwestern fringe of the Indus Delta system. The Indus Delta as a whole is the fifth largest delta in the world, formed by the river Indus and tidal creeks. It constitutes about 97% of the mangroves in Pakistan. The Study Area is part of the Indus Delta and includes the area under the PQA. Approximately 22% of the PQA area is covered by mangroves.<sup>305</sup> This is approximately one-quarter of the mangrove area in the country (see **Section 5.1**).

The mangrove habitat of the Indus River-Arabian Sea have been designated as critically endangered by the by the World Wildlife Fund (WWF). This habitat has been assessed for designation as a ‘Critical Habitat’ under the IFC Performance Standards as well (see **Section 5.8**). Additionally, based on the Asian Development Bank’s criteria, this habitat is also considered as a Critical Habitat (see **Section 5.8**) with additional importance of this habitat in the context of ecosystem services provided by this habitat.

The distribution of mangroves in the Indus Delta has changed significantly over the past several hundred years. Despite variations among sources, there is agreement that dense mangrove cover in Pakistan has declined due to multiple stresses, from about 600,000 ha in 1932 to just over 100,000 ha in 2010 (see **Section 5.3.2**). Recent trends, however, show a slight increase with greater persistence and regeneration in the northwestern part of the Indus Delta. Nevertheless, compared to other Asian countries, the mangroves in Pakistan have the highest disappearance rate of 2% per year, making them critically endangered (see **Section 5.3.2**). In addition to this, the mangroves in Pakistan are now predominantly composed of the highly salt tolerant species called *A. marina*; the other less salt tolerant species have gone extinct or survive only in localized patches, indicating increases salinity in the delta habitat (see **Section 5.3.2**).

### 8.2.1 Mangroves

Factors responsible for degeneration and regeneration of mangroves in the Study Area have been identified and include:

- ▶ reduction in fresh water flows and silt deposition from the River Indus which is expected to the long term sustainability of mangroves across the delta;
- ▶ direct loss through clearing;
- ▶ disposal of dredged materials on mangroves;
- ▶ harvesting of mangroves;
- ▶ soil erosion;
- ▶ water quality; and
- ▶ regeneration through plantations.

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<sup>305</sup> 31,316 ha as a fraction of the total Port Qasim area of 139,483 ha (see **Section 2**).

The following sections provide an assessment of impacts of Developments as well as of other activities on the mangrove habitats in the Study Area.

### **Reduction in Freshwater Flows**

The Study Area mainly receives fresh water and sediments in the Indus Delta flowing in from the Indus Basin in the southeast of the Study Area, and from catchment of Malir River draining into the northern end of the Study Area.

Surface water resources of Pakistan are mainly based on the flows of the Indus River and its tributaries. Large-scale irrigation infrastructure (the largest irrigation system in the world), has had a significant impact on the Indus delta. The Indus Basin Irrigation System (IBIS) consists of three major multi-purpose storage reservoirs, 19 barrages, 12 inter-river link canals, 45 major irrigation canals, about 148,000 water courses, and over one million tube wells delivering water to farms and for other productive uses. The annual Indus River volume is 177 billion cubic meters (BCM), of which about 128 BCM is diverted annually from the river system to canals (WB 2015). The 1991 Water Accord between the provinces recognized the need for a residual flow to the delta but in practice this has not been realized.

Extensive developments in the catchment of Malir River as it flows through the metropolitan Karachi area which include extraction of water for both agricultural and residential uses have also reduced the discharge of fresh water and sediments into the Study Area.

The reduction in fresh water and sediment flows into the Indus Delta and the Study Area has resulted in a reduction of soil deposition, delta seawater inundation, and decline in mangrove forests, fisheries and possible exacerbation of the impacts of natural disasters. While mangroves, especially *Avicennia marina*, are able to survive in seawater without regular fresh water input, it is unlikely that they can thrive indefinitely. WWF has already classified the Indus as in the top ten rivers at risk globally due to over abstraction and climate change (WWF 2007).

As stated in the baseline, there are a greater amount of Healthy Mangroves (see **Section 5.3.4** for classification) closer to Port Qasim than located further away towards the coast. Inflows of nutrient rich freshwater via sewage outfalls, as well as runoff during floods reporting though the relatively large catchment of Malir River, may be assisting the growth of mangroves.

### **Clearing of Mangroves for Construction of Port Facilities**

The Study Area (**Exhibit 3.2** in **Section 3.2**) includes 35,546 ha of mangroves, corresponding to 33% of the offshore area. The remaining 67% of the offshore area consists of creeks and open sea that cover 50% of the area, and 17% of no-mangrove areas that include mudflats, barren land, and areas where dredge materials have been dumped. Based on detailed analysis of 7 selected quadrats of 1.5 km by 1.5 km (see **Section 5.3.4**), Healthy Mangroves cover about 55% of the mangrove area, while Unhealthy Mangrove cover the remaining 45% of the mangrove area. The area covered by Dieback Mangroves is relatively small and is limited to strips of land where signs of erosion and harvesting are apparent (**Section 5.3.5**). Analysis of Google Earth™ satellite imagery indicates that while the area under Healthy Mangroves closer to mainland has

increased since development of Port Qasim, the area under Unhealthy Mangroves has increased away from Port Qasim (**Section 5.3.5**).

Loss of mangroves due to clearing and land reclamation to-date is estimated at 448 ha (see **Section 5.3.11**). In addition to this loss of mangroves due to erosion along Kadiro Creek over the last 10 years has been estimated as 44 ha (see **Section 5.3.11**).

To-date, construction of port facilities has resulted in clearing of about 328 ha (3.3 km<sup>2</sup>) of mangroves, consisting mainly of Healthy Mangroves. Mangroves covering about 120 ha (1.2 km<sup>2</sup>) have been buried under disposed dredging material. There are also anticipated Developments, the planned LNG Zone, as well as reasonably foreseeable PQA Developments on Bundal, Khiprianwala and Ziarat Shah Islands. These involve clearing of at least 1,324 ha (13.2 km<sup>2</sup>) of mangroves by 2050.

The impact of clearing to-date of 0.9% of the existing mangrove area associated with development of Port Qasim can be considered as minor. This clearing will expand to 3.7% of the existing mangroves in the Study Area by 2050 if all the planned Developments take place, which can still be considered as minor in terms of the area impacted. However, considering the classification of mangroves in the Indus Delta as Critical Habitat, the impact would be significant requiring credible offsets to comply with the IFC Performance Standards and ADB guidelines.

#### ***Clearing of Mangroves by Others Outside PQA Area***

The Defence Housing Authority and the defence organizations apparently have plans to clear mangroves in the western part of the Study Area for development of residential areas and installations.<sup>306</sup> The area that may be cleared by these organizations is presently unknown, but is likely to fall under the Healthy Mangroves. The Bundal Island and the Khiprianwala Island have also been marked for development of high end and high rise residential areas connected by bridges to the mainland (**Exhibit 3.4 in Section 3**). Mangroves on these islands cover about 711 ha (7.1 km<sup>2</sup>) of land, corresponding to 2% of the existing mangroves in the Study Area. Detailed plans for developments on these islands have yet to be prepared. Similarly, firm plans are also not available for developments that may be considered by DHA and defence organizations.

In the absence of firm plans for conversion of mangroves into urban areas outside the PQA Notified Area are not available, it is difficult to predict the likelihood of occurrence associated impacts. However, given the fact that the mangroves in the Study Area constitute Critical Habitat and demand for land for urban developments in Karachi will continue to increase, the impacts in the long run on mangrove habitats can potentially be significant.

#### ***Dumping of Dredge Material in Mangrove Areas***

Evidence of dumping of dredged material has been observed along with the resulting destruction of healthy mangrove areas on and around the location of dumping (see **Section 5.3.7**). To-date mangroves covering about 120 ha (1.2 km<sup>2</sup>) have been buried under disposed dredging material. PQA presently does not have a well-defined policy or guidelines for dumping of dredge materials, and no disposal areas have been marked in

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<sup>306</sup> Verbal communication with Mr. Rab Nawaz, Regional Director, WWF-P, Karachi, June 2015.

the plans as yet. While the mangrove area lost to dumping of dredge material is relatively small in comparison to the total area of 35,546 ha (355 km<sup>2</sup>) covered by mangroves, there is a risk of additional damage to mangroves by indiscriminate and unregulated dumping of dredge materials in future.

### ***Harvesting of Mangroves by Local Communities***

Harvesting of mangroves and grazing by camels in the mangrove areas is widespread in the Indus Delta (**Section 5.3.2**) and is considered as major threat to the mangrove ecosystem in the Indus Delta. Evidence of harvesting and utilization of mangroves by local communities for fodder and fuel, and construction of huts are recorded (**Section 6.4.8** and **Section 5.3.2**). Evidence of harvesting was also observed during the field survey of mangroves conducted as a part of this Study (**Section 5.3.12**). Given the limited scope of this study, it was not possible to establish the relative contribution of harvesting to the deterioration on condition of mangroves (such as degradation from Healthy to Unhealthy Mangroves) as opposed to that from other factors such as decreased flow of fresh water and silt in Indus Delta. While comparative figures are not available, it appears that level of harvesting in the Study Area is relatively lower, and confined mainly to the eastern part of the Study Area where the penetration and presence of the Sindh Forest Department as well as PQA is somewhat limited.

The dependence of community on mangroves for use as fuel wood was characterized as low for the Fishing Communities, the primary community involved in harvesting of mangroves (see **Section 6.5** and associated Ecosystem Service Review Report, HBP Ref: D5E01CIA). Intensity of harvesting was observed to be low to medium at some of the study sites (see **Section 5.3.12**). Given the established practice of harvesting mangroves in the local communities, expanding populations in the coastal area, and high cost of commercial fuels, the harvesting pressures are expected to continue and increase. The loss of mangroves due to harvesting can intensify if proper controls are not maintained on a continuous basis. The impact of harvesting by communities on mangrove habitats is therefore potentially significant.

### ***Ship Traffic and Port-Related Erosion***

There are clear indications that waves caused by ship traffic and construction of terminals have triggered erosion of mangroves. The current navigation channel of Port Qasim passes through Kadiro Creek, while its anticipated extension will stretch the channel further to Gharo Creek to the east of the existing port facilities at PQ (**Section 4.7.5**). The erosion along the current navigation channel and its anticipated extension are shown in **Exhibit 4.40**. Given the lack of high precision time series images, it is not possible to quantify the extent of erosion of mangrove areas with precision. However, compared to the area covered by the mangroves, the extent of damage caused to the mangroves on this account is not expected to be significant.

### **Erosion Related to New Channel Dredging**

With the construction of an additional channel to accommodate increasing ship traffic (**Section 2.2**), the extent of erosion is likely to double by 2050.<sup>307</sup> Compared to the area covered by the mangroves, the extent of damage caused to the mangroves on this account is not expected to be significant, provided the dredged materials are not dumped in mangrove areas and guidelines are followed to minimize erosion triggered by dredging.

### **Impact of Deterioration in Water Quality due to Wastewater Flow from Developments**

Water quality measurements conducted in the channels in the Study Area indicate that the level of contamination due to inflows of wastewater are low, and remain within acceptable limits (see **Exhibit 4.32** to **Exhibit 4.35** in **Section 4.6.3**). The main reason for this appears to be a high level of flushing in the Study Area by tidal flow (**Section 4.7.1**). An improvement in mangroves observed in the eastern part of the Study Area near the mainland (**Section 5.3.5**), however, has been attributed partly to the increased flow of nutrients mainly from the municipal waste water flowing into the sea. A similar trend has been observed in the mangroves in the Sandspit area located in Karachi further east of the Study Area, where municipal and industrial effluents from Lyari River are said to fertilize the mangroves.<sup>308</sup> The impact of wastewater flowing into the Study Area with its lower salinity and nutrient carry over is therefore apparently positive.

The contribution of Developments to the overall flow of wastewater into the Study Area is relatively small (**Section 4.6**), and major inflows are from the residential areas located within and adjacent to the Study Area, and the industries located in Landhi and Korangi (see map in **Exhibit 3.4** in **Section 3.2**). Furthermore, the inflow from Developments are mainly from the industry, which carry a much lower level of nutrients in comparison to the predominantly municipal wastewater flow, which also flushes in the waste from cattle pens located in Bhains Colony in the western Study Area (**Exhibit 3.4** in **Section 3.2**). The positive impact of inflow of nutrients with the wastewater from Developments on the mangroves is therefore expected to be minor now and in the long term.

### **Impact of Contamination of Sediments by Heavy Metals in Wastewater**

A low level of contamination from arsenic was found as compared to control locations away from PQA is a result of wastewater (**Section 4.7.6**). The mangroves are reported to fix heavy metals in the soil in which they grow (**Section 5.5.2**). In addition, the industrial activity in the Developments does not include any toxic heavy metal releasing operations such as leather tanning, steel, and textiles located elsewhere in and adjacent to the Study Area. Contamination from heavy metals is therefore not expected to impact the

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<sup>307</sup> With an additional channel, it would be possible to reduce erosion rates by lowering ship speeds in the access channel. However, in the long term the ship traffic will increase as the port activity increases. There also plans to construct additional terminals for liquid cargo such as LNG closer to the entry points into the channels from the sea from where the products can be piped to the shore. This will lower the ship traffic in the channels and travel times for the ships.

<sup>308</sup> Case Study: Conservation and Management of Mangrove Forests in Coastal Areas, Strengthening and Use of Country Safeguards Systems (TA 7566-REG) – Subproject - Environmental Training for Civil Servants in Pakistan, Asian Development Bank, 2015



mangroves now or in the long term, barring any new industrial activity that releases significant quantities of toxic metals and lacks environmental controls.

### **Regeneration**

Regeneration of mangroves in the Indus Delta has partly been attributed to conservation efforts by the IUCN and the SFD which have been involved in re-plantation initiatives. Other factors which may be responsible include changes in local morphology driven by changes in stream flows and an increase in atmospheric carbon dioxide (see **Section 5.3.2**). However, evidence for mangrove plantations, both from Google Earth imagery analysis and anecdotal evidence from locals, indicates that plantations in the Study Area have not been entirely successful (see **Section 5.3.10**).

### **8.2.2 Fish**

Fishery is a principal source of livelihood for a population of about 75% living in the Fishing and Fishing/Agriculture Communities of the Study Area, which includes poor and vulnerable households (**Section 6.5**). The value of catch of fish, shrimp, and crab catch in the Study Area is estimated at Rs 10,812 million per annum (**Section 6.4.5**), of which fish account for 68% of the value of the catch. A total of 128 fish species were recorded in Ketī Bander in a recent study (**Section 5.5.1**), of which 126 inhabit saline water, and 2 are adapted to brackish water. Ketī Bander is located in the same Indus Delta mangrove system as the Study Area about 80 km towards southeast, and is not impacted by industrial or port related developments. A similar number of saline water species is expected in the Study Area, with a possibility of brackish water species in the estuary where low salinity waste water as well fresh water from rainfall in the catchment flows into the estuary.<sup>309</sup> The low salinity waste water contains pollutants from municipal and industrial releases, and is likely to degrade the biodiversity of brackish water species.

A total of 66 species were collected in sampling conducted as a part of this study in September 2015 (**Section 5.5.2**).<sup>310</sup> Of these, 29 species were not observed at Ketī Bander in the recent study referred to above. None of the fish species recorded either at Ketī Bander or in the Study Area are classified as Endangered, Threatened, or Vulnerable.<sup>311</sup> There is one species<sup>312</sup> found at Port Qasim and four species<sup>313</sup> found at Ketī Bander that have restricted ranges. None of the species collected in the Study Area were brackish water type. Collection of additional species in the Study Area compared to Ketī Bander can be an indication of a higher level of richness of species in this part of the Indus Delta system, possibly attributable to better condition of mangroves and comparatively lower fishing pressures in inner creeks. Further studies at a regional level are needed to confirm this hypothesis.

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<sup>309</sup> Average TDS in freshwater streams of the Study Area were recorded at 2,019 mg/l, whereas average concentration of TDS in wastewater streams was recorded at 9,620 mg/l.

<sup>310</sup> The scope of the sampling was limited to one season and focused on detecting variations in diversity and abundance within the Study Area.

<sup>311</sup> IUCN Red List of Threatened Species

<sup>312</sup> *Colletteichthys dussumieri*

<sup>313</sup> *Albula vulpes*, *Scomberoides commersonianus*, *Cynoglossus macrostomus* and *Cynoglossus dubius*

The mangrove habitat in the Study Area constitutes a breeding and feeding area for fish and other marine biodiversity of the coastal area of Sindh. As discussed in **Section 8.2.1**, reduction in fresh water and sediment flows into the Indus Delta and the Study Area has resulted in a reduction of soil deposition, delta seawater inundation, and contributed to decline in mangrove forests and fisheries. A progressive decline in fish catch observed in Sindh since 1993 is illustrated in **Exhibit 6.27**.

While the water quality analysis for seawater in the estuary did not indicate a significant level of contamination from wastewaters generated at PQA or other nearby industries and communities, the elevated levels of heavy metals in seawater in comparison to the reference site (see **Section 4.6.3**, 'Seawater Analysis') indicate that over the long-term bioaccumulation of heavy metals within the ecosystem is occurring. This is of concern and needs to be addressed at the regional (Karachi) level. Levels of heavy metals in both fish tissue and liver are equally important, as they are either consumed by humans or completely utilized in chicken feed and, therefore, introduced into the food chain. The levels of arsenic in some samples of fish tissue analyzed as part of the current study, as well as the average concentration of arsenic in fish tissue and liver in a 2008 study were above thresholds where fish would be considered fit for human consumption. Nonetheless, the value of arsenic in fish tissue and liver was also comparably high in samples collected from the Ketu Bandar reference site in 2008, where impacts of industrial pollution are not expected. Groundwater in Indus Basin is known to be contaminated with arsenic,<sup>314</sup> which may be one of factors contributing to higher level of arsenic observed in the fish tissue samples collected at Port Qasim and the Study Area. Nonetheless, the cadmium and zinc in fish tissue and/or liver in a 2008 study (see **Exhibit 5.45**) were above the thresholds where the fish is considered unfit for human consumption and are considerably lower at the reference site.

The direct reduction in mangrove habitat due to past and expected Port Qasim related Developments as well as developments by other organizations as per available plans is expected to be insignificant (**Section 8.2.1**). Loss of mangrove habitat due to Developments is therefore not considered a significant risk to the fish in the Study Area. However, deterioration of water and sediment quality due to Developments and other economic activity both on and offshore is expected to have consequential impact through bioaccumulation over the long-term.

A principle threat to the diversity and abundance of fish is the non-sustainable fishing practices by the local community (**Section 5.5.2** and **Section 6.2.2**).<sup>315</sup> A decline in abundance of fish is indicated by a progressive decline in total catch of fish observed in Sindh since 1993 (See **Exhibit 6.27** of **Section 6.4.5**). Total fish catch has declined to as much as 63% of peak level in 1993 by 2014. PQA has limited leverage over non-sustainable fishing practices, as its primary mandate is port development, management and shipping lane maintenance. Regulation of commercial fishing in the creeks falls in the mandate of the Sindh Fisheries Department.

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<sup>314</sup> [http://nceg.uop.edu.pk/GeologicalBulletin/Vol-47\(2\)-2014/Vol-47\(2\)-2014-Paper13.pdf](http://nceg.uop.edu.pk/GeologicalBulletin/Vol-47(2)-2014/Vol-47(2)-2014-Paper13.pdf)

<sup>315</sup> Non-sustainable fishing practices include use of nets of prohibited mesh size, and high fishing pressure particularly from smaller boats in the estuary.

Impact of accidental releases of oil and other toxic products from tankers and other ships delivering cargo to Port Qasim and consequential impact on abundance of fish species can be a potential concern in view of an incident that took place in the KPT.<sup>316</sup> While no such incident has taken place at Port Qasim so far, the risk of such an event occurring remains.

In the long term, if the release of industrial effluent into the creek systems remains unchecked and unregulated, and if the industrial activity in the catchment of Malir River multiplies, accumulation of heavy metals in the sediments is likely to impact fish biodiversity as well as their suitability for human consumption.

### 8.2.3 Shrimp

Shrimp harvesting supplements the livelihood of the population living in the Study Area, more so of the poor and vulnerable families engaged in this activity using smaller boats operating closer to the mainland. The value of shrimp harvested is estimated at Rs 3,473 million annually, and accounts for 32% of the total value of the catch which includes fish, shrimp, and crabs (**Section 6.4.5**). A total of 2 shrimp species have been recorded in the field surveys conducted for this study during collecting information for small scale local fisheries and an additional 4 species were observed during sampling in September 2015 (**Section 5.5.3**). All species belonged to the same family.

Similar to fish as discussed in **Section 8.1.1**, the principle threat to the abundance of shrimp is the non-sustainable harvesting practices by the local community. While reliable data is not available, trend in decline in abundance of shrimp is expected to follow a trend similar to that for the fish. PQA has limited leverage over non-sustainable harvesting practices in the Study Area which fall in the mandate of Marine Fisheries Department. Impact of accidental releases of oil and other toxic products from tankers and other ships delivering cargo to Port Qasim would also be similar to that on fish, and possibly higher as the shrimp habitat is relatively restricted.

The long term impacts of release of heavy metals by the industries into the creeks in the Study Area may impact the abundance as well as suitability of shrimp for human consumption.

### 8.2.4 Crabs

The mangroves have crab species that fall into the families Grapsidae, Ocypodiidae, Xanthidae and Portunidae.<sup>317</sup> The local fishermen are engaged in catching two specific species namely *Scylla serrata* and *Portunus pelagicus* (see **Section 5.5.3**). In addition to this, during the sampling exercise carried out in September 2015 mean crab hole density was observed to be highest where mean adult mangrove tree density was highest (see **Exhibit 5.19** of **Section 5.3.6**) indicating a link (interdependence) between the populations of crabs and mangroves and highlighting their role as a keystone species in mangrove habitats (see **Section 5.3.6**).

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<sup>316</sup> Give reference for Tasman Spirit case, when, and how much spill and damage.

<sup>317</sup> Mangroves of Pakistan: Status and Management, IUCN (2005)

Crab holes were observed in abundance in the mangrove habitats in the Study Area. Similar to shrimp, collection of crabs supplements the livelihood of the population living in the Rehri Goth, Chashma Goth and Ali M Brohi Goth in the Study Area, more so of the poor and vulnerable families engaged in this activity using smaller boats operating closer the mainland. The value of crabs harvested is estimated at Rs 7.8 million annually, and accounts for less than 1% of the total value of the catch which includes fish, shrimp, and crabs (**Section 6.4.5**).

Since the principal habitat of crabs in the Study Area is the mangroves, loss of mangrove habitat on account of Developments discussed in **Section 8.2.1** will have a proportional impact on the crab population, which is predicted to be minor. Crabs are known to be more sensitive to heavy metals compared to shrimp.<sup>318</sup> Long term impacts of release of heavy metals by the industries into the creeks in the Study Area on the abundance and suitability of crabs for human consumption may therefore be higher than those for shrimp.

### 8.2.5 Marine Mammals

The Study Area includes habitat for dolphins, specifically the Indian Ocean Humpback Dolphin *Sousa plumbea* and Finless porpoise *Neophocaena asiaeorientalis* (see Section 5.6 of the Ecological Baseline). The degradation of the near-shore habitats, for example due to increased pollution, shipping activity and construction, could therefore result in adverse impacts on the population of these species. An instance of pollution adversely affecting dolphins has been reported from China, specifically bioaccumulation and biomagnification of organochlorine pesticides in Indo-Pacific Humpback Dolphins from the Pearl River Estuary.<sup>319</sup>

Collisions between ships and cetaceans have been reported to be a serious issue around the world.<sup>320</sup> In addition, noise generated during construction from piling and drilling in the ports can be harmful to cetaceans.<sup>321</sup>

### 8.2.6 Mudflats

Mudflats are an integral part of the mangrove habitat and an important part of the coastal intertidal zones (see **Section 5.4**). The communities of coastal invertebrate fauna are characteristic of these mudflats. Coastal intertidal areas have a diverse range of communities that inhabit muddy/clay shores (see **Section 5.4**). The surface and burrowing marine invertebrates play an important role in mixing the organically enriched

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<sup>318</sup> King Crabs of the World, Biology and Fisheries Management, Edited by Bradley G. Stevens, CRC Press, 2014

<sup>319</sup> Duan Gui, Riqing Yu, Xuan He, Qin Tu, Liaguo Chen and Yuping Wu, Bioaccumulation and biomagnification of persistent organic pollutants in Indo-Pacific humpback dolphins (*Sousa chinensis*) from the Pearl River Estuary, China. Chemosphere, Volume 114, Pages 106-113, November 2014

<sup>320</sup> World Wildlife Fund (WWF) Global, Ship strikes, Threats to Whales and Dolphins, WWF Global website <[http://wwf.panda.org/what\\_we\\_do/endangered\\_species/cetaceans/threats/shipping/](http://wwf.panda.org/what_we_do/endangered_species/cetaceans/threats/shipping/)>, accessed March 17, 2016

<sup>321</sup> Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations, Brandon L. Southall, Ann E. Bowles, William T. Ellison, James J. Finneran, Roger L. Gentry, Charles R. Greene Jr., David Kastak, Darlene R. Ketten, James H. Miller, Paul E. Nachtigall, W. John Richardson, Jeanette A. Thomas, & Peter L. Tyack, Aquatic Mammals, Volume 33, Number 4, 2007

bottom sediments and are the key linkages in transferring the energy from lower trophic level to the next higher trophic level in the food chain. The marine invertebrate communities reported from the Study Area are characteristic of fine sediments from muddy to clayey. Dominant communities reported in the Study Area include Fiddler Crab *Uca sp.*, Mud Skippers *Boleophthalmus spp* and *Telescopium spp* assemblages, bivalve mollusks, Pinnotherid crabs and *Cerithium sp* Barnacles (see **Section 5.4.1**).

Mudflats the Study Area are feeding areas for both resident and migratory birds, and are potential areas for replantation of mangroves. Data on the distribution of mudflats and the extent to which the mudflats have been converted in the past into onshore and off shore industrial and port facilities is not available, as it is difficult to distinguish between mudflats and other barren areas in satellite images available. While it is not possible to assess the impacts of Developments and land use by others on mudflats in the Study Area, mudflat habitats in the Study Area are likely to face risks similar to those for mangroves. These can be potentially be significant for urban developments by organizations and institutions other than PQA.

### 8.3 Livelihoods Related to Mangroves

Livelihoods for a large population in the Study Area depend on catching fish in the creeks in the mangrove areas, and on associated activities such as boat building, repair, and net making. The Socioeconomic Survey shows that the livelihoods of the Fishing Communities are almost entirely dependent (almost 75% of households, including those who are directly involved in fishing or fishing related business like boat and net making and repair etc.) on marine fishery resources of the creeks of PQA Area and open sea, with little diversification of income sources. A majority of the fishermen operate on small boats, relying on catching fish in the PQA creeks near the mainland. The mangroves also play a vital role for fishermen fishing on larger boats in the open sea as the mangrove ecosystem provides essential food for the fish as well as spawning grounds, for shrimp and prawn to grow. In most cases, fish from the deep sea breed in the creeks, and the mangroves provide shelter and protection for the fish to mature before they can swim back to open sea. In addition to fish, harvesting of shrimp and crab in the Study Area supplement the incomes of Fishing Communities.

‘Income from fish, shrimp and crab’, is the prioritized Valued Environmental Component (VEC) which is the principal indicator for the socioeconomic dependence of the local communities on the environmental resources of the Study Area (**Section 7**). Evidence collected for the Physical and Socioeconomic Baseline studies (**Sections 4** and **Section 6**) show that it is likely that this VEC will be directly impacted by the cumulative effects of continued current practices and several anticipated and reasonably foreseeable developments in the Study Area. These include:

- ▶ Non-sustainable fishing practices
- ▶ Restricted access to fishing areas
- ▶ Conversion of mangroves for urban developments
- ▶ Deteriorating water quality in creeks
- ▶ Climate change



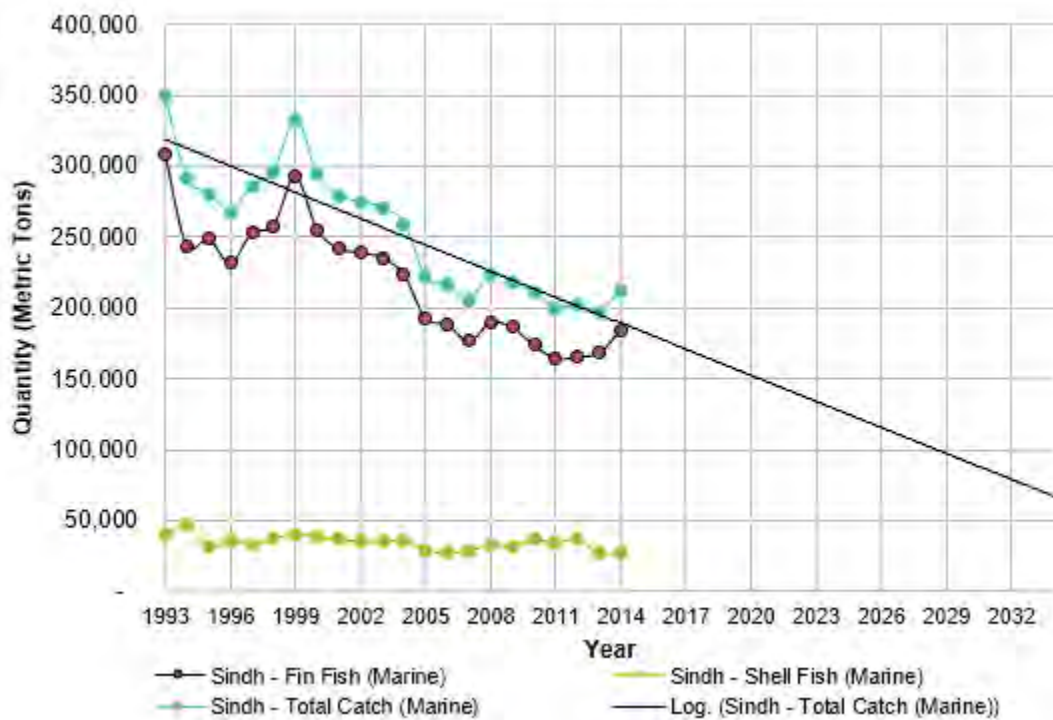
### **Non-sustainable Fishing Practices**

Socioeconomic Baseline (**Section 6.4.5**) shows that annual fish catch in Sindh over a period of 20 years from 1993 to 2003 has decreased considerably by 39% (**Exhibit 8.9**). This corresponds with an increase in the number of boats in Sindh by 34% over the same time period (**Exhibit 6.28**). It is around the same time that the use of illegal small sized nets called *Bulla Gujja* that trap small immature fish became popular in Fishing Communities in the Study Area. Almost 71% of the respondents from the Study Area reported use of illegal fishing nets as the main reason for decline in fish catch (**Section 6.2.2** and **Section 6.4.5**). Stakeholder consultations inform that the increase in number of boats, year round fishing and use of illegal nets has resulted in overharvesting of fish in the Korangi, Phitti and Gharo creeks.

All surveyed fishing settlements reported a change in the creeks in which they fish over the past few years due to decrease in the population of fish (**Section 6.4.5**). Majority of the respondents agreed that unsustainable fishing practices are one of the major reasons for the decreasing fish population.

If unsustainable fishing practices and overfishing continues, there will be a potentially significant impact on the incomes of fishermen. Extrapolating the current trends (**Exhibit 8.9**) to twenty years from now, the fish catch could decline to 33% of present day level. According to the Socioeconomic Baseline, 75% of the households in the Fishing Communities and 40% of the households in the Fishing/Agriculture Communities are entirely dependent on fishing for income (**Section 6.4.5**). Non-sustainable fishing practices will therefore result in a potentially disastrous impact on the incomes, wellbeing, and vulnerability of Fishing Communities putting their livelihoods at a serious risk. As discussed in **Section 8.2.2**, this impact is not triggered by the Developments and PQA has very limited leverage to control unsustainable fishing practices, which primarily fall in the mandate of the Marine Fisheries Department.

**Exhibit 8.9: Fish Catch Trend in Sindh**



### **Restricted Access to Fishing Areas**

Consultations with stakeholders reveal that the existing shipping lane for Port Qasim passes through the Phitti and Kadiro Creeks, which are preferred fishing grounds for communities from Ibrahim Hyderi to Rehri. Access to these creeks and to fishing areas in Gharo has been disrupted due to this shipping lane, restricting fishermen to Korangi Creek (which is polluted), and forcing them to use lengthy routes or take risks crossing the shipping lane to access fishing grounds east of the existing navigation channel. Small fishing boats trying to cross the shipping lane to access Phitti, Kadiro and Gharo Creeks, often suffer from incidents of loss and damage to boats and nets from strong waves generated by large cargo carrying vessels. Deepening of the existing shipping lane to accommodate passage of larger cargo vessels as proposed in the Developments will further increase these risks.

The dredging and operation of a new shipping lane along Chara, Rakhal and Chhan Wado Creeks as planned by PQA (**Section 2.2**) will further restrict the access of local fishermen, as they will have to circumvent or cross two shipping lanes instead of the existing one. To assess the impact of the development of the alternate navigation channel, the number of fishing boats operating in the route of the alternate shipping channel were estimated using Google Imagery™, and were then verified from the local fishermen. On average, in peak seasons (August to November and March to May), 110 to 120 boats (approximately 5% of the fishing boats of the Study Area) make trips to, or adjacent to the proposed route of the alternate navigation channel. In addition, almost 50% of the large fishing boats pass through the Chhan Waddo, Rakhal and Chara creeks to reach the

Waddi Khuddi Creek and open sea toward southeast of the PQA Notified Area (**Exhibit 8.10**). This analysis indicates that livelihood of nearly 20% to 30%% of both small and large scale fishermen may be affected due to the location of the PQA existing and proposed alternate navigational channels.

Restricted access to fishing areas due to Developments can potentially reduce the incomes of fishermen in Fishing Communities in two ways. First, fishermen will be further restricted to the remaining fishing areas which are easily accessible, increasing the pressure on fishing in those area and potentially resulting in overfishing and decrease in fish population there. Second, fishermen will be forced to use longer routes to access other fishing areas, resulting in higher costs and therefore lower income from each fishing trip. The long term impact of operation of two shipping lanes for Port Qasim on the livelihoods of Fishing Communities is therefore likely to be significant.

These Developments may however benefit the Fishing Communities in Gharo. As fishermen from Karachi will have further restricted access to Gharo creek, the communities in Gharo will have less competition for fishing. Restricted fishing areas and reducing income can potentially force fishermen from communities in Ibrahim Hyderi and Rehri to migrate to other areas, possibly Gharo. There is a risk that they may not be welcome to settle in such areas.

### **Conversion of Mangroves for Urban Developments**

As discussed in **Section 8.2.1**, the Developments at PQA will require utilization of very limited mangrove habitat. However, conversion of mangroves into urban developments outside PQA Notified Area may result in loss of fishing areas and breeding grounds for fish, potentially impacting the incomes of fishermen fishing in creeks and in the deep sea. Initial plans for such developments by Bahria Town and DHA already exist. The Ecological Baseline (**Section 5**) categorizes the mangroves in PQA and adjacent areas towards the west as 'Healthy Mangroves' and classifies them as 'Critical Habitat'. Mangroves support the livelihoods of local fishermen as fishing grounds, and are breeding areas for deep sea fish. Fish from the deep sea breed in the creeks, with the mangroves providing shelter for the fish till they mature and swim to the deep sea. Clearing of Healthy Mangroves will reduce the breeding grounds for fish, potentially resulting in decreasing fish population and most likely reducing the incomes of fishermen and subsequently those involved in associated services. As Fishing Communities do not have any alternative sources of livelihood, reduced income from fishing may force fishermen to seek employment in the newly built urban and commercial developments, possibly as daily wage labor/low wage household help. A secondary impact of reduced fishing based livelihoods can therefore be the conversion of existing Fishing Communities into urban slums, as well as increasing their vulnerability. There are also reasonably foreseeable PQA Developments on Bundal, Khiprianwala and Ziarat Shah Islands (**Section 2.2**). However, these islands have sparse mangrove cover and utilization of land on these islands for construction of port facilities will not result in large areas of mangroves being cleared, and therefore will not greatly impact the incomes of fishermen.

As discussed in **Section 8.2.1**, in the absence of firm plans for conversion of mangroves into urban areas outside the PQA Notified Area are not available, it is difficult to predict the likelihood of occurrence associated impacts. However, given the fact that the

mangroves in the Study Area constitute Critical Habitat and demand for land for urban developments in Karachi will continue to increase, the impacts in the long run on the incomes associated with fishing can potentially be significant.

### ***Deteriorating Water Quality in Creeks***

The Study Area has a large number of industries. There are nearly 176 industrial units operating in PQA, while 278 are in various stages of development. Korangi and Landhi Industrial Areas are home to Pakistan's largest textiles, pharmaceutical, cosmetic, steel, chemical, automobile and flour mill industries (**Section 6.4.5** for details). The Physical Baseline (**Section 4.6**) shows that wastewater enters the Gizri, Korangi, Kadiro and Gharo Creeks, within the Study Area mainly from the industries located in Korangi and Landhi Industrial Areas through the Malir River. In addition to this, multiple open drains carrying untreated raw sewage discharge into Kadiro and Korangi Creeks from large settlements including Ibrahim Hyderi, Rehri Goth and Bhains Colony, as well as from Karachi city.

The fishermen consulted maintained that the quality and quantity of fish, shrimp and crab available in creeks is impacted by the poor quality of water in the creeks.<sup>322</sup> The fishermen also maintained that pollution has significantly reduced the fishing potential in Gizri, Gharo and the western extent of Korangi creeks and most fishermen avoid fishing there, increasing pressure on the fish population in less polluted creeks. A survey of quality of water the creeks conducted as a part of this study indicates that there is no significant deterioration in water quality due to a high level of tidal flushing in the creeks (**Section 4.6.2**). Nonetheless, there is lower abundance of fish in the areas closer to the coast based on fish surveys carried out as part of this Study (**Section 5.5.2**). The principal reason for lower abundance and diversity of fish closer to the mainland observed in the study (**Section 5.5.2**) therefore appears to be the non-sustainable fishing practices which are more intense closer to the mainland where the smaller boats can reach easily.

In the long term, if the water quality in the creeks continues to deteriorate due to untreated industrial and municipal liquid waste drainage, the toxicity levels of the water in the creeks will increase, having potentially impacting on the fish population, in turn adversely impacting the livelihoods of those dependent on fishing. While the magnitude of this impact is difficult to predict, management of water quality in the creeks to protect the biodiversity and livelihoods of Fishing Communities would be prudent and desirable following the precautionary principal.

### ***Climate Change***

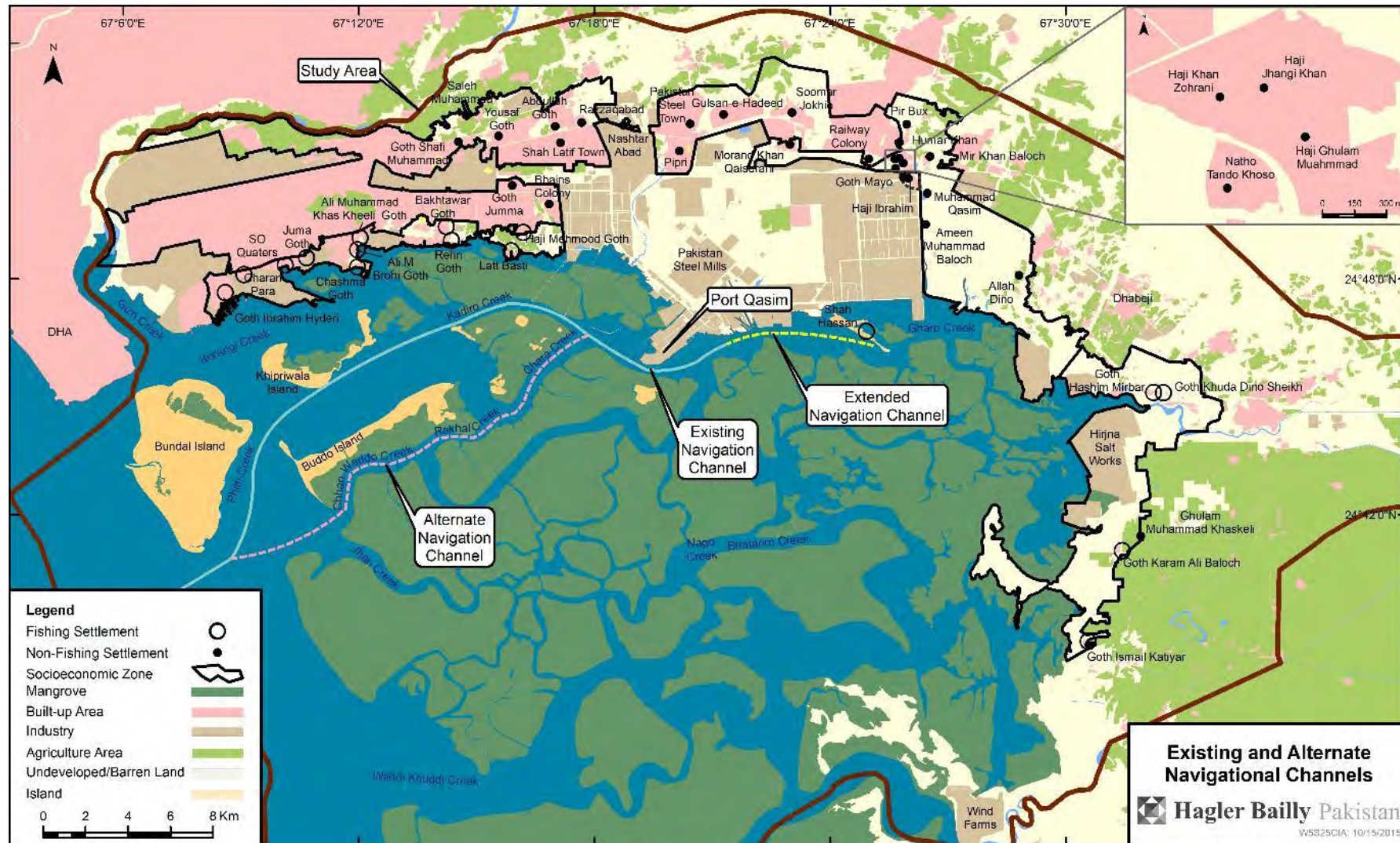
The health of mangrove ecosystem in the Study Area and in surrounding mangrove areas depends largely on inflow of fresh water and sediment into the creeks. Flow of freshwater into the Indus Delta and floodwater inflows from rainfall in the catchment of Malir River maintain ecological balance of the marine ecosystem. Communities in the Study Area reported that decreasing rainfall since 1992 has resulted in reduced freshwater inflows into the Indus Delta. Further studies are needed to assess the likelihood, magnitude and significance of this risk.

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<sup>322</sup> Ecosystem Service Review for Industrial and Port Developments at Port Qasim', Hagler Bailly Pakistan, June 2015, prepared as a part of this study.



**Exhibit 8.10: Route of PQA's Existing and Alternate Navigation Channels**





## 8.4 Conclusions

### **Air Quality**

The concentration of NO<sub>x</sub> and SO<sub>2</sub> in the ambient air may already be exceeding the target limits (IFC ambient air quality guidelines in this case as it is more stringent than the SEQS for ambient air). The increase is currently in a relatively small area which is presently either unoccupied or is covered by industrial units. However, this situation is likely to change in future. With the anticipated development of industrial zones, installation of power plants, increase in shipping, road and rail traffic the impact zone as well as the impact intensity of these two pollutants will increase significantly under the business-as-usual scenario of emission controls. Although, currently no communities are affected, it is predicted that by 2050 air quality in several communities in the north and northwest of the PQA will be severely affected.

Particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) are not likely to be a concern from PQA activities. However, it may be noted that the concentration of these pollutants are already high due to natural sources and to some extent due to air-borne dust from traffic movement.

### **Mangrove Ecosystem and Biodiversity**

#### Mangroves

1. Mangroves in Indus Delta constitute a 'Critical Habitat' under the IFC Performance Standards. About 0.3% of the existing mangrove area has been lost to development of Port Qasim to date. The loss will expand to 2.1% of the existing mangrove in the Study Area by 2050 if all the planned Developments take place, which is minor in terms of the area impacted. Possible developments outside the PQA area, triggered by a high demand for land in Karachi, could expand this loss further. **Considering the classification of mangroves in the Indus Delta as Critical Habitat, the impact would be significant requiring credible offsets to comply with the IFC Performance Standards and ADB guidelines.**
2. PQA presently does not have a well-defined policy or guidelines for dumping of dredge material. While the mangrove area already lost to dumping of dredge material to date is relatively small, **there is a risk of additional damage to mangroves due to unregulated dumping of dredge materials in future, particularly from dredging of the second channel** to accommodate future port traffic.
3. Given the established practice of harvesting mangroves in the local communities, expanding populations in the coastal area, and high cost of commercial fuels, the harvesting pressures are expected to continue and increase. **The loss of mangroves due to harvesting by local communities can intensify if proper controls are not maintained on a continuous basis.**

#### Fish, Shrimp, and Crabs

1. **Non-sustainable fishing practices by the local community including use of prohibited fine mesh nets are a principle threat to the diversity and**

**abundance of fish in the Study Area.** Total fish catch has declined to as much as 63% of peak level in 1993 by 2014. PQA has limited leverage over non-sustainable fishing practices which fall in the mandate of the Marine Fisheries Department.

2. Impact of accidental releases of oil and other toxic products from tankers and other ships delivering cargo to Port Qasim and consequential impact on abundance of marine life can be a potential concern.
3. In the long term, if the release of industrial effluent into the creek systems remains unchecked and unregulated, and if the industrial activity in the catchment of Malir River multiplies, accumulation of heavy metals in the sediments is likely impact fish and crab biodiversity as well as their suitability for human consumption.

#### Marine Mammals

The Study Area includes habitat for dolphins, specifically the Indian Ocean Humpback Dolphin *Sousa plumbea* and Finless porpoise *Neophocaena asiaeorientalis*. The Indian Ocean Humpback Dolphin population has been sighted numerous times within the Study Area. The species is likely to be negatively impacted by the adverse effects of increased human activities in the Study Area such as **increase in pollution, increased shipping activity and further developments (both on-shore and off-shore).**

#### Mudflats

Mudflats the Study Area are feeding areas for both resident and migratory birds, and are potential areas for replantation of mangroves. **Mudflat habitats in the Study Area are likely to face risks similar to those for mangroves, particularly from urban developments by organizations and institutions other than PQA.**

#### **Livelihoods Related to Mangroves**

1. Fishery and associated activities such as boat building and repair is a principal source of livelihood for a large population in the Study Area, which includes poor and vulnerable households. **If non-sustainable fishing practices and overfishing continue, the fish catch and the corresponding incomes could decline to 33% of present day level.** PQA has limited leverage over non-sustainable fishing practices which fall in the mandate of the Marine Fisheries Department.
2. **Operation of Port Qasim has hindered the access of fishing communities, particularly those that use small fishing boats, to the preferred fishing areas. The dredging and operation of a new shipping lane as planned by PQA will further restrict their access.**
3. Clearing of mangroves and deposition of toxic metals in the creeks will impact the abundance of fish, shrimp and crab, and consequently the livelihoods of local communities. The significance of these impacts will increase over time if effective regulatory regimes to control land use and flow of toxic pollutants into creeks are not established.

## 9. Preventive Actions and Management Measures

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The Study Area is located on the northwestern fringe of the Indus Delta system which is a unique example of a natural wetland in the Arabian coastal biogeographic region (**Section 5 - Ecological Baseline**). The delta consists of creeks, estuaries, mud, sand, salt flats, mangrove habitat, marshes, sea bays and straits. The mangroves and channels provide shelter to many aquatic and terrestrial species. The estuarine creeks are the nursery ground for many species of fish and shrimps. In addition to its ecological importance, the coastal ecosystem in the Study Area is an important source of income and livelihood for the fishing communities that are poor and vulnerable (**Section 6 – Socioeconomic Baseline**). The communities living adjacent to the PQA industrial area depend on employment in the industry for their livelihoods, and are vulnerable if the industries impact the air quality.

**Section 7** of this report identified and prioritized the following Valued Environmental Components (VECs):

- ▶ **Physical Environment:** Air quality as it impacts public health.
- ▶ **Ecological Environment:** Mangrove ecosystem and biodiversity including diversity and abundance of fish, shrimp, and crab species, marine mammals, mangrove habitats, and intertidal mudflat habitats.
- ▶ **Socioeconomic Environment:** Income from harvesting of fish, shrimp, and crab.

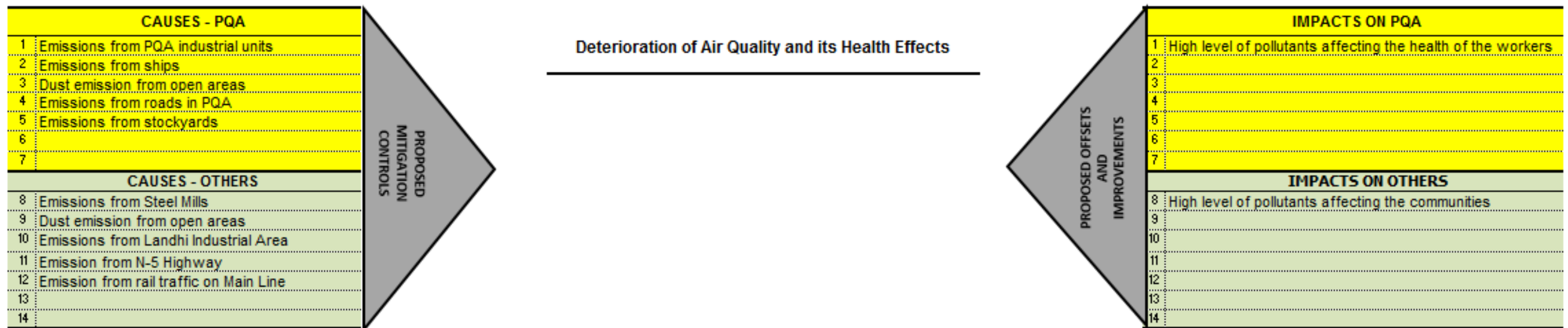
**Section 8** discusses the impacts of the Developments on the prioritized VECs.

**Exhibit 9.1** (Air Quality), **Exhibit 9.2** (Mangrove Ecosystems and Biodiversity), and **Exhibit 9.3** (Income from Harvesting of Fish, Shrimp and Crab) provide a summary of:

- ▶ the impacts on the VECs in the Study Area;
- ▶ their causes;
- ▶ proposed preventive measures to address the causes; and
- ▶ proposed remedial measures and improvements where it will not be possible to mitigate the impacts.

In the exhibits, the causes, proposed preventive measures, and proposed remedial measures and improvements are assigned separately to PQA and other stakeholders, and the institutional responsibilities for actions are indicated. The suggested management strategy and the measures to manage the impacts are discussed in this section.

**Exhibit 9.1: Material Risk Diagram for Deterioration of Air Quality**



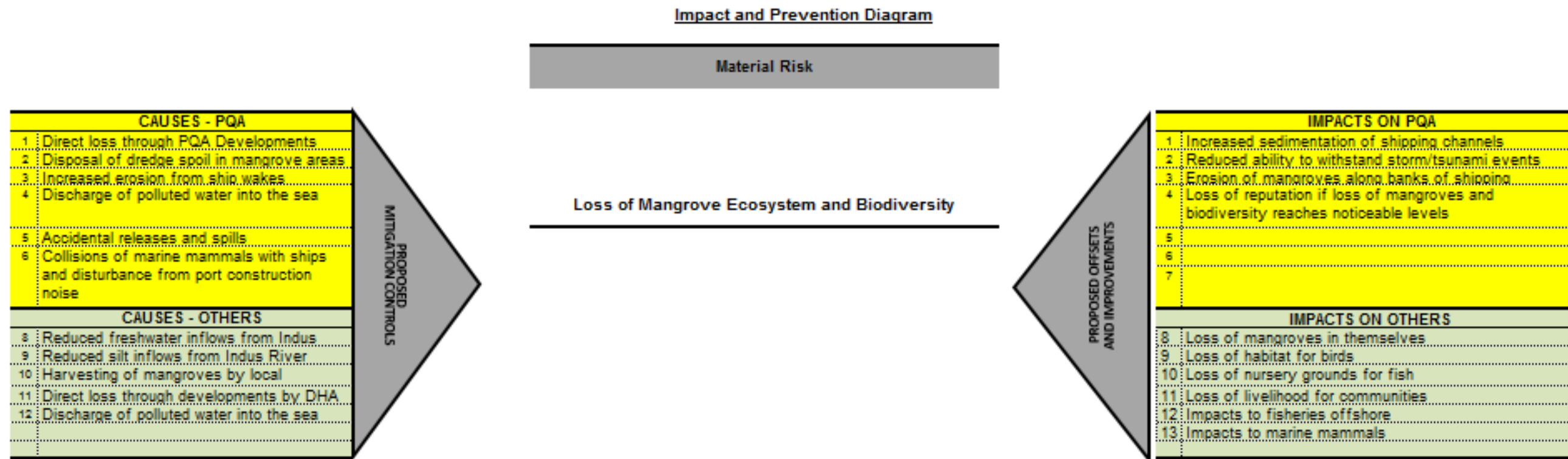
PROPOSED PREVENTIVE MEASURES - PQA		LINK TO CAUSES	RESPONSIBILITY
1	Development of regional level air dispersion model to assess air quality impacts and develop specific strategies and measures	1 - 12	PQA
2	Develop zoning plans for industries to reduce air quality impacts on local communities	1	PQA
3	Work with industry in Notified Area to enforce NEQS for industrial emissions	1, 2, 4, 5	PQA, SEPA and industries
4	Develop emission inventory for PQA		
5	In longer term set up targets for total emission from PQA	1, 2, 4, 5	PQA
6	Consider a permit system of air pollutants for industrial units within PQA	1	PQA

PROPOSED REMEDIAL MEASURES AND IMPROVEMENTS - PQA		LINK TO IMPACTS	RESPONSIBILITY
1	Develop and implement strategy for management of dust emissions from open areas	1, 8	PQA
2			
3			
4			
5			
6			

PROPOSED PREVENTIVE MEASURES - OTHERS		LINK TO CAUSES	RESPONSIBILITY
1	Enforce environmental protection laws and standards	8, 10, 11	SEPA
2	Work with industry in Landhi and Korangi to enforce NEQS for industrial emissions	4, 12	SEPA, Industry Associations
3	Develop PQA zoning plan to industries in areas around PQA	9	District government
4			
5			
6			

PROPOSED REMEDIAL MEASURES AND IMPROVEMENTS - OTHERS		LINK TO IMPACTS	RESPONSIBILITY
1	Develop and implement strategy for management of dust emissions open areas	1, 8	District government
2			
3			
4			
5			
6			

**Exhibit 9.2: Material Risk Diagram for Loss of Mangrove Ecosystem and Biodiversity**



PROPOSED PREVENTIVE MEASURES - PQA	LINK TO CAUSES	RESPONSIBILITY
1 Develop environmental zoning plan to limit extent of loss of mangroves in Notified Area	1	PQA
2 Develop and enforce guidelines for disposal of dredge in Notified	2	PQA
3 Limit ship speeds in critical areas if possible and consider breakwaters in critical areas	3	PQA
4 Work with industry in Notified Area to enforce NEQS for industrial effluents	4	PQA, Industry Assoc.
5 Conduct an independent review of spill contingency plans and upgrade plans and equipment	5	PQA
6 Develop, calibrate and update hydrodynamic, sediment and water quality models for the port area for predicting changes	5	PQA
7 Assess risk to marine mammals from ship collisions and noise from port construction, and enforce guidelines for protection if required	6	PQA

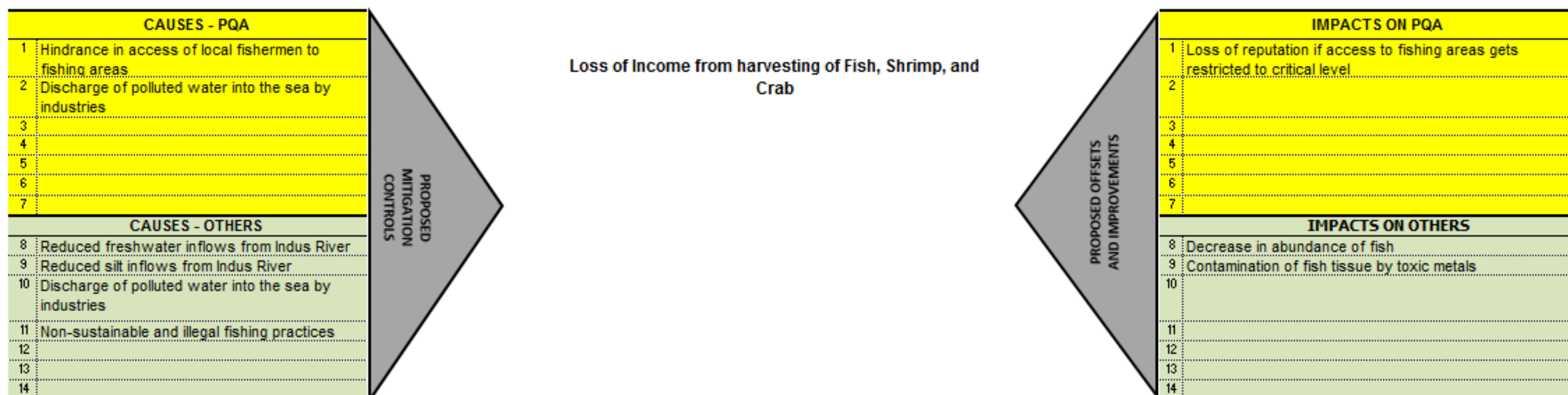
PROPOSED PREVENTIVE MEASURES - OTHERS	LINK TO CAUSES	RESPONSIBILITY
1 Enforce laws for protection of mangroves through watch and ward	10	SFD
2 Work with industry in Landhi and Korangi to enforce NEQS for industrial effluents	4,12	SEPA, Industry Associations
3 Develop zoning plan to limit extent of loss of mangroves in critical	1,11	SEPA, PQA
4 Develop and enforce guidelines for dredging and disposal of dredge material	2	SEPA, PQA
5 Install plants for treatment of municipal effluent	12	Distt. Govt
6		

PROPOSED REMEDIAL MEASURES AND IMPROVEMENTS - PQA	LINK TO IMPACTS	RESPONSIBILITY
1 Continue and sustain plantations at suitable alternate locations	8	Industry
2 Improve protection of mangroves through better patrolling	8,9,10,11,12	PQA, SFD
3 Develop, calibrate, and update hydrodynamic, sediment, and water quality models for the port area for predicting changes	1,2,3,8	PQA
4		
5		
6		

PROPOSED REMEDIAL MEASURES AND IMPROVEMENTS - OTHERS	LINK TO IMPACTS	RESPONSIBILITY
1 Support research on mangrove ecosystem in Indus Delta	8,9,10,11,12	SWD, Others, PQA
2 Conduct research on environmental flow release from Kotri Barrage	8,9,10,11,12	PCRWR, WWF, IUCN
3		
4		
5		
6		



**Exhibit 9.3:** Material Risk Diagram for Loss of Income from Harvesting of Fish, Shrimp, and Crab



PROPOSED PREVENTIVE MEASURES - PQA	LINK TO CAUSES	RESPONSIBILITY
1 Limit ship speeds in critical passage areas and times if possible	1	PQA
2 Monitor and control the release of heavy metals that can contaminate fish tissue	2	PQA
3		
4		
5		
6		

PROPOSED PREVENTIVE MEASURES - OTHERS	LINK TO CAUSES	RESPONSIBILITY
1 Monitor and control the release of heavy metals that can contaminate fish tissue	10	SEPA, Industry Associations
2 Work with fishing community to restrict illegal fishing practices and maintain sustainable harvesting levels	1, 11	MFD, Fishing Community
3		
4		
5		
6		

PROPOSED REMEDIAL MEASURES AND IMPROVEMENTS - PQA	LINK TO IMPACTS	RESPONSIBILITY
1 Provide training for skill development to fishing communities to reduce their vulnerability	1	PQA, Industry
2 Support MFD to control non-sustainable fishing practices in Notified Area	8	PQA, Industry
3		
4		
5		
6		

PROPOSED REMEDIAL MEASURES AND IMPROVEMENTS - OTHERS	LINK TO IMPACTS	RESPONSIBILITY
1 Conduct research on environmental flow release from Kotri Barrage to sustain livelihoods of fishermen	8	PCRWR, WWF, IUCN
2 Do social mobilization and educate the fishing community on importance of sustainable fishing for livelihoods	8	MFD
3		
4		
5		
6		

## 9.1 Management Strategy

The development scenario considered covers existing, under construction, anticipated, and reasonably foreseeable ‘Developments’ in PQA as defined in **Section 2**. The time horizon for the strategies and management measures proposed in the section is therefore the same as that of the Developments, i.e., of the order of 35 years extending to 2050. Should the Developments be revised at some point in time in view of emerging infrastructure requirements, a revision or update of the strategy and management measures would be required.

Essential features of the management strategy presented in this section were discussed with the stakeholders in a workshop held in June 2015, and presented in Section 6 of the report ‘Ecosystem Services Review for Industrial and Port Development at Port Qasim’ prepared as a part of this study. Recommendations presented earlier were developed and refined further in view of the insights gained through preparation of baselines, and extended to the VECs prioritized in **Section 7** of this report.

### 9.1.1 Spatial Considerations

The Physical Baseline (**Section 4**), Ecological Baseline (**Section 5**) and Impact Assessment (**Section 8**) show that a complex combination of regional and local factors are responsible for the changes in physical and ecological conditions taking place in the Study Area. These changes have been and are impacting the livelihoods of the local communities, and present long term risks to the port as well as other assets located in the coastal area. Given the paucity of data and research it is not possible to determine with precision the extent to which various factors, regional as well as local, are contributing to these risks and impacts. However, drawing on the analysis presented in this report, certain linkages can be established between the principal factors and the observed impacts and potential risks as discussed below.

#### **Regional Level**

*Diversion of Water and Sediment Flowing into Indus Delta for Agriculture:* Increase in salinity and change in quality of sediment has resulted in degradation of mangroves and habitats in the delta (**Section 5.3.2**), extending to parts of the Study Area distal from Port Qasim (**Section 5.3.5** and **Section 5.3.6**). Distribution of mangrove and aquatic species has also been affected due to changes in salinity profiles.

*Harvesting of Mangroves by Communities:* Harvesting of mangroves by communities in the Indus Delta and in the Study Area has contributed to degradation of mangroves (**Section 5.3.12**).

*Non-sustainable Fishing Practices:* This practice is widespread in the Indus Delta and in the Study Area and has resulted in decline in fish catch reflecting a decrease in abundance of fish species (**Section 6**). The extent to which biodiversity has been affected is not well understood.

#### **Study Area – Local Level**

*Diversion of Freshwater and Sediment Flowing into the Study Area from Malir Catchment:* The impact has not been studied and is not well understood, but would be

similar to those in the Indus Delta following diversion of flow from the river for agriculture. Flow of freshwater and sediment from the catchment is limited to extreme flood events as there is high demand for water for agriculture and domestic uses.

*Erosion and Sedimentation Triggered by Port Development and Operations:* Channel banks have eroded due to changes in tidal flow patterns, combined with impact of ship wake. Settling of eroded material would be contributing to sedimentation of channels and increasing dredging costs.

*Unregulated Disposal of Dredge Materials:* Some mangrove habitat has been lost due to this practice mainly by PQA.

*Unregulated Flow of Contaminated Wastewater into the Creeks:* Industrial effluents, mainly from industries located outside PQA Notified Area, are contributing to contamination of sediment and water in the creeks, which may impact the mangrove habitats and marine fauna in the long term.

*Deterioration of Air Quality:* Both the existing and the planned industrial capacity will contribute to deterioration of air quality experienced by the populations living east the Study Area.

### 9.1.2 Management Scenarios

The following two management scenarios were considered for development the strategy to manage cumulative impacts:

- ▶ **Business as Usual:** This scenario assumes continuation of current practices and trends in environmental management of the Study Area, as evidenced by lack of proactive environmental management in the past. The impact assessment presented in **Section 8** assumes this scenario.
- ▶ **Collaborative Management:** This scenario assumes proactive environmental management by PQA in its zone of influence, combined with collaboration with other institutions that have an influence over the Study Area and/or impact its environment.

While other intermediate or ideal scenarios could also be constructed, these two scenarios illustrate the significance of threats to the ecosystem, and value of opportunities to protect ecosystem functions and services for the collective benefit of the stakeholders.

#### ***The Business as Usual Scenario***

The significant defining aspects of the Business as Usual Scenario and its possible outcomes are summarized below:

- ▶ PQA has limited environmental management capacity and relies primarily on the companies holding the land and carrying out operations in the Notified Area to manage environmental impacts on an individual basis.
- ▶ Non-sustainable dredging and dredge disposal practices associated with port development and operation will continue resulting in loss of mangrove habitat

- ▶ Erosion of mangroves and siltation of the channels will continue due to changes in tidal flow patterns following dredging and impact of ship wakes as traffic increases.
- ▶ The regulatory framework for industries is essentially that of reliance on the environmental regulator, the Sindh Environmental Protection Agency (SEPA), which has a very limited monitoring and enforcement capacity in view of limited number of staff and technical capacity.
- ▶ Some industries including multinationals and responsible corporate entities practice self-regulation but the impact of their better practices is nullified by non-complying industries.
- ▶ Other polluters located outside the Notified Area including industries and residential areas continue to discharge effluents and gaseous emissions into the Study Area.
- ▶ Fishing activities by local communists remain unregulated and continue non-sustainable harvesting practices.
- ▶ Communities mainly on the east of Notified Area continue non-sustainable fodder and fuel wood extraction from mangroves.

The long term outcome of this scenario in terms of prioritized VECs will be high level of degradation of mangrove habitat and ecosystems resulting in substantial and irreversible loss of coastal ecosystem functions and services, and degradation of air quality for communities living in areas adjacent to PQA Area. Some aspects of the ecosystems such as mangroves closer to Port Qasim may survive due to increased supply of nutrients from municipal and industrial wastewater drained into the creeks.

### ***The Collaborative Management Scenario***

It is assumed that PQA and the owners and operators of terminals and industries located within the PQA Notified Area will individually and collectively fulfill their environmental and social responsibilities as mandated by law to protect their assets, and to manage their corporate and reputational risks.

While PQA is not legally responsible for the impacts on the environment caused by industries and communities located outside the Notified Area, it would be prudent for PQA and the industries and port operators located within PQA to take an interest in management of VECs in the area of their operations. Such an approach will enhance the image of PQA as a responsible organization, protect PQA against potential liabilities due to others that may be wrongly attributed to PQA, and enhance the value of the PQ as a desirable location for the port facilities and industry.

Principal actions and measures recommended for implementation independently by PQA and the industries and business located within the PQA Area, and by other businesses and institutions located outside the PQA Notified Area are listed below.

### ***Principal Actions and Measures by PQA***

- ▶ Preparation and implementation of an Environmental Zoning Plan for PQA Notified Area.

- ▶ Preparation and implementation of guidelines for disposal of dredge materials.
- ▶ Assessment of risk of collisions of ships with cetaceans and preparation and implementation of guidelines for avoiding collisions of ships with cetaceans if required.
- ▶ Preparation and implementation of spill contingency plans for the port.
- ▶ Setting an example for other polluters outside the Notified Area including industries and residential areas by achieving compliance with SEQS, and applying pressure on them through regulators and stakeholders to discourage them from discharging effluents and gaseous emissions into the Study Area.
- ▶ Setting up hydrodynamic and sediment models for prediction of impact of proposed developments and operations on circulation, sedimentation and erosion, and consequentially on ecosystems and ecosystem services.
- ▶ Continuation of plantation of mangroves to offset clearing to address land use change as a driver for ecosystem change, although a proper replantation strategy and planning is need to ensure offsets are sustainable e.g. through secondary management.
- ▶ Building up environmental management capacity to regulate the port operations and businesses operating in the Notified Area to manage environmental impacts on an individual and collective basis.

***Principal Actions and Measures by Others with Participation from PQA***

- ▶ Preparation and implementation of an Environmental Zoning Plan for areas west of the PQA Notified Area where residential and other developments are being considered.
- ▶ Regulating fishing activities by local communists in collaboration with the concerned government departments and sustainable harvesting practices are introduced and established.
- ▶ Active watch and ward (patrolling) and regulatory pressure is applied on communities to either stop fodder and fuel wood extraction from mangroves or maintain harvesting at sustainable levels.
- ▶ Conducting research on mangrove ecosystems to support development of appropriate management strategies.
- ▶ Conducting studies on release of environmental flows from Kotri Barrage to achieve a balance between the ecology in the Indus Delta and the needs of the communities living in the delta, and the agriculture in the upstream areas.

The long term outcome of this scenario in terms of ecosystem services and environment will be maintenance and most likely enhancement of coastal ecosystem functions and services, and sustainable livelihoods.



## 9.2 Proposed Approach for Management of VECs



The Collaborative Management Scenario is suggested as a realistic and feasible option for management of VECs. The transition from the present Business as Usual to this scenario will require extensive and sustained effort over a period of time, and will essentially consist of building upon initiatives that have already been identified and partly tested by institutions such as IUCN, WWF-P, the Sindh Forest Department, and the Sindh Wildlife Department. The following management approach is proposed to achieve this transition:

1. An **environmental management framework** consisting of a set of preventive measures and management measures including environmental zoning of the Study Area to maintain a balance among:
  - ▶ activities such as development and operation of port and industry infrastructure that are necessary for the economic growth of the country;
  - ▶ maintenance of ecosystem services that are important for local livelihoods and well-being;
  - ▶ protection of ecosystems and biodiversity, consistent with the policies of the government and commitments made by the country under conventions such as Ramsar and the Convention on Biological Diversity; and
  - ▶ management of air quality to protect health of the communities residing in the vicinity of the Notified Area

2. An **institutional and policy framework** that purposes strengthening of key departments in PQA and defines the roles, responsibilities and mandates of participating institutions in environmental management of the Study Area. These include the PQA, industries and port operators within the PQA, regulatory agencies, relevant government institutions, and other institutions such as the Korangi and Landhi associations of trade and industry.
3. A **financial management framework** that generates and provides funds for environmental management and defines mechanisms for transparent and effective utilization of funds.
4. A **monitoring and evaluation framework** that relies on continuous professional, scientific and independent monitoring of the extent to which the environmental management objectives are being achieved and identifies of causes of poor performance or failure. The outcomes of monitoring and evaluation would form the basis of revision and updating of management frameworks following principles of adaptive management.

### 9.3 Preventive Actions and Measures

Consistent with management strategy outlined in **Section 9.1**, specific preventive measures were developed in consultation with the PQA and other stakeholders. Suggestions and recommendations for environmental management for each of the prioritized VECs are presented in this section. A strategy to address VECs and ecosystem services in the Study Area needs to consider the local as well as regional factors listed above (**Section 9.1**). The management actions have therefore been classified in the following manner:

*Actions by PQA:* The actions would address the impacts on the environment in the Study Area due to present and planned activities in the Notified Area which is in the jurisdiction of PQA.

*Actions by Others with Participation from PQA:* These actions would address the impacts on the environment in the Study Area due to communities and industries located outside the PQA Notified Area, such as management of flow of freshwater and silt into Indus Delta, non-sustainable fishing and mangrove harvesting practices, and regulation of quality of effluent drained into the creeks by the industries and municipalities located in the Study Area

#### 9.3.1 Air Quality

##### **Preventive Measures by PQA**

##### **Enforcement of SEQS for Industrial Effluents**

It is recommended that PQA work with the Bin Qasim Association of Trade and Industry and SEPA to introduce management and control measures to ensure that SEQS are adhered to and gaseous emissions into the atmosphere do not increase in the future.

### Preparation and Implementation of an industrial zoning plan for PQA Industrial Zones

A zoning plan has been introduced in the PQA Master Plan. The plan needs a revisit in order to incorporate the air quality issues. Areas in the PQA which are immediate upwind of residential areas shall be designated for industries with insignificant emissions.

### Develop emission inventory from PQA and other areas

An emissions inventory is a database that lists, by source and type, the amount of air pollutants emitted into the atmosphere. PQA, in collaboration with the SEPA and the industrial associations can develop an emission inventory to track all the emission from PQA and surrounding sources. This can be done through regular reporting of air pollutants by the industries as required under the SMART<sup>323</sup> framework. A revision of the SMART regulations may be required in order to cover all industrial units and all relevant pollutants.

### Development of a regional air quality model

In order to design and implementing methods and technologies for tracking changes in pollutant emissions and pollutant concentrations, develop strategies for preventive and document and improve the effectiveness of air pollution preventive activities, it is critical to develop a regional level air quality model based on actual emissions from the emission sources (industrial units, ships, road traffic and other sources).

### Establish targets for emission from PQA

In the long term, taking into consideration the technologies and regulatory regimes, PQA shall establish targets for limiting or reducing emission from PQA area. Both short-term and long-term targets may be established.

### Introduce a permit system for air pollutants

In order to meet the emission targets in the long term, a permit system can be considered for industrial emissions. This approach has been adopted in a number of industrialized countries. Each industrial unit may be given a mutually agreed long term goal for emission reduction. The emission permit shall specify the quantity of pollutants that individual units are permitted to emit. The permit may be revised periodically in order to meet the long-term goal of individual industrial units.

### **Preventive Measures by Others**

It is proposed that the following preventive controls may be introduced by others:

1. SEPA and industrial associations can work together to improve enforcement of emission control. This is particularly important for Landhi and Korangi industrial area located to the west of PQA

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<sup>323</sup> Self-Monitoring and Reporting Tool was introduced by Pakistan EPA and adopted by SEPA. The SMART framework allows industries to report effluents and emissions for specific industries in a prescribed format.

2. Zoning plans for areas north of the PQA which are still sparsely populated shall be developed by the concerned district government taking into consideration the future emission scenarios from PQA and other industrial areas.

### **Remedial Measures and Improvements**

Develop and implement strategies for management of open areas

The open areas are the major source of windblown dust in the PQA and surrounding areas. It is difficult to mitigate these, however, certain measures may be undertaken to reduce emission from these areas:

- ▶ Working with the owners of the plots that are already developed, measure shall be taken to reduce emission from these areas. The measures may include plantation of grass, paving or compacting and stabilizing the open areas;
- ▶ Stabilizing the plots which are not developed by for example planting suitable grass, compacting, and limiting access to the land by vehicles; and
- ▶ Paving the shoulders of roads.

### **9.3.2 Mangrove Ecosystems and Biodiversity**

#### **Preventive Measures by PQA**

Preparation and Implementation of an Environmental Zoning Plan for PQA Notified Area

The Environmental Zoning Plan (EZP) will cover both terrestrial and coastal parts of the Study Area. A Biodiversity Action Plan (BAP) can also be separately developed for the mangroves if so indicated by further analysis and consultations. **Exhibit 9.4** summarizes the types of zones and restrictions that can be considered. The IUCN guidelines for protected areas can be consulted for further guidance.

**Exhibit 9.4: Possible Environmental Zoning Framework for PQA Notified Area**

<i>Type of Zone</i>	<i>Purpose</i>	<i>Examples of Restrictions in the Zone</i>
Core Zone	To protect: <ul style="list-style-type: none"> <li>► Biodiversity,</li> <li>► Species that may be at risk, and</li> <li>► Species that are of importance for ecosystem services</li> </ul>	<ul style="list-style-type: none"> <li>► No fishing<sup>324</sup>, hunting, infrastructure development, or clearing of mangroves</li> <li>► Entry for research and protection purposes</li> <li>► Passage for local communities based on traditional practices and rights</li> <li>► Inflows limited to natural streams</li> </ul>
Sustainable Use Zone	To maintain ecosystem services important for local livelihoods	Regulated fishing with restrictions on the type, quantity, timing, method, and location of catch.
Limited Use Zone	To allow economic activity that does not have an extensive and irreversible long term impact	<ul style="list-style-type: none"> <li>► Regulated passage for commercial vessels</li> <li>► Regulated extraction and disposal of dredge materials</li> </ul>
Intensive Use Zone	To construct economic infrastructure such as jetties and terminals	Regulated construction and operation of facilities including permitted clearing of mangroves

Further research on the biodiversity in the Study Area is required to define the boundaries and restrictions for the zones outlined in **Exhibit 9.4**.

**Guidelines for Disposal of Dredge Materials**

Guidelines for disposal of dredge material from channels should be developed by PQA. Expert guidance should be sought for preparation of these guidelines, and experience gained elsewhere in similar conditions should be reviewed<sup>325</sup>. The key is to keep the sediment in the delta system and on nearby islands (man-made or natural mangrove islands). A suggested framework for development of the guidelines is outlined below:

- Identify nearby islands for disposal such as Bundal Island, Buddo Island, and Khiprianwala Island. These are adjacent to the navigation channel and will be cheapest solution for disposal.
- Another option is to create habitat areas with the material. Bird islands or tidal creeks for mangroves can be constructed. Examples exist in the US and elsewhere for this preventive approach where ports are located in the migratory bird path or destination similar to that in the Indus Delta. Tidal creeks can be man-made to develop internal flushing of the island to restore habitat areas. Such islands can also provide protection in the outer delta against typhoons and tsunamis.

<sup>324</sup> Fishing for the purpose of this document includes catching fish, shrimp, and crabs for sale or own use.

<sup>325</sup> A 'Living Shoreline' concept is being developed in Louisiana, where freshwater has been diverted out of the Mississippi River system for other purposes. A lack of freshwater (and thereby sediment) has exacerbated the shoreline erosion for the state. A shoreline and marsh loss has decreased the storm protection of southern Louisiana. There are new techniques being applied for gray solutions (green + solid protection) to improve habitat – oysters, fisheries, wetlands, marsh, mangroves, etc.  
<http://deltaforall.com/our-approach/>



- ▶ Placement of dredged material in mangrove areas that are eroding and need shore protection. This could be a revetment made of rock to protect the toe or leading edge of a mangrove area. Once the revetment is in place, dredge material can be disposed of to reclaim land and allow mangroves to naturally restore.
- ▶ The guidelines should address the characteristics of the disposal material and the appropriate quantities that can be disposed in site specific conditions.

#### **Assessment of Risks to Cetaceans and Preparation and Implementation of Guidelines for Management of Risks**

While literature reports indicate regular occurrence of dolphins in the Study Area (see Section 5.6), systematic studies on the abundance particularly in the fishing channels are not available. The consultations with stakeholders have not revealed any incidences of collisions of ships with dolphins or porpoises in the shipping channels. Study of these aspects need to be made a part of wildlife monitoring studies that may be conducted in the Study Area in future. In case a risk of injuries or fatalities to dolphins or porpoises from ship movement is indicated, guidelines on management of risks including detection of cetaceans and limiting of ship speeds should be prepared and shared with the ship operators. Similarly, if the risk to cetacean populations due to noise from construction activities in the port is indicated, guidelines on management of risks during construction including use of ‘quiet’ technologies and ‘soft start’ procedures in order to build up noise levels gradually should be prepared and shared with the ship operators.

#### **Enforcement of SEQS for Industrial Effluents**

The impact of effluents discharged by the industries located in the PQA Area on the water quality in the creeks is relatively small in comparison to that of the effluents from industrial areas of Landhi and Korangi located east of the Notified Area (**Section 8.2.1**). However, it is recommended that PQA work with the Bin Qasim Association of Trade and Industry and SEPA to introduce management and control measures to ensure that SEQS are adhered to and pollutant discharges into the creeks do not increase in the future. This can be done through regular reporting of water quality discharged by the industries as required under the SMART<sup>326</sup> framework, followed by a phased program to achieve compliance with SEQS. In addition to SMART, monitoring of water quality should be carried out in Korangi, Kadiro and Gharo Creeks, as well as a reference site. Options for setting up common effluent treatment plants can be explored jointly by the PQA and industry.

#### **Spill Contingency Plans for Oil and other Hazardous Cargo**

The risk of damage to the mangrove ecosystem from accidental spills of hazardous materials will increase as the ship traffic in PQA increases. PQA has already prepared an oil spill contingency plan, and has the basic equipment to handle spills of less than 1,000 tons. For larger spills, PQA gets assistance from the national agencies that have the required capacity. PQA needs to acquire expert assistance to review the existing spill

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<sup>326</sup> Self-Monitoring and Reporting Tool was introduced by Pakistan EPA and adopted by SEPA. The SMART framework allows industries to report effluents and emissions for specific industries in a prescribed format.

contingency plans to respond to the present and expected risks. Appropriate augmentation of staff and facilities can be made following this review.

#### **Control of Erosion Due to Ship Wake**

PQA should seek expert assistance for feasibility, design and construction of protective systems such as geotextiles in critical mangrove areas where high erosion rates have been observed (**Section 4.7.5**). These protective systems need to be specially designed following the concept of 'living shoreline' to protect the ecology of the mangroves at risk.

PQA already maintains speed limits for vessels in critical passage areas where risk of erosion is high and where safety is a concern. PQA should arrange to conduct special studies to determine optimum speed of ships at vulnerable sections of the channels to reduce erosion of banks from ship wakes while avoiding excessive increase in time required for passage of vessels.

#### **Hydrodynamic, Sediment and Water Quality Modeling for the Creeks**

Both PQA and terminal operators located within PQA have raised concerns on acceleration of erosion and sedimentation triggered by Developments within the Notified Area and elsewhere outside the Notified Area mainly towards the west where residential and other developments are apparently being considered. PQA should acquire expert services for collection of long-term (at least 1 year) hydrographic, sedimentation, and water quality data geared towards fulfilling requirements for modelling, followed by preparation of a calibrated model that can predict the erosion and sedimentation in the creek system (See **Appendix F**). The model can then be used to determine changes in circulation, sedimentation and erosion as part of EIAs for port developments to address change in land use as a driver for change in mangrove habitat. Habitat indices and ranges can be defined such as mangrove classification (**Section 5.3.4**), salinity, substrate (clay/sandy soils), and water velocity (2-4 feet per second). Then if the mangroves are determined to be suitable, a biologist can determine if the fish and other biodiversity will be present based on habitat suitability. The model will also allow PQA to address the impacts of maintenance dredging as well as dredging of the alternate navigation channel, while keeping in view technical and financial limitations and constraints.

#### **Preventive Measures by Others**

##### **Enforcement of Protection through Improved Watch and Ward**

The SFD will support the PQA in control of mangrove harvesting as described in the following section on 'Offsets and Other Management Measures'. While the SFD has the legal mandate for protection of mangroves, it has limited resources at its disposal for carrying out this function. The approach to protection therefore proposed is that PQA will arrange for logistic support and enforce protection to the extent that it falls within its capacity and mandate, while the SFD will accompany the PQA staff and enforce the provincial laws prohibiting cutting of mangroves.

### Preparation and Implementation of an Environmental Zoning Plan for the Study Area

The Environmental Zoning Plan prepared by PQA for PQA Notified Area as described above under 'Actions by PQA' can be extended by other stakeholders including SEPA, the SFD, the SWD, and the NGOs such as IUCN and WWF-P to cover the entire Study Area and possible eastwards in Karachi where major housing developments have been planned by organizations such as the DHA.

### Enforcement of SEQS in Industries and Installation of Municipal Effluent Treatment Plants

Following the initiatives taken by PQA and industry located within PQA as described above under 'Actions by PQA', enforcement of SEQS can be extended by SEPA and the concerned industry associations to the industrial areas located west of PQA, mainly the Landhi and Korangi industrial area. The option of common effluent treatment plants can also be explored if a similar initiative proves to be successful at PQA.

### Guidelines for Land Reclamation

Land reclamation activities can directly increase sediment loads in the creeks as the dumped material is eroded by tidal and wave action, and also by altering the tidal flow patterns. In the framework of the Zoning Plan for the Study Area, guidelines for reclamation of land need to be developed by SEPA in consultation with other stakeholders to regulate and control extensions into the sea.

### **Remedial Measures and Improvements**

#### Continue and Sustain Plantations at Suitable Alternate Locations

The EIAs conducted for the industry and terminal projects located in PQA Area typically required the project proponents to plant ten trees for each tree cut to clear land for development. While there are doubts about long term success of mangrove plantations (**Section 5.3.10**), efforts should continue to make the plantations successful and research into methods and techniques for making the plantations successful.

#### Control of Mangrove Harvesting and Illegal Fishing

Given the limited success in mangrove reclamation and plantations, in-situ protection of mangroves needs to be given importance. It is best and most economical to protect the mangroves where they already exist, and there is little advantage in plantations if a larger mangrove area is being lost due to illegal harvesting. PQA presently conducts vigilance in the creeks using large size patrol boats that have very limited mobility in the smaller channels in the creek system. This limits the capability of the PQA staff to track down and arrest persons engaged in illegal harvesting of mangroves and fishing using prohibited nets and methods. PQA needs to add a suitable number of low draft smaller size boats which can be carried on the existing or new larger and faster boats to facilitate patrolling and vigilance. The staff of the SFD and the MFD needs to accompany the PQA staff to make arrests under the law as needed.

### **Support Research on Mangrove Ecosystem in Indus Delta**

As recommended in **Section 5.3.13**, research needs to be conducted to understand the causes of degradation of mangroves in the Study Area to provide inputs for adaptive management (**Section 9.7**). Parameters such as changes in soil conditions, drainage patterns, and nutrient inflow can be linked to changes in physical conditions predicted by hydrodynamic and sediment modeling to predict changes in mangrove habitat and ecosystem.

### **Conduct Research on Environmental Flow Release from Kotri Barrage**

Environmental flow requirement of Indus Delta has been a subject of much discussion and debate ever since the social and ecological impacts of diversion of water and sediment from the delta became apparent. Estimates for the quantity and timing of flow required vary widely, and there has been no attempt as yet to develop integrated and holistic models to understand and predict the induced changes in Indus Delta. Lack of a sound scientific approach to the problem is perhaps the principal reason that consensus for action to arrive at solutions in the framework of sustainable development could not be reached. Experience exists in Pakistan in application of holistic models such as DRIFT in Himalayan rivers to provide a decision support system to the stakeholders which can assist the stakeholders in evaluation of alternate flow and development scenarios. PQA as an important stakeholder can support other stakeholders such as the Pakistan Council for research on Water Resources, the Federal Flood Commission, the Planning Commission, and independent institutions such as WWF-P and IUCN that have institutional mandates and longstanding experience in conservation of mangroves in the country.

## **9.3.3 Income from Harvesting of Fish, Shrimp, and Crab**

### ***Preventive Measures by PQA***

#### **Educate the Fishing Community on Safety in Shipping Channels**

As discussed in **Section 8.3**, the fishing communities have complained about restricted access to fishing areas which impacts their income from fishing. PQA maintains that for safety reasons fishing in shipping channels is prohibited as the fishing vessels are at risk from the wakes generated by the passing ships. However, crossing the shipping channels to reach fishing areas in the creeks is not an issue as this can be done in the time windows available between passage of two ships. PQA also maintains that the fishermen also take undue risks to fish in the shipping channels as the fish catch tends to be higher there owing to restrictions placed on fishing. PQA in collaboration with the MFD needs to establish regular contact with the fishing community to explain the safety requirements and restrictions, and enforce the restrictions following discussions with the community.

#### **Monitor the Release of Heavy Metals in Creeks that can Contaminate Fish Tissue**

In conjunction with enforcement of SEQS in the industry to limit pollutant discharge by the industries into the creeks, PQA needs to monitor the quality of effluents being discharged by the industry in PQA Area into the sea. The monitoring framework presented in **Section 7.3** of this report ‘Indicators for VECs and Threshold, Targets and Limits’, can serve as a guidance for this purpose.

### **Preventive Measures by Others**

Following the actions by PQA as described above, the institutions with mandates outside the PQA Area can extend the efforts of PQA to the rest of the Study Area. The industry associations such as LATI and KATI can organize to monitor the pollution levels in effluents in the streams draining the effluents from their areas, with focus on toxic metals. Similarly, the MFD can support the PQA in its efforts to educate the fishing community on safety and restrictions in fishing channels.

### **Remedial Measures and Improvements**

#### **Provide Training to Fishing Communities for Skill Development**

In view of the expected decline in fish catch (see **Exhibit 8.6** in **Section 8.3**), the livelihood and employment opportunities for the fishing communities are expected to decline, and there is a need to develop alternative means of income for the fishing communities. While the industry is not directly responsible for this decline, PQA and the industry, through their CSR programs, can work together to provide training and skill development to the fishing communities to prepare them for alternative employment.

#### **Control of Non-Sustainable Fishing Practices**

As already discussed in the ‘Offsets and Other Management Measures’ for mangroves in **Section 9.3.2**, PQA can collaborate with and provide support to the MFD for control of illegal and non-sustainable fishing practices in the PQA Area.

#### **Conduct Research on Environmental Release from Kotri Barrage**

The mangroves in the Study Area that are rich fishing grounds for the local community are an extension of the Indus Delta mangrove system. Subsistence and commercial fisheries in the Study Area, particularly on its south eastern boundary, is partly dependent on the health of the mangrove ecosystem in the Indus Delta. As recommended in **Section 9.3.2**, PQA and other stakeholders having interest in the Indus Delta can collaborate to support research on environmental release from Kotri barrage to improve sustainability of fishery in the Indus Delta.

## **9.4 Institutional and Policy Framework**

This section presents recommendations for an institutional framework that can be adopted to facilitate implementation of Preventive Measures for which the mandate and responsibility lies with the PQA.

**Exhibit 9.6** presents a list of institutions, their relevance to environmental management in the Study Area, their capacity for managements of ecosystem services, and their possible role in regulation and management of ecosystem services. **Exhibit 9.6** draws on the institutional analysis included in the Stakeholder Engagement Plan, and information collected during the course consultations with institutional stakeholders as a part of this study. The leadership for management of VECs and ecosystem services is best assumed by PQA. However, recognizing the institutional limitations and limited environmental management capacity of PQA, extensive support will have to be provided to PQA to build capacities in the initial phase of implementation. Institutions already active in



research, protection and management of coastal ecosystems in Karachi have the capacity to provide the needed support. The suggested roles and responsibilities of identified institutions can be categorized as follows:

- ▶ *Leadership*: PQA and Bin Qasim Association of Trade and Industry
- ▶ *Capacity Building and Management Support*: WWF, IUCN, and possibly TCCR
- ▶ *Enforcement and Management Support*: SEPA, SFD, SWD, MFD, OPSW
- ▶ *Research*: NIO, Center of Excellence Marine Biology
- ▶ *Observation and Management Support*: LATI, KATI, FDB

Most of the institutions listed above operate under defined mandates, and legal and policy frameworks. The environmental policies of PQA and guidelines, will, however, have to be developed in further detail if PQA has to assume a leadership role.

The following two options were considered for leadership and high level supervision and oversight of environmental management in the PQA Area:

- ▶ PQA Environmental Management Board, or
- ▶ Environmental Committee

In either case, the lead institution would have representation from PQA, BQATI, and other key stakeholders such as WWF, IUCN, SFD, and SWD can be constituted to direct and evaluate implementation.

The advantage in the first option is that the Board would have the legal authority and financial means to take and implement decisions related to environment in its area of jurisdiction. However, the disadvantage of this option is that legal basis for the formation of the Board will have to be created, and it is that the Federal Government will have to notify and empower such an entity as ports and shipping is a federal subject under in Pakistan. In discussions with PQA, it was clear that in the presence of the PQA Board which is empowered to deal with development and management of the port, it would not be advisable to create another high level entity to deal with environmental matters. The policy and high level oversight can be provided by the existing PQA Board, while implementation related to environment which is a functional matter can be best dealt with by a Committee operating under the rules and regulations of the PQA. For these reasons and following advice from PQA, formation of an Environment Committee is recommended. The recommended institutional approach is summarized below.

**Addition or identification of a Member Environment in the Board of PQA:** This action will strengthen the oversight and supervision capacity of the PQA Board on environmental matters. The person should ideally have a private sector background with longstanding experience in environmental policy and management in a large corporation.

**Formation of an Environment Committee in PQA:** The Environmental Committee will report directly to the Chairman, and will have representation from the industry and terminals operators in PQA and DGs Technical, Operations, and Planning. The Chairperson of the Committee can be taken from the private sector to enhance participation and involvement of the industry. It would be appropriate for PQA to provide secretariat support to the Committee including venue for holding meetings, managing

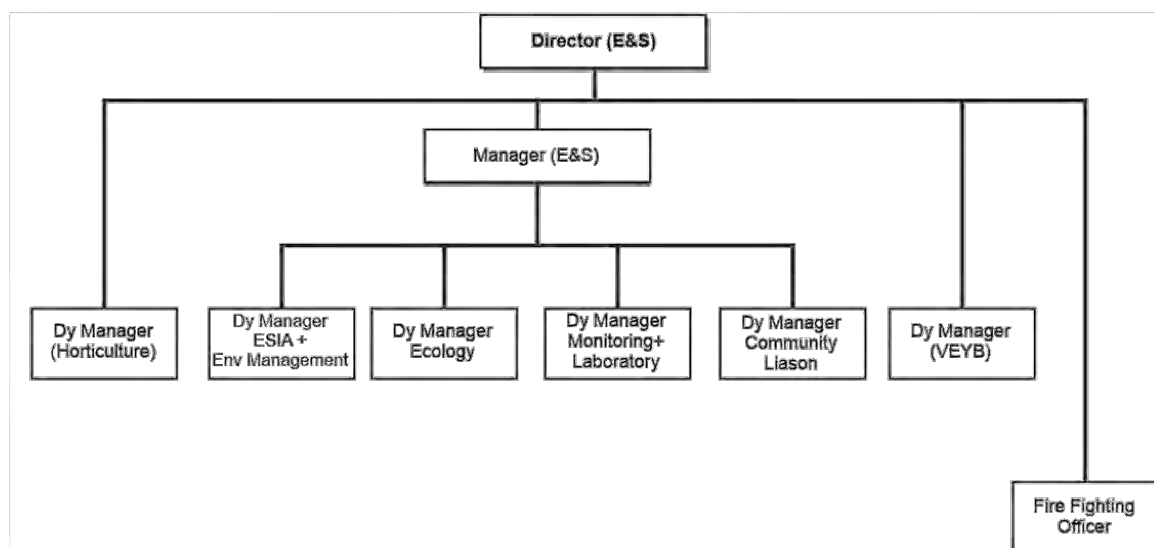
meetings, maintaining records of proceeding, and following up on the decisions of the Committee.

**Strengthening and capacity building** of the following departments and sections in PQA:

- ▶ **Environment and Safety Department:** Capacity to manage physical, ecological and socioeconomic aspects of environment, environmental monitoring, review of ESIAs, and coordination with industry in PQA and external stakeholders.
- ▶ **Hydrography Section in the Technical Division:** Capacity to manage and supervise collection of hydrography data in and around the port area.
- ▶ **Dredging Department:** Capacity to manage development of hydrodynamic and sediment transport models and to operate and interpret the results for predicting changes in sedimentation and erosion patterns, and providing advice on design of new facilities.
- ▶ **Restructuring of Environment Department:** A position of Manager Environment is proposed, who will manage and coordinate the following functions for which respective Deputy Managers will be engaged: ESIAs and Environmental Management, Ecology, Monitoring and Laboratory, and Community Liaison.
- ▶ **Placement of E&S Department under the DG - Technical:** This is recommended to maintain coordination among the functions of environment, hydrography, and dredging for the reasons listed above.

A proposed structure for the E&S Department is provided in **Exhibit 9.5**.

**Exhibit 9.5:** Proposed Strucutre of E&S Department



## 9.5 Financial Management Framework

The following is an outline of the proposed financial mechanism to support implementation of recommendations of the CEA.

Principal actions proposed are:

- ▶ **A separate Fund for environmental management** titled Port Qasim Environmental Management Fund can be opened with appropriate legal cover under the rules of the PQA.
- ▶ **The Fund can be managed by the Environment Committee** with representation from industry as discussed in the previous section. This will include decisions on where to use the funds, and how to maintain accountability and transparency.
- ▶ **Inflows into the Fund can include mandatory and voluntary contributions from the land holders in PQA** on the basis of defined fees or incremental land charges, fines and penalties collected by PQA on account of environment, pollution charges, and contributions from donors.
- ▶ **The amounts in the Fund can be used to support activities for implementation of protection and management of environment** such as protection and patrolling, research and monitoring, community engagement, effluent treatment, clean-ups, and restoration.

## 9.6 Monitoring and Evaluation

Following the Pressure-State-Response framework, the framework for monitoring of changes in VECs is described in **Section 7.3**. In addition to regular reviews by PQA and sharing of the results with the stakeholders, the Board should review the monitoring and evaluation (M&E) reports at least once a year.

**Exhibit 9.6:** Institutional Stakeholders, Capacities, and Possible Roles

<i>Stakeholder</i>	<i>Relevance</i>	<i>Capacity for Management of Ecosystem Services</i>	<i>Possible Role in Regulation and Management of Ecosystem Services</i>
<b>Government Authorities</b>			
Port Qasim Authority	Responsible for Management of Port Qasim	Low, limited number of staff assigned	Leadership for management of ecosystems. Development of EMP and guidelines Regulation in Notified Area
Sindh Environmental Protection Agency	Regulatory agency for environmental protection	Low	Provide enforcement support to PQA both for environmental impact assessments and operations.

<i>Stakeholder</i>	<i>Relevance</i>	<i>Capacity for Management of Ecosystem Services</i>	<i>Possible Role in Regulation and Management of Ecosystem Services</i>
Ministry of Ports and Shipping, Islamabad Represented in Karachi by Office of Ports and Shipping Wing (OPSW)	<ul style="list-style-type: none"> <li>► Pollution control from ships in harbor and territorial waters”</li> <li>► Examination of international conventions pertaining to ports and shipping and following ratification of conventions, formulation of maritime laws and regulations for implementation by shipping industry</li> </ul>	Low	Provide enforcement support to PQA
Marine Fisheries Department	Responsible for management of fisheries and other living resources in the exclusive economic zone of Pakistan.	Medium	Provide PQA with management support and support on data.
Sindh Fisheries Department	Responsible for management of fisheries and other living resources in near shore areas.	Medium	Provide PQA with management support and watch and ward on illegal fishing activities with involvement of PQA for support.
Fisheries Development Board	Provide and maintain a platform for enhancing and promoting fisheries sector in Pakistan	Medium	Provide PQA regional coordination with the private sector involved in fisheries.
Sindh Forest Department (SFD)	Custodian of mangrove forests and mandated to protect them Managing, developing and administering the mangrove forests	Medium	Already managing protection of mangroves with moderate success. PQA can support SFD to deliver protection in the Notified Area.
Sindh Wildlife Department (SWD)	Managing, developing and administering the wildlife resources in the mangrove forests	Medium	Limited penetration in mangroves to protect biodiversity including bird life. PQA can support SWD to deliver protection in the Notified Area.
<b>Non-Governmental Organizations</b>			
International Union for Conservation of Nature (IUCN)	Operates “Mangroves for the Future” Project in the Study Area	High	Can provide effective policy and management support to PQA and other stakeholders

<i>Stakeholder</i>	<i>Relevance</i>	<i>Capacity for Management of Ecosystem Services</i>	<i>Possible Role in Regulation and Management of Ecosystem Services</i>
Worldwide Fund for Nature (WWF)	Was involved in mangrove conservation projects in the past, currently developing "Design Implementation of Creek Survey and Detailed Creek Survey Manual" for FAO	High	Can provide effective policy and management support to PQA and other stakeholders
Trust for Conservation of Coastal Resources (TCCR)		Not determined	
Pakistan Fisher Folk Forum	"a non-governmental organization that works to advance the goal of social, economic, cultural and political rights of small scale indigenous fisher communities in Pakistan"	Not determined	
<b>Scientific and Research Organizations</b>			
National Institute of Oceanography (NIO)	Research in oceanography	High	Can provide research support to PQA
Center of Excellence Marine Biology, University of Karachi	Research and education in marine biology	High	Can provide research support to PQA
<b>Industrial Associations</b>			
Bin Qasim Association of Trade and Industry (BQATI)	Represents the industries located in the PQA notified area and can serve as a coordinating entity for collective action on part of the industry	Low	The most important partner and stakeholder. Participation of the Association is critical for the success of the EMP implementation.
Landhi Association of Trade and Industry (LATI)	Jurisdiction of this estate begins from Farooque Textile Mill located at road to Port Qasim including Export Processing Zone and all industries located at National Highway to Khagar Phatak  Directly or indirectly the effluent from the estate is discharged to the creek	Low	Participate as an observer in the EMP process.  Can learn from PQA experience in CEA and participate in protection of biodiversity in mangroves



Stakeholder	Relevance	Capacity for Management of Ecosystem Services	Possible Role in Regulation and Management of Ecosystem Services
system <sup>327</sup>			
Korangi Association of Trade and Industry (KATI)	Represents the 4,500 industrial and commercial units in Korangi	Low	Participate as an observer in the EMP process.  Can learn from PQA experience in CEA and participate in protection of biodiversity in mangroves

## 9.7 Adaptive Management

The definition of adaptive management has three components. There is a corresponding goal for the adaptive management program for each of those components.

The first component consists of evaluating the accuracy of the predicted environmental impacts. The corresponding goal is to improve the predictive capability of the models such as those for air quality, hydrodynamics, sedimentation, and water quality and methods used to identify and quantify project-induced impacts.

The second component consists of assessing the effectiveness of the preventive measures. Here the goal is to identify how effective the implemented preventive measures are at reducing impacts. **Section 7.3** lists and describes the monitoring indicators recommended. Physical parameters would be monitored within the creek system that describes how the system is functioning with the preventive in place. Biota would also be monitored to determine the system's biological responses to those parameters. After monitoring data is available, the updated models would be rerun using the observed conditions.

The final component is modifying the project as needed to ensure the levels of environmental effects within the range acceptable to the stakeholders. Suggested thresholds for indicators of state are included in **Exhibit 7.4** in **Section 7**. The goal for this component is to implement whatever modification is needed to the preventive plan to keep the levels of observed environmental effects below the thresholds and within the range acceptable to the stakeholders.

At the institutional level, the proposed Environment Committee can take adaptive management decisions following review of monitoring and evaluation reports. Review and approvals can be sought from the PQA Board where matters of policy and budgetary support from PQA are involved.

## 9.8 Budgetary Implications for Implementing the Recommendations

**Exhibit 9.7** provides an indicative budget for environmental management at PQA for implementation of preventive actions and measures described in **Section 9.3**. The budget

<sup>327</sup> According to the association website, there are 1,200 plots in the estate. It has a water supply of 35 million gallons per day (mgpd) representing a shortfall of 65 mgpd. Assuming that the shortfall is met by other means, the estate would be discharging at least 50 mgpd of effluent.

does not cover the additional staff requirements at PQA described in **Section 9.4**. It is assumed that staff costs will be absorbed by PQA in the revenue budget of the organization.

Major items in one-time and capital costs for environmental management include setting up and calibrating the hydrodynamic and sedimentation model, setting up air quality model, purchase of low draft patrolling boats, and installation of buoys for cordoning of sensitive fish breeding areas. The indicative budgetary requirement for these is estimated at USD 1.23 million.

Major items for annual recurring costs include hydrodynamic and sediment flow monitoring, air and water quality monitoring, ecological monitoring, surveillance to control illegal and non-sustainable fishing and harvesting of mangroves, awareness and education of local communities, and special studies for environmental management. Annual indicative budgetary requirement for these is estimated at USD 293,000<sup>328</sup>.

Given a current revenue base of PQA from shipping as well as land charges of about USD 57 million, the capital or one-time costs for environmental management are estimated 2.2% of the PQA revenues, while the recurring costs correspond to 0.5% of the annual PQA revenues.

**Exhibit 9.7: Indicative Budget Estimate for Environmental Management at PQA**

	<i>One Time</i>	<i>Recurring</i>
<b>Hydrodynamic Modeling</b>		
Data Collection and Setting up the Model	1,000,000	
Ongoing Data Collection		150,000
<b>Air Quality</b>		
Setting up the Regional Air Quality Model	20,000	
Air Quality Monitoring		10,000
Water Quality Monitoring		12,000
Mangroves and Ecological Monitoring		15,000
<b>Monitoring and Surveillance of Mangrove Areas</b>		
Low Draft Boats, 4	60,000	
Annual Operating Cost of Boats		26,000
Floating Checkpoint for Monitoring	20,000	
Floating Buoys for Cordoning off of Prime Fish Breeding Areas	100,000	
Community Education and Awareness		5,000
Miscellaneous Monitoring Equipment	30,000	
Special Studies and Training		75,000
<b>Total</b>	<b>1,230,000</b>	<b>293,000</b>

<sup>328</sup> Excluding additional PQA staff costs.

	<i>One Time</i>	<i>Recurring</i>
Annual Revenues from Shipping	47,619,048	
Annual Revenues from Land Charges	9,523,810	
<b>Total Annual Revenues</b>	<b>57,142,857</b>	
<b>Capital or One Time Cost as % of Revenues</b>	<b>2.20%</b>	
<b>Recurring Cost as % of Revenues</b>	<b>0.50%</b>	