



Ministry of Climate Change
Government of Pakistan



Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

A Handbook on
*Pakistan's Coastal and
Marine Resources*



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ABBREVIATIONS

CBD	Convention on Biological Diversity
CFCs	Chlorofluorocarbons
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO ₂	Carbon dioxide
dB	Decibels
EEZ	Exclusive Economic Zone
ESBN	Estuarine Set Bag Net
GHGs	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature and Natural Resources
LBOD	Left Bank Outfall Drain
KPT	Karachi Port Trust
MAF	Million Acre Feet
MGD	Million Gallons per Day
MPA	Marine Protected Area
MSC	Maritime Stewardship Council
NGO	Non Governmental Organization
NM	Nautical Mile
PEPA	Pakistan Environmental Protection Act
PQA	Port Qasim Authority
PSM	Pakistan Steel Mills
SIDA	Sindh Irrigation and Drainage Authority
TED	Turtle Excluder Device
WWF	World Wide Fund for Nature-Pakistan



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PREFACE

Pakistan is endowed with diversified natural capital spanning from a long coast to the second highest mountain peak (K2) of the world. The 990 kilometers long coastline, shared by the coastal provinces of Sindh and Balochistan, leads onto the maritime zones of Pakistan. These extend up to 350 nautical miles. Firstly there are the offshore territorial waters up to 12 nautical miles (22.22 kilometers), then the area between 12 and 20 nautical miles acts as the buffer zone; finally, the area beyond the 20 nautical mile line up to 200 nautical miles is regarded as the exclusive economic zone (EEZ) which covers an area of about 240,000 km² of the Arabian Sea. More recently the EEZ has been further extended by about 50,000 km² through the recognition of Pakistan's continental shelf claim under article 76 of UNCLOS (UN Conference on the Laws of the Seas).

The coastal and marine resources constitute an integral part of Pakistan's economy, also acting as the country's strategic gateway. Three operational seaports and major urban and industrial centers located along the coast are hubs for economic development and exhibit a great potential for emerging economic development opportunities such as, China Pakistan Economic Corridor (CPEC).

Mangroves and coastal and marine fish stocks are the principal living natural resources in Pakistan's coastal zone together with small patches of coral reef, sea turtles, dolphins and porpoises, and a rich bird fauna, especially of migratory species. Small-scale fishing in the mangrove wetlands is a vital subsistence activity for coastal households in Sindh and Balochistan provinces. However, various pressures resulting from urban and industrial development like overfishing, deforestation of mangroves, dredging, land reclamation, and pollution from disposal of solid waste and sewage are the widespread concerns along the coast. The coastal areas are also highly vulnerable to the impacts of climate change.

The Handbook on Pakistan's Coastal and Marine Resources developed with support from Mangroves for the Future Programme gives an overview of the coastal and marine areas of Pakistan with specific focus on ecosystems, biodiversity resources and key issues facing sustainable management. It also highlights the various current and future actions and approaches that contribute to the sustainable management of the coastal and marine resources of Pakistan.

I am confident that the Handbook will promote a better understanding of various environmental concepts related to coastal marine areas of Pakistan. Many of the environmental concepts presented are part of the syllabi of the secondary and tertiary level academic institutions in Pakistan. Hence, this Handbook will be a useful knowledge resource and reference guide on environmental concepts, especially in the context of Pakistan, for a wide range of audience including resource managers, researchers, teachers, students, media persons and, of course, the general public.

I admire efforts of the authors of this handbook which is a useful addition to the knowledge resource on coastal and marine resources of Pakistan.

Syed Abu Ahmed Akif

Secretary, Ministry of Climate Change/

Chair National Coordinating Body, MFF Pakistan



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1. COASTAL ZONE OF PAKISTAN

1.1 Coastline of Pakistan

Pakistan's coastline is about 990 km long, bifurcated in two parts, Sindh Coast (270 km) and Makran Coast (720 km). The Exclusive Economic Zone (EEZ) of Pakistan covers an area of about 240,000 sq. km. The maritime zone of Pakistan, including the continental shelf, extends up to 350 nautical miles from the coastline. The shelf of the coast is dominated by the Indus (a major river of Pakistan) canyon in the coast. The continental shelf varies in size distinctly along the Sindh and the Balochistan provincial coasts. The seaward coastal zone up to 12 nautical miles (NM) from the coastline is basically within the jurisdiction of the two provinces (Sindh & Balochistan). The coastal zone beyond the 12 NM up to 24 NM is the contiguous zone and beyond the 12 NM up to 200 NM is under the jurisdiction of the federal government.

Geographically, the coast of Pakistan can be divided into five parts, starting from the Iran border at Gwatar Bay in the West up to the Indian border at Sir Creek in the East:

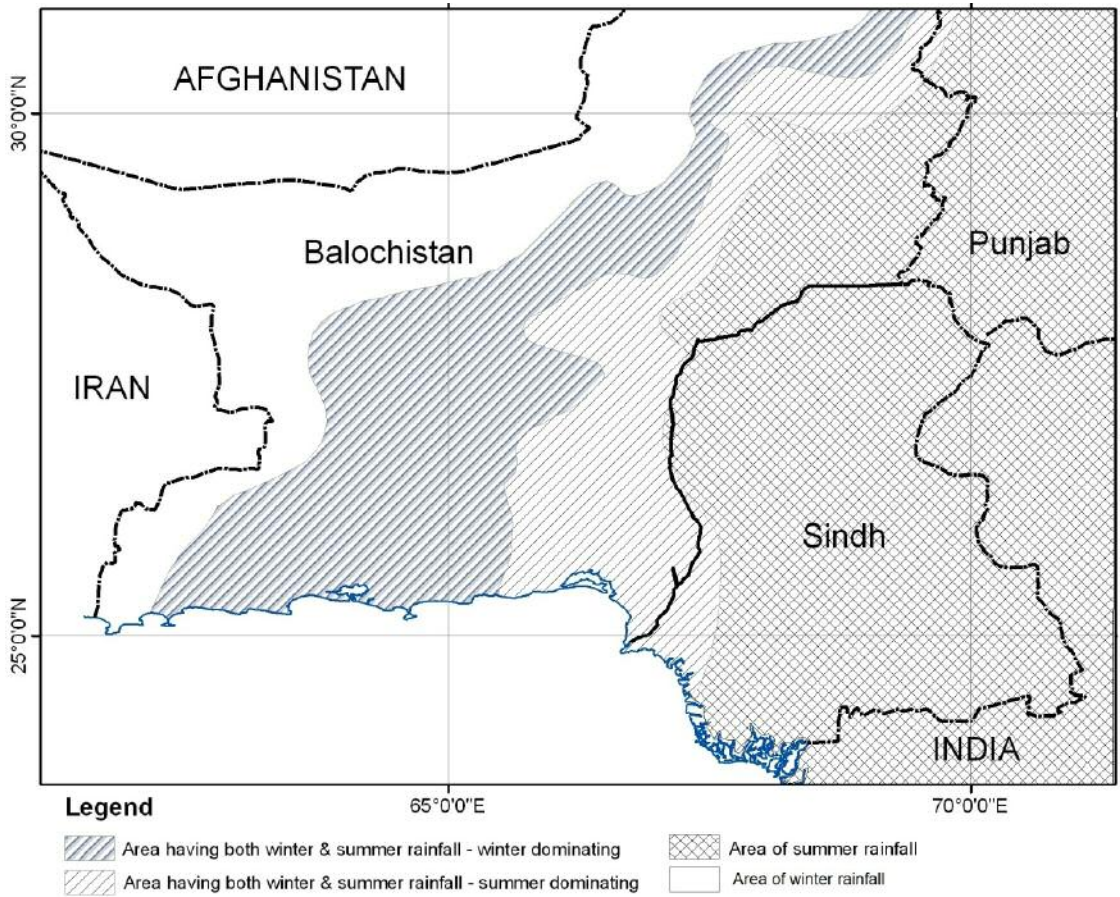
- Gwadar Coast
- Lasbela Coast
- Karachi Coast
- Thatta Coast from Korangi Creek up to Indian border at Sir Creek
- Rann of Kutch from Badin to Tharparkar Districts

1.2 Sindh Coast

The Sindh coastal region is located in the South-Eastern part of the country between the Indian border along Sir Creek on the east to Hub River along the Balochistan coast on the west. The Sindh Coast can further be sub-divided into two parts, the Indus Delta Creek system and the Karachi Coast. The Indus Delta (approx. 1000 sq. miles) is the most prominent ecological feature of the Sindh Coast (covers 85% of the coastal belt in Sindh) the coastal morphology of which is characterized by a network of tidal creeks and mudflats occupied by mangrove vegetation.

The Indus Delta starts from Korangi Creek and extends to Sir Creek. The area covered by the Indus Delta is more than 600,000 hectares of tidal land and mud flats, most of which are inundated during flood tides. There are seventeen major creeks in the Indus Delta dominated by one of the largest arid mangrove forests in the world. Mangroves are used as fuel and fodder for livestock and camels. These mangrove forests are divided into two main blocks, the Keti Bundar block and the Shah Bundar block. Beyond the Shah Bundar block of the Thatta District there is a narrow belt of the Rann of Kutch which has important wetlands.

The Karachi Coast constitutes a coastal belt of about 100 km in length situated between the Gharo Creek and Hub River on the west. The Karachi Coast starts from Hub River out fall in the Arabian Sea and the open sea coastline of Karachi ends at Korangi Creek. Further along Korangi-Phitti and Gharo Creeks, it ends at the Ghagar Nala outfall into Gharo Creek. There are three main islands, i) Churna, which is



located about a kilometer beyond Hub River outfall, ii) Shams Pir, in the western back waters behind Sandspit, and iii) Bundal Island located not far from Sea View beach. The western backwaters and the eastern backwaters (the Chinna Creek) of the Karachi Port house mangrove forests. Situated along the Karachi Coast are two ports, a nuclear power plant, two fish harbours, two industrial estates and the Steel Mill. Beaches of touristic importance are at Hawkes Bay, Sandspit, Manora, Clifton and Sea View.

1.3 Balochistan Coast

The Balochistan coast extends from the mouth of the Hub River in the east to the middle of the Gwadar Bay (bordering Iran) in the west and stretches over a distance of about 770 km. The Balochistan coast can also be sub-divided into the Lasbela and the Gwadar (districts of Balochistan province) coasts. The Balochistan Coast has many bays which include Gwadar Bay, Gwadar West and East Bays, Pasni Bay and Sonmiani Bay having Miani Hor as its back water lagoon. The Balochistan coast is hyper-arid to arid (sub) tropical and includes piedmont plains and low hill ranges. Locally, small tidal mangrove forests, both natural and artificial, are present on the mouth of seasonal rivers draining in the Arabian Sea. About 20 nautical miles from Pasni in the sea is an uninhabited island, Astola.

Geologically, the Balochistan Coast is bound by the Makran Coast range from west to east up to Hala range. The Lasbela Coast boundary in the north is the southern foothills of the Hala range. Tectonically, the Makran coastal area is very active with numerous active fault lines running along the Makran Coast.



2. SEA PORTS IN PAKISTAN

A port is a location on the coast or shore containing one or more harbours where ships can dock and transfer people or cargo to or from land. Port locations are selected to optimize access to land and navigable water for commercial needs and for shelter from wind and waves. Pakistan, since its independence, inherited one port i.e. Karachi Port which was developed by the British regime in 1886. Later on, two other major ports i.e. Bin Qasim Port and Gwadar Port were established along the coastline of Pakistan.

2.1 Karachi Port

The Port of Karachi is one of South Asia's largest and busiest deep-water seaports, handling about 70% of the nation's cargo (25 million tons per annum) located in Karachi, Pakistan. The geographic position of the port places it in close proximity to major shipping routes such as the Strait of Hormuz. The administration of the port is carried out by the Karachi Port Trust (KPT).

The Karachi Port is a premier port of Pakistan. The port comprises a deep natural harbour with an 11 kilometer long approach channel which provides safe navigation for vessels up to 75,000 tones dead weight (DWT). The port has 30 dry cargo berths including three container terminals and three liquid cargo handling berths. The main areas of port activity are two wharves; East Wharf with seventeen vessel berths and West Wharf with thirteen vessel berths. The maximum depth alongside the berths at the East Wharf is 13 meters and at the West Wharf it is 11.3 meters. The Karachi Port handles about 14 million tons of liquid cargo and 12 million tons of dry general cargo.

The flow of cargo to and from the port is hampered by severe congestion in the harbour with several other maritime facilities located close to the port. The West Wharf also hosts a ship repair facility and a shipyard and naval dockyard. To the south of the port are the Karachi Naval Base and the Karachi Boat Club. Adjacent to the West Wharf is the Karachi Fishing Harbour, which is administered separately from the port and is the base for a fleet of several thousand fishing vessels.

2.2 Port Qasim

The Port Muhammad Bin Qasim, also known as Port Qasim, is a deep-water seaport in Karachi, Sindh, Pakistan, on the coastline of the Arabian Sea. This port has been named after the Muslim general Muhammad bin Qasim who conquered Daybul Bundar along the coastal areas of Sindh around 712 AD. It is located in an old channel of the Indus River at a distance of 35 kilometers east of Karachi city center. It is Pakistan's second busiest port, handling about 35% of the nation's cargo (17 million tons per annum). Port Qasim and Karachi Port handle more than 90% of all external trade of Pakistan.

The Port Qasim covers a total area of 12,000 acres (49 km²) wherein many industrial zones operate. In addition to the Pakistan Steel Mills (PSM) and K-Electric (formerly

KESC) Bin Qasim Power Plant, around 80% of the Pakistan's automotive industry is located at Port Qasim. The port also provides direct waterfront access to two major nearby industrial areas, Export Processing Zone (Landhi) and Korangi Industrial Area. Port Qasim is managed by Port Qasim Authority, a semi-autonomous government body.

The approach to the port is along a 45-kilometer long navigation channel which provides safe navigation for vessels up to 75,000 tones dead weight (DWT). Port Qasim is connected to the national highway through a 15 km long highway and through a 14 kilometer railway track to the national railway network.

2.3 Gwadar Port

Gwadar Deep Water Port has been constructed as the third port of Pakistan. Situated on the Balochistan coast, it is about 460 km away from Karachi and 120 km from the Iranian border. Because of its ideal location at the mouth of the gulf and opposite strategic choke points of the Strait of Hormuz and Gulf of Oman, the port is visualized to become a regional hub serving incoming and outgoing commercial traffic of the Middle East and Gulf countries. Keeping in view the significance of Gwadar Port, the government has declared Gwadar as a Duty Free Port and Free Economic Zone.



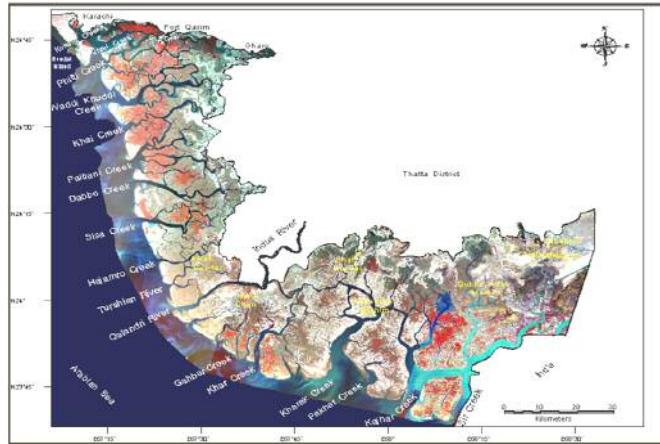


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3. IMPORTANT FEATURES OF PAKISTAN'S COAST

3.1 Indus Delta

The Indus Delta is an important landmark of Pakistan’s coastline extending up to 150 km along the Arabian Sea. The delta consists of several major and minor creeks formed by the River Indus before discharging into the Arabian Sea. The delta is a fan-shaped delta consisting of creeks, estuaries, mud flats, sand dunes, mangrove habitat, marshes and sea bays. The Indus Delta is the sixth largest delta in the world. It is spread over about 600,000 hectares from Korangi Creek bordering the city of Karachi to Sir Creek along the Indian border in the east. The Indus Delta comprises of 17 major creeks and numerous minor creeks and an extensive area of mud flats occupied by mangrove forests. The delta receives freshwater from the Indus River that flows through the delta before reaching the Arabian Sea.



In the recent past, a Left Bank Outfall Drain (LBOD) has been constructed on the area located on the left bank of the Indus with the primary aim of reclaiming the agricultural lands by lowering the water table thereby reducing the salinity from the arable lands. The drain was designed to address the problem of waterlogging and salinity by providing a comprehensive system of surface and sub-surface drainage through a network of lateral and spinal drains to transport excess salts and drainage effluents to the coastal zone near the Indian border. This saline effluent, having salinity as high as 30 millisiemens per centimeter, was continuously discharged into the Indus Delta.

3.2 Rann of Kutch

The Rann of Kutch and its adjoining tidal mudflats area is part of the great Thar Desert. The Thar region forms a bigger desert, representing the eastern most link of the great Afro-Asian desert chain stretching eastward from the Sahara. The Rann of Kutch is spread



over an area of 566,375 ha and is an ideal habitat for a number of wild animals and birds of global significance. The Rann of Kutch was declared a wildlife sanctuary in 1980, and is located in the central south-east of the Sindh province. This area consists of old stabilized sand dunes that run parallel in south-west to north-east direction with broad inter-dunal valleys between the dune tops. The marshy stretch or tidal mudflat area in its southern end is the most attractive feature of the project area. The Rann was created as a delta of the Hakra River that flows along the eastern boundary of Sindh.

The Rann of Kutch comprises fixed sand dunes of which some are more than 170 meters in height with extensive inter dune valleys with alluvial soils. The Pakistan side portion of Rann of Kutch is a desert area with barren land covered with scattered grasses. The area has three distinct habitats, a sand-dune strip, the Karoonjhar hill range and the coastal saline marshy zone.

A large portion of the Rann of Kutch lies in India, which includes permanent saline marshes, coastal brackish lagoons, tidal mudflats and estuarine habitats. It is supplied water from the rain-fed rivulets and streams flowing in from both Pakistan and India. The climatic conditions over the year are semi-arid tropical with very little precipitation measuring less than 300 mm. The summers are usually very warm with temperatures rising to 45° C whereas winters are mild with temperatures dropping to about 5° C. Humidity ranges between 50% and 80% during summers and monsoons, respectively. People are engaged in rain-fed agriculture and livestock rearing, and earn livelihoods from handicrafts, sale of fuel wood and working as skilled and unskilled laborers in coal mining.

The common plant species famous in the Rann of Kutch are *Salvadora persica* (Khabbar), *Acacia nilotica* (Babul), *Acacia senegal* (Kumbat), *Ziziphus numularia* (Ber), *Prosopis cineraria* (Kandi), *Tamarix dioica* (Lai), *Capparis aphylla* (Karir), *Azadirachta indica* (Neem), *Tecommella undulata* (Lohiro) and other species.

The Rann of Kutch area supports many locally and globally threatened species, including the Great Indian Bustard (*Ardeotis nigriceps*), Houbara Bustard (*Chlamydotis undulata*), Sarus Crane (*Grus antigone*), and more than 1% of the biogeographical population of flamingos. The Rann of Kutch is also home to many large mammals. These include the endangered Asiatic wild ass (*Equus hemionus khur*), Striped hyena (*Hyaena hyaena*), Desert cat (*Felis lybica*), Caracal, a medium-sized wild cat (*Felis caracal*), Honey badger (*Mellivora capensis*), Chinkara (*Gazella bennettii*), Nilgai or Blue bull (*Boselaphus tragocamelus*), and Gray wolf (*Canis lupus*) and a variety of reptiles, including the endangered Indian monitor lizard (*Varanus bengalensis*), Indian sand boa (*Eryx johnii*) and Saw-scaled viper (*Echis carinatus*).

3.3 Sea Turtle Nesting Beaches

The important sea turtle nesting beaches along the Pakistan coast include Sandspit and Hawksbay beaches near Karachi, and Ormara-Taq Beach, Astola Island and

Daran beaches along the Makran coast. These beaches are nesting sites of sea turtles which lay their eggs on these beaches during July to December. Sandspit and Hawksbay beaches are two of the eleven globally most important nesting beaches. Thousands of Green Sea Turtles (*Chelonia mydas*) nest on Sandspit and Hawksbay beaches every year.



3.4 Gwatar Bay

Gwatar Bay is the transboundary coastal/marine wetland area which is shared by both Pakistan and Iran. It is an important area for marine fisheries and other marine animals including whales, dolphins, sea turtles, migratory birds and mangroves.

3.5 Coastal and Marine Islands

3.5.1 Bundal and Buddo Islands

These islands are located in Korangi, Phitti and Jhari creeks. Bundal Island is one of the largest and highest of all the islands along the Sindh Coast, with a length of about 8 km. The width of the island varies - it is about 4 km wide in the north and 1 km in the south. There are shifting sand dunes on the island, some of which gain heights of up to 3 m. A portion of the northern area of the island is covered at high water and has a thick growth of mangroves at the extreme northern point. Bundal is also used by fishermen as a transit point when they venture out to the high seas for fishing, drying their catch of fish and mending their nets.

3.5.2 Churna and Kaio Island Complex

The Churna–Kaio Islands Complex is located west of Karachi. Churna consists of an island which is medium sized and faces the Hub River Delta, whereas a small islet, Kaio Island, is located near the town of Gaddani. The area is known for high biodiversity because of a variety of habitats, such



as, its diversified coral assemblage around Churna and Kaio Islands and the rich mudflats and oyster reefs. Churna–Kaio Islands Complex is known to be an important basking and feeding area for marine mega fauna including baleen whales, whale shark, mobulids and sunfishes.

Churna Island is located offshore near Mubarak Village, Keamari Town of Karachi. Churna Island is a small uninhabited island located in the Arabian Sea, about 9 km (5.6 mi) west of the mouth of the Hub River, at the boundary between the provinces of Balochistan and Sindh. Churna is approximately 1.2 km (0.75 mi) long and 0.5 km (0.31 mi) wide. Amateur diving, snorkeling and jet skiing are getting popular in the area. Some of the beaches, including Gaddani and Sonara (at the mouth of the Hub River) are thronged by picnickers, especially on weekends.

Due to power plants and a substantially large ship breaking industry present in the area, the ecology is seriously being affected. Considering high biodiversity and the threats it is facing, the area requires immediate steps for its protection to continue to provide livelihood opportunities and tourism facilities for the country. A management option could be to control commercial and recreational activities in the Churna-Kaio Island Complex and designate it as a ‘no-take zone or marine protected area’.

3.5.3 Astola Island

This is a small, uninhabited island in the Arabian Sea in Pakistan’s territorial waters along the Balochistan Coast. Astola Island is locally known as ‘Haft Talar’, or the island of seven hills. The island is a part of Pasni sub-district of Gwadar District.¹ Astola Island is 39 km away from Pasni. The island is about 4 km in length, and 1.5 km wide at its maximum width point. The island is located at the latitude and longitude coordinates of 25° 7'20.19"N and 63°50'57.91"E.

The Island is an ecologically important site, as it inhabits colonies of corals and its sandy beach provides nesting ground for the endangered green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbracata*). The Astola saw-scaled viper (*Echis carinatus astolae*) is endemic to the island.

There is sparse scrub vegetation on the island comprising of halophytic plants indicating the saline nature of the soil. Lithophytes (Lichens), aquatic weeds, sea urchins, sea anemones and corals have also been seen on the coast. Large mammals are not known to have existed on the island, however small



Astola Island. © Moazam Khan

¹ Astola Island <http://www.pakistantoursguide.com/astola-island.html>

terrestrial mammals, like rodents, inhabit the island. Many types of migratory and resident birds can be seen on Astola Island. Waterfowls migrate through the area twice a year and use the island as a staging and wintering ground. The sea off the island's coast is pristine and comprises of pelagic and demersal species. Coral reefs are also found around the Island. The area is also rich in supporting life for cetaceans. 75 finfish species from 36 families have been reported in the waters of Astola Island.

Astola Island is an eye-catching site to invite eco-tourists for camping, fishing and scuba diving expeditions and for observing turtle breeding². The wetland is facing threats mainly from anthropogenic activities, pollution resulting from dumping of crude used oil, washing of tankers at sea collection of turtle eggs, use of illegal fishing nets, trawling, dumping of waste materials (ghost nets) and mining of corals.

3.6 Sites of Ecological Significance/ Protected Areas

3.6.1 Ramsar Sites

Ramsar sites are wetland areas of international ecological significance. Along the Pakistan coast, there are seven Ramsar sites including Rann of Kutch, Nariri-Jaboh Lagoon, Indus Delta, Miani Hor, Astola Island, Ormara Turtle Beach and Jiwani. They are important sites for roosting and feeding of migratory birds which migrate from Siberia for wintering at various wetlands in Pakistan. These birds migrate along the “Indus Flyway” which is one of the seven bird migration routes in the world. It is also called the “Green Route”.

3.6.2 National Parks

Hingol National Park along the Makran coast is the only national park bordering the coast in the Lasbela district of Balochistan. It is the largest national park in Pakistan declared for protection of several endangered species of wildlife.



3.6.3 Wildlife Sanctuaries

There are a few wildlife sanctuaries located along the coast of Pakistan which include the Rann of Kutch, Keti Bundar (North), Keti Bundar (South) and MarhoKotri Wildlife Sanctuaries in Sindh. The Kurkhera Wildlife Sanctuary has an area in Miani Hor and the Buzi Makola Wildlife Sanctuary comprises of the entire Kalimat Hor along the Balochistan coast.

² <http://pak-t-house.blogspot.com/2014/01/astola-island.html>

3.7 Sites of Archaeological Significance

3.7.1 Bhambore

Bhambore is an ancient town dating to the 1st century BC located along the Sindh coast. The city ruins lie on the N-5 National Highway, east of Karachi. It dates back to the Scytho-Parthian era and was later controlled by Muslims from the 8th to 13th century after which it was abandoned. Remains of one of the earliest known mosques in the region, dating back to 727 AD, are still preserved on the site. Bhambore was a medieval port city deriving its wealth from imported ceramic and metal goods, an industrial sector, and trade. The city was strategically located at the mouth of the Indus River, linking it with the rest of the Scytho-Parthian empire and international traders in the Indian Ocean.

3.7.2 Rato Kot and Juna Shah Forts

Rato Kot Fort was built as an anchorage and look out post for pirates during the Indo-Arabian sea trade era around 800 AD on the Karachi Coast.

Juna Shah Fort is also present, 18 km south of the Port Qasim Complex. These forts were built for defense purposes as well as for monitoring and securing trade routes.

3.7.3 Mud Volcanoes

Among several earth science wonders here, one massive attraction is the presence of eighteen mud volcanoes. The earliest account of the presence of mud volcanoes in Balochistan dates back to 1840. In fact, the largest and highest known mud volcano in the world is found along the



Balochistan coast. These are about a kilometer off the main Coastal Highway leading from Lasbela to Gwadar. One of these termed 'Chandargup' is a sacred Hindu worship place. The Hindus worship these mud volcanoes because they are believed to be the habitat of a god, Babhknath.

3.8 Urban and Industrial Developments

With the exception of Karachi metropolitan city along the Sindh coast, and Hub and Gwadar along the Balochistan coast, no other major urban settlements exist along Pakistan's coast.

Karachi is a major hub of being the main commercial and industrial center of Pakistan. About 70% of the total industry of Pakistan is located in Karachi city. The

major industry comprises of textiles, chemicals, pharmaceuticals, electronic goods, food, oil refineries, tanneries, iron and steel, thermal power generation, etc. The total number of industrial units in Karachi is estimated to be about 6,000. Most of the industry is located in the Sindh Industrial Trading Estate (S.I.T.E), Landhi Industrial Trading Estate (L.I.T.E), Korangi Industrial Area and West Wharf Industrial Area.

Outside Karachi, the main industrial areas include the Hub Industrial Trading Estate (H.I.T.E) including the marble city, and the Gadani shipbreaking yard along the Balochistan coast. A deep seaport has been constructed in Gwadar and is expected to be an important port for shipping in future.

3.9 Coastal Agriculture

Traditionally, agriculture, forestry and fishing played almost equal roles in the socio-economic patterns of the coastal communities. Agricultural activities are still widely practiced in the coastal areas of Thatta and Badin districts in Sindh province and in the Hub, Sonmiani and Phore areas with the major crops being cotton, banana, wheat, rice, pulses, vegetables, fodder and fruits. However, availability of water for agriculture in coastal areas is declining due to upstream diversions and climate induced scarcity.

3.10 Coastal Tourism and Recreation

Tourism and recreation in the coastal areas of Pakistan is largely limited to beaches along the Karachi coast and a few beaches along the Balochistan coast such as Gaddani and Kund Malir. However, tremendous potential for recreation and nature based tourism exists in the Indus Delta, and along the Balochistan coast at Churna Island and Astola Island, Jiwani and Hingol areas (e.g. Buzy pass, Hindu Temple at Hanglaj and Mud Volcano Chandar Gup).





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4. MANGROVES FORESTS

4.1 What are Mangroves?

Mangroves are salt tolerant plants (trees and shrubs) found in tropical area which have adapted to survive in saline and brackish water. They occur naturally in sheltered coastal areas, such as river mouths, creeks, backwaters, lagoons, bays and estuaries where freshwater meets the seawater. Their survival is dependent on tidal inundation. Mangroves make up one of the world's most unique ecosystems because they thrive where no other trees can survive – in the transition zone between the ocean and land. They are also among the world's most productive ecosystems.

A total number of 69 species in 27 genera, belonging to 20 families are considered as true mangrove species³.

Approximately 1/4th of the world's tropical coastline comprises mangrove ecosystems which are estimated to extend along an area of between 167,000 and 181,000km², in 112 countries (Spalding et al., 1997; Kathiresan & Bingham, 2001 in Ibid). Forty percent of mangroves occur in South and Southeast Asia (Spalding, 1997). The single largest area of mangroves in the world lies in Bangladesh, in the Sundarbans, extending over 600,000 ha (Bandaranayake, 1998 in Ibid). Sundarbans mangroves are shared by Bangladesh and India.

4.2 How Do Mangroves Survive?

Mangroves possess special characteristics that distinguish them from other plants and help them in adapting to saline and flooded conditions. They possess long “prop roots” or “stilt roots” that emerge from stems and branches and help them become stable by anchoring in the soil to withstand tidal forces and storms. They also help in trapping of sediments to create an environment that supports their living.



Importance of Mangroves

- Protect the land from erosion.
- Play an invaluable role as nature's shield against cyclones and disasters, protect shorelines.
- Breeding and nursery grounds for a variety of fish and shrimp.
- Harbour a variety of life forms like invertebrates, fish, amphibians, reptiles, birds and even mammals like tigers.
- Source of timber, fuel and fodder.
- Sequestration of CO₂
- Purify the water by absorbing impurities, harmful heavy metals and help us to breathe clean air by absorbing pollutants.
- Potential source for recreation and tourism.

³ Duke, 1992; Bringham and Kathiresan, 2001; Selvam et al., 2004 in Miththapla, 2008.

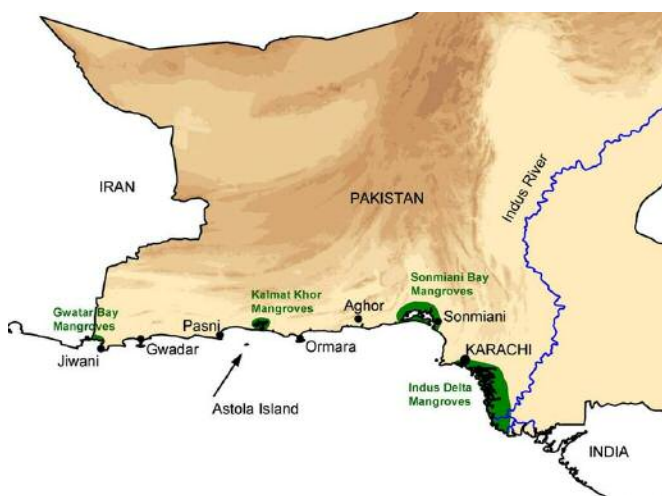
Mangrove roots also have pores on them called “lenticels”, which help the tree to breathe.

Another adaptation feature of mangroves is the growth of “pencil roots” or “pneumatophores”. These are specialized roots that grow upwards from the ground in the air like sticks, and help the trees to access oxygen. This is important because mangrove forests often grow in waterlogged and oxygen deficient soil conditions. Apart from this, mangrove leaves have special salt glands which help them secrete excess salt from inside the leaves, thus helping them survive in salty conditions. Also, mangroves contain filters on their roots to keep salt out; while in some trees the leaves store extra water to balance the salt content.

Mangroves are “viviparous” plants. The vivipary is a special adaptation feature that ensures favorable conditions for the growth of seeds i.e. the seeds germinate while they are attached to the mother plant. The seedling or “propagules” grow larger and stronger before they get detached from the mother plant. As the propagules fall down they become lodged in the soil or mud, or may be transported with the water somewhere else to anchor and grow. Because, the propagule is a half-grown seedling, it germinates immediately after being anchored in a suitable environment and starts putting out leaves.

4.3 Mangroves in Pakistan

Mangroves are an important feature of the coastal areas of Pakistan. They are most abundant in the Indus Delta which constitutes 97% of the total mangrove cover found in Pakistan; whereas the rest 3% mangroves are found at three locations along the Balochistan coast, at Miani Hor, Kalamat Hor and Jiwani.



Originally, eight species of mangroves were found in the Indus Delta; however, four of these have become extinct due to increasing levels of salinity (Box 1). Of these *Avicennia marina* is the dominant species which accounts for about 90% of all the mangrove species found in Pakistan. The other species include *Rhizophora mucronata*, *Ceriops tagal* and *Aegiceras corniculatum*.

Along the Makran Coast there are three mangrove species. Miani Hor is the only area where three mangrove species occur naturally including, *Avicennia marina*, *Rhizophora mucronata* and *Ceriops tagal*. In Kalamat Hor (Pasni) and Gawatar (Jiwani) Bay, only the *Avicennia marina* species is growing.

Historically, mangroves have occupied most parts of the Indus Delta. During 1958, an area of 344,846 ha comprising of varying densities of mangroves, mud flats and water channels was declared as protected forests and put under the management control of the Sindh Forest Department. However, the stocked area has reduced significantly. An assessment by the Sindh Forest Department in 1985 using Landsat Data and ecological surveys revealed an area of 280,470 ha under mangroves. Furthermore, SUPARCO in 2003 revealed the total mangrove cover to have reduced to 86,728 ha (IUCN Pakistan 2005)⁴. WWF Pakistan in 2008-09 estimated an area of approximately 98,128 ha, of which 92,412 ha (94%) existed in the Indus Delta; 1,056 ha in Sandspit area along the Karachi coast and the remaining 4,660 ha mangroves along the Makran coast. A recent assessment carried out by the Sindh Forest Department in 2009 has revealed an area of approximately 107,000 ha in the Indus Delta, showing a slight increase in the mangrove cover.

Box 1

Mangrove Species	Status
<i>Avicennia marina</i>	Present
<i>Rhizophora mucronata</i>	Present
<i>Ceriops tagal</i>	Present
<i>Aegiceras corniculatum</i>	Present
<i>Ceriops roxburgiana</i>	Extinct
<i>Bruguiera congugata</i>	Extinct
<i>Rhizophora apiculata</i>	Extinct
<i>Sonneratia caseolaris</i>	Extinct

4.4 Status and Management of Mangroves in Pakistan

There are several agencies managing mangrove forests along the coast of Pakistan. Approximately half of the 600,000 ha mangroves area found in the Indus Delta has been put under the administrative control of the Sindh Forest Department. Of this area, 64,400 ha was transferred



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to Port Qasim Authority for port operations in 1973. The remaining half area in the Indus Delta was classified as ‘wastelands’ and put under the administrative control of the Board of Revenue. A small area of mangroves, approximately 2,000 ha, is under the control of the Karachi Port Trust and Defence Housing Authority.

Legally, all the mangroves found along the coast of Sindh have been declared as protected forests from 2010. Mangroves along the Balochistan coast do not have any legal status except for 294 ha mangroves in Miani Hor which were declared as “Protected Forest” in 1958 and are under the administrative control of the

⁴ IUCN Pakistan

Balochistan Forest Department. The remaining areas under mangrove cover are either communal property or with the Balochistan Board of Revenue.

4.5 Factors Responsible for Degradation of Mangrove Ecosystem in Pakistan

The mangrove ecosystem has been under severe stress resulting from human induced and natural pressures such as, reduction in inflow of freshwater from Indus due to construction of barrages and reservoirs, pollution, cutting for fuel wood collection and livestock grazing, especially camels.



4.5.1 Browsing by Camels and Grazing by Buffaloes and Cows

Mangroves are a good source of fodder for animals, especially camels. Camel browsing in the mangrove forest is extremely harmful to the growth and natural regeneration of mangroves.

4.5.2 Harvesting of Mangroves

They are cut for fuel wood and timber and other uses by the coastal communities. Some people also cut mangroves wood and leaves for commercial purposes.

4.5.3 Geophysical Factors/Changes

Geophysical factors and changes affecting the mangrove ecosystems are mainly coastal erosion and deposition of sediments transported by the Indus. Due to reduced river flows and silt deposition in deltaic areas, the potential for new mudflat development is decreasing. The wave action is increasing which is resulting in coastal erosion and hence mudflat areas are shrinking for any possible future mangrove colonization. The erosion of creek banks is particularly evident, where tidal action is strong.

The meandering of small creeks and channels is the natural process causing changes in the mangrove habitat because some areas are cut off from the regular supply waters, while others receive additional silt deposits, resulting in high lying areas.

4.5.4 Freshwater Scarcity

Mangrove development is best in areas that receive significant freshwater runoff. IUCN Pakistan has estimated that an average flow of 1 cusec (28 liters/second) of freshwater for each 40 ha (100 acres) area is required for healthy growth of

mangroves. As per the Water Accord, 1990, 10 MAF is allocated at Kotri Barrage (Hyderabad) but the release of this quantity of water has been erratic. As a result, decrease in river flows over time has impacted badly on the mangrove ecosystem and the mangrove cover has been reduced both qualitatively and quantitatively.⁵

The problem of reduced flow of freshwater to coastal areas is most pertinent to the Indus Delta because of the large variations in the total water availability in the river system and increased upstream diversions for agricultural uses.

4.5.5 Sea Intrusion

“Sea water intrusion (or salt water intrusion) is the encroachment of saline water into fresh ground water regions in coastal aquifer settings” (Werner and Simmons, 2009 in Karen C., *et al* 2016, pg. 232).⁶ Seawater can also intrude into surface water bodies, such as the Indus River, lagoons and



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wetlands. This is because seawater is heavier and denser than freshwater. As a result, freshwater tends to float on top of seawater.

Werner and Simmons (2009) find that sea intrusion due to sea level rise is in the range of tens of meters to several kilometers, depending on recharge and groundwater tables persisting. Observations on the distance to which sea intrusion has progressed inland vary between 54 km inland on areas adjacent to the Indus River (IPCC, 2003), 80 km upstream in the link canals and 150 km from the river mouth up to Thatta-Sujawal Bridge affecting 567,000 hectares of previously arable land (SIDA 2013)⁷. This has forced nearly a million people to migrate out, inflicted huge financial losses and pushed the boundary of the sea further inland.

4.5.6 Coastal Pollution

Karachi is a coastal city and the industrial hub of the country where many medium and large sized industries are located. It is also the biggest urban center of the country.



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5 http://www.wwf.org.pk/pdf/forest_mangrove_rcpakistan.pdf

6 Karen C. Seto, William D. Solecki, and Corrie A Griffith (eds.), 2016. The Routledge Handbook of Urbanization and Global Environmental Change. Routledge New York.

7 SIDA 2013. Sindh Water Sector Improvement Phase-I Project: Preparation of Regional Plan for the Left Bank of Indus, Delta and Coastal Zone.

Due to inadequate arrangements for treatment of the industrial, domestic and municipal effluents, they are discharged into the coastal waters. Coastal pollution is an ultimate threat to the biodiversity of coastal ecosystems.

4.5.7 Population Pressure

The mangrove ecosystem is suffering from population pressure from three sources including, local population, migrants from within the country and migrants from outside the country. The in-country migration is primarily for fishing in the coastal belt.

4.6 Mangroves Conservation and Rehabilitation

Until the recent past, mangroves were considered as wastelands and their conservation and management was not a priority. However, realization about the fragile nature of the mangrove ecosystem and its economic, social and environmental significance has grown both locally and internationally. Efforts are underway at local and regional levels for protection and restoration of degraded mangroves. Mangroves for the Future (MFF) is one such regional effort to conserve mangroves and other coastal ecosystems. In Pakistan, several government and non-government agencies have stepped forward to protect and rehabilitate degraded mangrove ecosystems as discussed below.

4.6.1 Mangroves Rehabilitation by Government Agencies

Since 1985, about 80,000 ha of mangroves have been replanted or rehabilitated along the Sindh and Balochistan coasts by provincial forestry departments. The Indus Delta has been dominated by mangrove restoration activities. Two mega projects for mangroves rehabilitation, financed by the Government of Sindh, are under implementation by the Sindh Forest Department in the Indus Delta. These projects target mangrove rehabilitation over 100,000 ha in the Indus Delta. One of these projects is being implemented jointly by the Sindh Forest Department and IUCN Pakistan. The Sindh Forest Department achieved the Guinness World Record during 2013 for planting the highest number of mangroves by a team of 300 community planters in day light. The Balochistan Forest Department has also taken several steps for mangrove restoration along the Balochistan coast, including creation of a Coastal Forest Circle for effective management of mangroves along the Balochistan coast, besides restoration of mangroves. Some other government agencies such as Port Qasim Authority and Karachi Port Trust are also involved in mangroves plantation and rehabilitation in their respective areas.

4.6.2 International Organizations

IUCN and WWF have been actively engaged in mangrove restoration programs in Sindh and Balochistan. Since 1985 IUCN Pakistan, in collaboration with the Sindh Forest Department, has jointly implemented mangrove rehabilitation programmes along the Sindh coast. IUCN and WWF have been involved in mangrove rehabilitation along the coast through the involvement of local communities.

4.6.3 Local Non-Government Organizations and Coastal Communities

Recognizing the importance of mangroves, donor-funded projects have been implemented by the local NGOs and CBOs of the coastal area with the support of local communities. Some of their initiatives are supported by the private sector organisations working along the coast of Pakistan.

4.7 Techniques for Restoration of Mangroves

The following methods are commonly used for mangrove restoration in the coastal areas of Sindh and Balochistan:

4.7.1 Direct Sowing

This is the most common and most successful technique used in Pakistan. It uses mature propagules or seeds collected from the field and sown directly into the soil. This technique has been used for all the mangrove species in



Pakistan. In the case of *Rhizophora mucronata* and *Ceriops tagal*, the seed is embedded. In the case of *Avicennia marina*, a small pit is made for sowing the seeds. Two or more seeds are put in the same pit to ensure germination success. Seeds are sown directly into the soil using finger pressure.

4.7.2 Nursery Stock

Mangrove nurseries are established near the planting sites and nursery stock is made available to supplement the planting stock especially for restocking in failures. This technique is employed for all mangrove species.



Nursery beds are prepared as per standard layout on the nursery site, polythene bags are filled with soil and mangrove seeds are sown. The tidal water is used for irrigation either by direct flushing during high tide or artificially through hand watering.

4.7.3 Wildings

Wildings are naturally germinated 1-2 month old saplings with a ball of earth. They are taken out using an auger and transplanted to the planting site. This technique is used for *Avicennia marina*. This technique is mostly used to fill the gaps with a good success.



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5. MARINE LIFE OF PAKISTAN

The Arabian Sea, bordering the coast of Pakistan, is known to be rich in marine biodiversity, as a result of prevailing monsoon dynamics leading to strong seasonal upwelling of nutrient rich water from the depths along the narrow continental shelf resulting in high surface productivity and rich plant and animal life. This results in Pakistan's coastal waters having a rich diversity of vertebrates, including cetaceans (dolphins, whales and porpoises), turtles and fishes, as well as invertebrates.

5.1 Cetaceans (Whales, Dolphins, Porpoises)

5.1.1 Whales

Pakistan has a rich dolphin and whale population in coastal and offshore waters of Pakistan (Gore et al. 2012). Of these, there are 11 whale species found in Pakistan including four baleen whales and seven species of toothed whales (Box 2). Longman's Beaked Whale has also been reported in 2014. There is a general belief that Pakistani waters are important feeding grounds for these whales because of rich planktonic shrimp found in these coastal waters.

The whale population in Pakistani waters is limited and most reports are either based on direct sightings or beached carcasses. The Arabian Humpback Whale is considered to be one of the most endangered animals, having a total population of about 70 individuals distributed between India, Pakistan, Iran, Oman and Yemen. It is a non-migratory whale subspecies. It was recorded near Port Qasim in May, 1989. The population of other baleen whales, including Fin Whale, Blue Whale and Bryde's Whale, has also reduced along Pakistan's coast.

Toothed Whales are not very common in Pakistan and are rarely seen in coastal and offshore waters. Most of these species are known from the stranding on the beaches. In the recent past, a number of occurrences of Dwarf Sperm Whale, Pygmy Sperm Whale, and Longman's Beaked Whale have been reported from offshore waters.

Box 2

Baleen Whales

- i. Fin Whale or Rorqual, *Balaenoptera physalus*
- ii. Blue Whale, *Balaenoptera musculus*
- iii. Bryde's Whale, *Balaenoptera edeni*
- iv. Arabian Humpback Whale, *Megaptera novaeangliae indica*

Toothed Whales

- i. Sperm Whale, *Physeter macrocephalus*
- ii. Dwarf Sperm Whale, *Kogia sima*
- iii. Pygmy Sperm Whale, *Kogia breviceps*
- iv. Killer Whale, *Orcinus orca*
- v. False Killer Whale, *Pseudorca crassidens*
- vi. Cuvier's Beaked Whale, *Ziphius cavirostris*
- vii. Longman's Beaked Whale, *Indopacetus pacificus*

Dolphins

- i. Common Bottlenose Dolphin, *Tursiops truncatus*
- ii. Spinner Dolphin, *Stenella longirostris*
- iii. Long-beaked Common Dolphin, *Delphinus capensis*
- iv. Electra Dolphin, *Peponocephala electra*
- v. Risso's Dolphin, *Grampus griseus*
- vi. Indian humpback dolphin, *Sousa plumbea*
- vii. Finless porpoise, *Neophocaena phocaenoides*

5.1.2 Dolphins

Six species of dolphins are reported from coastal and offshore waters. Large pods of Bottlenose Dolphin and Spinner Dolphin are occasionally found along the coast of Pakistan.



One species of porpoise i.e. Finless Porpoise has been reported from the coastal waters of

Pakistan. This small species is found close to the coastline and in the mangrove creeks and lagoons along the Pakistan coast. A serious reduction in their population has occurred mainly because of frequent entanglement in fishing gear and increasing pollution. In the coastal areas, including in the creeks and lagoons of the Indus Delta, another species of dolphin i.e. Indian humpback dolphin is found in considerably large numbers. Recent studies have indicated that there are about 70 Indo-Pacific Humpback dolphins found in the Miani Hor lagoon.

All species of cetaceans, including whales, dolphins and porpoises, are endangered. The populations of these important marine animals are seriously threatened because of commercial exploitation (whaling), entanglement in fishing gear (by-catch), climate change, ship strikes, toxic contamination, oil and gas developments, and habitat degradation.

5.2 Sea Turtles

Of the seven species of Sea Turtles, five species are reported (Table below) from Pakistani waters.

All the Sea Turtle species are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Three of these species are classified as critically endangered by IUCN and another three species as endangered.

Table1. Species of Marine Turtles

S. No.	Scientific Name	Common Name
Family Cheloniidae		
1	<i>Caretta caretta</i>	Loggerhead sea turtle
2	<i>Chelonia mydas</i>	Green sea turtle
3	<i>Eretmochelys imbricate</i>	Hawksbill sea turtle
4	<i>Lepidochely solivacea</i>	Olive Ridley sea turtle
5	<i>Lepidochely skempi</i>	Kemp's Ridley sea turtle
6	<i>Natatorde pressus</i>	Flatback sea turtle
Family Dermochelyidae		
7	<i>Dermochely scoriacea</i>	Leatherback sea turtle

The Most common marine turtle found in Pakistan is the Green Turtle which grows up to 1.5 m long and can weigh 200 kg. Widely distributed in tropical and

subtropical waters, the number of nesting females is estimated to be 203,000. The species is classified as Endangered. Major nesting grounds of the Green Turtle are located at Hawksbay and Sandspit along the Sindh coast, and Ormara, Astola Island and Daran (Jiwani) beaches along the Balochistan coast. The



Green Turtle lays eggs mostly during July to December. The eggs are carefully laid in a closed chamber dug by the female in clutches of 75 to 120 eggs. Hatchlings emerge mostly at night from eggs after an incubation period of 55 to 105 days depending on the season.

The Olive Ridley Turtle used to be the second high-nesting species along Pakistan's coast. It has a deeper body and slightly up-turned shell edges. The maximum length is 80 cm. They are also slightly less heavy, reaching up to 45 kg in weight. The species is classified as Endangered. The Olive Ridley used to nest at Sandspit and Hawksbay beaches during March to October with peak nesting during July and September. However, its nesting has declined after the oil spill at the Karachi Coast in 2003. No nesting of Olive Ridelies has been reported since 2012 in Pakistan; however, recent studies have indicated a large population in the offshore waters.

The Leatherback Turtle had been reported on five occasions. One dead and two live turtles were reported from Gwader in recent years. This turtle is named after its shell, which is leathery rather than hard like other turtles. It is the largest marine turtle species in size, typically reaching up to 180 cm in length and weighing 500kg. This species is classified as Critically Endangered.

The Hawksbill Turtle is named after its narrow pointed beak. It is usually less than 1 m in length, and weighs 140 kg. The species is classified as Critically Endangered. It was reported from offshore waters of Pakistan in 2013 on three occasions.

The Loggerhead Turtle has a characteristically large head which supports powerful jaw muscles, necessary for feeding on hard shelled prey like mollusks and crustaceans. Its average size is 92 cm in length and 115 kg in weight. The species is classified as Endangered. It was reported from Balochistan on one occasion in 2009.

The other two sea turtle species i.e. the Kemp's Ridley Turtle and Flatback Turtle have not been reported from Pakistan.

Turtles are facing a number of threats, the most serious being mortalities as fisheries by- catch and habitat degradation. It is estimated that annually about 30,000 turtles

get entangled in fishing nets. Previously, the local fishing communities used to kill the marine turtles entangled in their fishing nets; however, because of increasing awareness, fishermen now tend to release the entangled sea turtles back into the sea.

Loss and degradation of habitats due to encroachment of nesting sites for construction of huts has seriously affected the breeding population of marine turtles. Debris from construction and solid waste on the sandy beaches also affects the nesting of marine turtles in Pakistan. Although poaching of turtle eggs in Pakistan has been stopped, predation of turtle eggs still takes place and a large number of eggs are dug out and eaten by feral dogs. Emerging turtle babies are heavily predated upon by crabs, crows, kites, dogs, mongooses and sea gulls.

5.3 Corals

Corals are marine organisms that are part of a group of species known as “Cnidaria”. The most unique feature of corals is the highly evolved form of “symbiosis” or mutual, positive relationship between the coral polyp and zooxanthellae – single-celled algae – that live inside the coral tissue. The algal cells utilize energy from the sun through photosynthesis. This provides oxygen and food for the coral organisms to

feed on. In return, the corals provide the micro-algae with shelter. This kind of association is called a mutualistic association since both organisms benefit from each other. This symbiosis between algae and animals also contributes to the brilliant colors of the coral. While much of a



coral’s diet is obtained from zooxanthellae, they can also “fish” for food. During feeding – usually at night when the algae inside the coral tissue cannot photosynthesize – a coral polyp will extend its stinging tentacles out of its body and wave them in the water. When the tentacles come in contact with small organisms, plankton or other food particles, the stinging cells on their surface (called cnidoblasts or cnidocytes) stun or kill the prey, which is then passed to the mouth of the coral.

In Asia, extensive reefs are found in India (e.g. the Union Territory of Lakshadweep, Andaman and Nicobar Islands, Gulf of Mannar and Gulf of Kutchh), Indonesia, Maldives, Sri Lanka and Thailand. Smaller coral communities are also found in Bangladesh (e.g. St Martin’s Island), Pakistan, and many other countries.

5.3.1 Coral Reefs

Most corals are attached to the seabed and many people think they are plants or rocks. But corals are actually the animals that are responsible for building the reef. Though they can exist as individual polyps, they generally occur in communities or

reefs that consist of many polyps. These polyps produce calcium carbonate; a hard substance that the organism uses as a protective outer layer. The basic structure of a coral reef consists of this “exoskeleton”, which remains after they die. New polyps grow over the skeletons, and over many decades the reefs grow in size, with the thin layer on the top of the reef remaining alive with corals and other species. Most of the coral reefs we see today are less than 10,000 years old and formed after the last ice age ended and the melting glaciers caused the continental shelves to flood due to rising sea levels. Coral reefs are usually found in the deeper seas, away from the continental shelves. 92% of the coral reefs on earth are found in the Indo-Pacific region, whereas the Atlantic and Caribbean regions contain the remaining 8%.

Types of Coral Reefs

There are three main types of reefs – fringing reefs, barrier reefs and atolls as well as patch reefs that are common along many Indian Ocean coastlines.

- i. Fringing and patch reefs usually lie near emergent land. They border the coastline closely or are separated from it by a narrow and relatively shallow stretch of water. The reefs around Sri Lanka, continental India and the Andaman coast of Thailand are fringing and patch reefs.
- ii. Barrier reefs grow parallel to the coast, but are separated from land by deep lagoons that are tens of, or even 100, kilometers wide. The largest and most famous barrier reef in the world, the “Great Barrier Reef” consists of 2,900 individual reefs and 900 islands stretching over 2,600 km of the Australian coast. Other notable large barrier reefs include those found in New Caledonia and Belize Barrier reefs.
- iii. Atolls are large, ring-shaped reefs found far off the coast. They are formed when islands slowly sink under the sea (this may happen over many thousands of years because, for example, the volcanic activity that formed the island stops) while the coral reefs around the islands keep growing in order to stay close to the sea surface. This creates a ring of coral reef that surrounds a lagoon. The emergent part of an atoll reef is often covered with accumulated sediments, which creates islands. The most characteristic vegetation growing on these reefs tends to be coconut trees. Maldives and the Union Territory of Lakshadweep, India are built up of coral atolls.

Importance of Coral Reefs

A tremendous amount of biodiversity is found in coral reefs as they are home to 25% of all marine creatures. This number is staggering, considering that coral reefs cover only about 0.2% of the ocean floor, and hence shows their immense ecological importance. Coral reefs hold tremendous value for ecosystem services, tourism, fisheries and coastline protection. It has been estimated that the global economic value of coral reefs is about 30 to 375 billion USD per year.

Threats to Coral Ecosystem

Coral reefs are declining due to several natural and anthropogenic reasons. Climate change is perhaps the most daunting threat to coral reefs all over the world. For example, rising seawater temperatures and climate change can lead to breakup of

symbiosis relationship between corals and microalgae, since corals live very close to their thermal maximum. As corals heat up, the zooxanthellae start working in overdrive and producing compounds that are toxic to the coral. The coral is forced to expel the zooxanthellae as a survival strategy in a phenomenon known as “coral bleaching”. In the process of bleaching, the corals’ calcium carbonate skeletons become visible through their translucent tissues. A bleached coral is not quite dead, as it can survive for days by using its tentacles to trap plankton floating by for food, but it is severely weakened and is easily killed by any disease or competing seaweed in the area. Bleaching can also be caused by large-scale changes in temperature due to climatic phenomena such as El Niño, coupled with the gradual warming induced by global climate change.

Box 3: El Niño and La Niña Phenomenon

El Niño and La Niña are opposite phases of the so called El Niño-Southern Oscillation (ENSO) cycle which occurs due to variations in temperature between the ocean and atmosphere in the east-central Equatorial Pacific. La Niña is sometimes referred to as the cold phase of ENSO and El Niño as the warm phase of ENSO. El Niño occurrence can have significant impact on weather patterns, ocean conditions, and marine fisheries across large portions of the globe for an extended period of time.

El Niño called The Little Boy, or Christ Child in Spanish was originally identified by fishermen off the coast of South America in the 1600s, with the appearance of unusually warm water in the Pacific Ocean. El Niño refers to a cyclic warming in sea surface temperatures across the central and east-central Equatorial Pacific.

La Niña means The Little Girl in Spanish. La Niña is also sometimes called "a cold event." It is a reverse of El Niño conditions. La Niña conditions represent periods of below-average sea surface temperatures across the east-central Equatorial Pacific (NOAA)¹.

El Niño

In normal, non-El Niño conditions, trade winds blow toward the west across the tropical Pacific, away from South America. These winds pile up warm surface water in the west Pacific raising sea-surface temperature by approximately 14 degrees Fahrenheit (8 degrees Celsius). Cooler ocean temperatures dominate offshore the northwest South America, due to an upwelling of cold water from deeper levels. This nutrient-rich cold water supports diverse marine ecosystems and major fisheries.

The cycle starts when warm water in the western tropical Pacific Ocean shifts eastward along the equator toward the coast of South America. Normally, this warm water pools near Indonesia and the Philippines. During an El Niño, the Pacific's warmest surface waters sit offshore of northwestern South America. This phenomenon occurs every three to five years but may come as frequently as every two years or as rarely as every seven years. Each event usually lasts nine to 12 months. Typically, El Niños occur more frequently than La Niñas.

El Niño creates stronger wind-shear and more-stable air over the Atlantic, which makes it harder for hurricanes to form. However, the warmer-than-average ocean temperatures boost eastern Pacific hurricanes, contributing to more-active tropical storm seasons.

Strong El Niños bring above-average precipitation and below-average winter temperatures in the southern United States from California to the Atlantic coast. It results in below average rainfall and warmer-than-average temperatures in the northern United States.

El Niño also affects precipitation in other areas, including Indonesia, which tend to be drier-than-normal conditions. The drought like conditions can be widespread, affecting southern Africa, India, Southeast Asia, Australia, the Pacific Islands and the Canadian prairies. Temperatures in Australia and Southeast Asia run hotter than average².

8 <http://oceanservice.noaa.gov/facts/ninonina.html>

9 <http://www.livescience.com/3650-el-nino.html>

Besides coral bleaching, the other stresses to corals include coral mining, trampling of corals, anchoring on the reef and fishing of herbivorous fish, poor water quality, and sand pumping or dredging activities.

5.4 Corals in Pakistan

Pakistan does not have a true coral reef ecosystem, however, coral patches are found in some restricted locations mainly along the Balochistan coast. In Pakistan, 29 different species of coral have been found at 9 locations along the coast, the most prominent ones being the Churna and Astola Islands (Box 4). At Astola Island, the hard corals are common. Though no true coral reefs have been found in Pakistan, there is evidence of a “proto-reef” (a reef in its early stages of formation) at Astola Island.

Threats to Corals in Pakistan

Corals in Pakistan are threatened by extensive gillnetting and small scale coral mining to sell them for aquarium trade in Karachi. Coral areas are known to be rich in fish, therefore, fishermen lay their nets in the coral areas for catching these fish. Because of the entanglement in the coral area, the nets get damaged and, at the same time, the corals are dislodged, and as loose corals cannot survive, therefore, they die. Similarly, abandoned fishing nets cover up corals resulting in their death. Anchors of fishing boats also damage corals severely. Furthermore, pollutants such as urban and industrial waste, agrochemicals and oil can poison coral and thus prevent their formation.

Coral aquaculture or coral farming is a practice that serves to counter the decline in coral reefs. A great tool for restoring coral reefs, the process of coral aquaculture bypasses the early growth stages of corals, when they are at the greatest risk of dying. Coral seeds are usually obtained from nurseries and then replanted on the actual reef. Coral farmers naturally live near the reefs and farm either for the purposes of conservation or merely for income.

Box 4

Coral Species of Churna Island

- i. *Goniopora albiconus*
- ii. *Alveopora sp.*
- iii. *Favites pentagona*
- iv. *Leptastrea cf. bottae*
- v. *Coscinaraea monile*
- vi. *Psammocora superficialis*
- vii. *Psammocora sp.*
- viii. *Dendrophyllia robusta*
- ix. *Goniopora columna*
- x. *Alveopora sp.*

Coral Species found at Kaio Island

- i. *Porites harrisoni*
- ii. *Goniopora albiconus*

Hard Coral Species at Astola Island

- i. *Goniopora djiboutiensis*
- ii. *Goniopora cf. savignyi*
- iii. *Goniopora somaliensis*
- iv. *Porites harrisoni*
- v. *Porites lutea/lobta*
- vi. *Porites monticulosa.*
- vii. *Porites nodifera*
- viii. *Porites solida*
- ix. *Alveopora sp.*
- x. *Favites complanata*
- xi. *Favites pentagona*
- xii. *Favites spinosa*
- xiii. *Leptastrea pruinosa*
- xiv. *Plesiastrea versipora*
- xv. *Coscinaraea monile*
- xvi. *Coscinaraea sp.*
- xvii. *Psammocora obtusangulata*
- xviii. *Turbinaria sp.*
- xix. *Acanthastrea hillae*
- xx. *Acanthastrea maxima*
- xxi. *Pocillopora damicornis*
- xxii. *Montipora molli*

Soft Coral Species at Astola Island

- i. *Echinogorgia sp.*
- ii. *Bebryce sp.*
- iii. *Paraplexaura sp.*
- iv. *Clathraria sp.*

5.5 Seaweeds

Seaweed is the common name for countless species of marine plants and algae that grow in the ocean as well as in rivers, lakes, and other water bodies. They are generally attached to a hard or rocky substrate in coastal areas. Seaweeds can be classified into three broad groups based on pigmentation: brown, red and green. Brown seaweeds are usually large compared to red and green seaweeds which are of a similar size. Naturally growing seaweeds are often referred to as wild seaweeds, in contrast to seaweeds that are cultivated or farmed.

Seaweeds are well known for their economic, medicinal, biological and environmental importance. They are mainly used in cosmetics, animal fodder, human food, seaweed extracts, alginates, medicines, fertilizers, agar and carrageenan. They are used as food in many countries such as China, France and Mexico. The market value of a variety of seaweed products directly or indirectly consumed by humans has been estimated to be approximately US\$ 5.5 to 6 billion per year. Food products for human consumption contribute about US\$ 5 billion of this (FAO 2016)¹⁰. Thus, they are an important source of livelihood for the coastal communities. Seaweed beds are considered as an important nursery and feeding grounds for invertebrate and vertebrate fauna.

A total of 234 species and 110 genera of seaweeds are reported from the coast of Balochistan, exhibiting a great biological diversity, distributed among 57 families, 33 orders, 12 classes and 6 divisions (Shameel 2001)¹¹. Many types of seaweeds have been reported in the rocky shores of the Karachi coast.



10 FAO 2013. Fisheries and Aquaculture Information and Statistics Service – 17/01/2016.

11 Shameel, M. 2001. An approach to the classification of algae in the new millennium. Pak. J. Mar. Biol. 7: 233-250.

5.6 Conservation Actions to Protect Marine Life in Pakistan

For the conservation of marine animals, a number of steps have been taken. Wildlife sanctuaries and Ramsar sites have been established along the coast of Pakistan for ensuring the conservation and protection of threatened wildlife, including marine life. There are a few wildlife sanctuaries located along the coast of Pakistan which include Rann of Kutch, Keti Bundar (North), Keti Bundar (South) and Marho Kotri Wildlife Sanctuaries in Sindh. There are a number of wetlands along the coast of which eight have been declared as Ramsar sites. Of these, Indus Delta, Jubho Lagoon, Nurreri Lagoon and Rann of Kutch are located in Sindh, whereas Astola Island, Jiwani Coastal Wetland, Miani Hor and Ormara Turtle Beach are located in Balochistan.

A major step for the conservation of marine cetaceans has been taken by the Government of Balochistan by declaring all species of marine mammals as protected under the Balochistan Wildlife (Protection, Preservation, Conservation and Management) Act, 2014.

There are no dedicated Marine Protected Areas (MPAs) in Pakistan; however, Hingol National Park located in Balochistan contains a marine ecological zone having cetaceans, sea turtles and a patch of planted mangroves. IUCN Pakistan, under its Mangroves for the Future Programme, has taken steps to establish Marine Protected Areas in Pakistan in collaboration with the Ministry of Climate Change and other relevant stakeholders. The aim of MPAs is to promote responsible fishery



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management and habitat protection. In essence, MPAs serve to limit potentially destructive and damaging activities. MPAs serve both social and biological concerns, including reef restoration, aesthetics, biodiversity, and economic benefits.

As regards the conservation of sea turtles in Pakistan, the Wildlife Departments of Sindh and Balochistan provinces, Marine Fisheries Department, IUCN Pakistan and WWF Pakistan have taken various steps for conservation of sea turtles through awareness raising of local fisher folks, establishment of hatcheries, protection of turtle nesting beaches, and encouraging the use of Turtle Excluder Devices (TED) in trawl nets to reduce mortality of sea turtles. However, the following priority actions are required to strengthen the existing conservation measures.

- i. Preparation and implementation of a sea turtle conservation strategy for Pakistan.
- ii. Declaring the important turtle nesting beaches as protected by the relevant provincial government.
- iii. Addressing the by-catch issue with the fisheries sector for reducing incidental mortality of sea turtles and other marine species in fishing operations.
- iv. Strengthening capacities of relevant institutions in marine species conservation.
- v. Encouraging community based management of sea turtle nesting sites and linking them with sustainable livelihood incentive options for the local communities, such as ecotourism.
- vi. Exploring possibilities of regional collaboration in conservation and management of marine species and landscapes.
- vii. Preparation and implementation of Cetacean conservation and management plan.





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6. MARINE FISHERIES

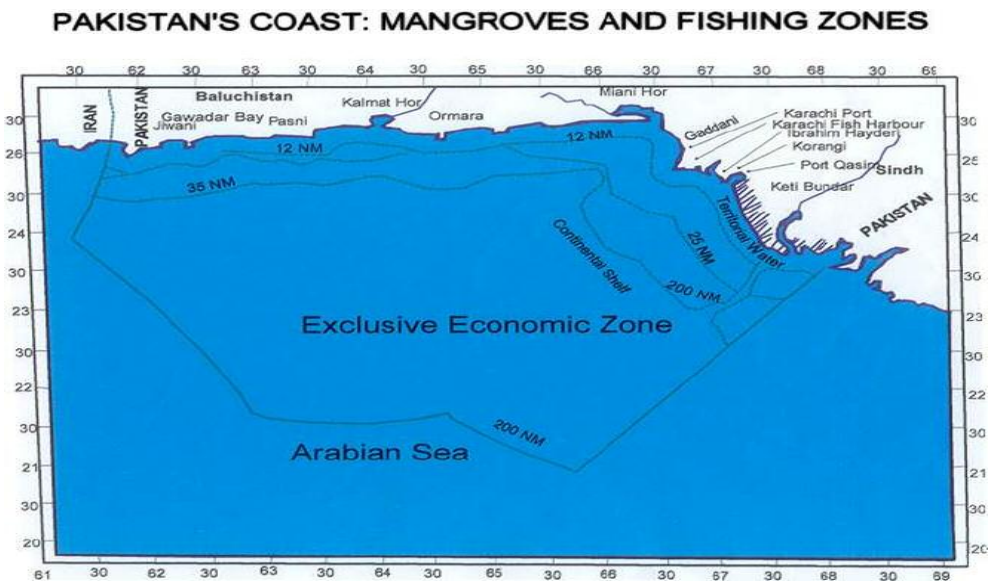
6.1 Introduction

Pakistan's coastline is 990 km long and very rich in marine resources as its vast creek system of the River Indus and shallow sub-tidal areas provide ideal conditions for growth of fisheries resources.

Fishing is an important economic activity along the coast of Pakistan as about 80 % of the coastal population (excluding Karachi) is engaged in fisheries related activities. The Fisheries sector has shown a steady increase since the creation of Pakistan. In the beginning, all the fleet consisted of sail-driven boats that used to operate in shallow waters along the coast. Motorization of fleets began in the 1960s and now large fishing vessels, fitted with onboard freezing facilities, are being constructed locally and operated in coastal and offshore waters. The present production of fish and shellfish is estimated to be about 355,000 m. tons.

6.2 Exclusive Economic Zone of Pakistan (EEZ)

This is a sea zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. The existing EEZ of Pakistan comprises a 240,000 sq. km offshore area. An additional area of 50,000 sq. kms has been added to Pakistan's EEZ by the UN very recently and consequently, it has increased to 290,000 sq. kms.



6.3 Fishing Areas

Pakistan has rich fishing grounds all along the coastline. Major fishing grounds along the coastline are located at Khori Great Bank and the mouth of Indus creeks in Sindh, and Sonmiani, Ormara, Pasni, Gwader and Jiwani along the Balochistan coast. There are three categories of fishing being done in Pakistan including small

pelagic fish (these include fishes that are found in water column in the coastal waters, including sardines), large pelagic (large fishes found in the offshore waters, including tuna and marlins) and demersal fish (bottom dwelling fishes such as shrimp, snappers and pomfrets). Fishing grounds for small pelagic species, especially sardines, are located in the shallow coastal waters and creek areas of the River Indus. Tuna, marlins and other large pelagic species are caught in the offshore waters, at times about 300 to 500 nautical miles from the coastline. Demersal fish, such as shrimp, snapper, crabs, lobster, croakers and catfish, are caught all along the coastline up to a depth of about 50 m.

6.4 Fishing Seasons

Fishing is continued all along the coastline throughout the year; however, the main fishing season is between August and November. During southwest monsoon (May to September) fishing activities are reduced because of high wind and rough seas. Catches are also high during March and April. During June and July, the Government has imposed a ban on catching shrimp along the coast of Pakistan.

6.5 Fishing Techniques

In Pakistan, gillnetting is the most common technique being used by the fishermen for catching fish in coastal waters as well as offshore waters. Gillnets are like a wall of netting that hangs in the water column. They are used for catching sardines and small fishes along the coastline. Large meshed gillnets are used in offshore waters for catching tuna and marlins.

Shrimp and bottom dwelling fish are caught through trawling which involves pulling a bag like net behind a fishing boat. The trawl nets (locally known as gujja) are operated in shallow waters for catching shrimp whereas in the

Table 2. Commercially Important Fish and Shellfish of Pakistan (2014)

Fish and Shellfish Species (English Names)	Local Name	Annual Production (in m. tons)
River shad	<i>Palla</i>	513
Sardine	<i>Tarli</i>	47,000
Indian mackerel	<i>Bangra</i>	24,000
Sharks	<i>Mangra</i>	9,000
Rays	<i>Pittan</i>	8,000
Catfish	<i>Khagga</i>	19,000
Eels	<i>Baam</i>	4,200
Threadfin bream	<i>Chakori</i>	5,000
Mulletts	<i>Boi</i>	9,000
Groupers	<i>Gisser</i>	13,000
Croakers	<i>Sua</i>	16,000
Queenfish	<i>Aal</i>	10,000
Snappers	<i>Hira</i>	1,100
Grunts	<i>Dhotar</i>	4,000
Sea breams	<i>Dandia</i>	4,000
Ribbonfish	<i>Chind</i>	13,000
Pomfrets	<i>Poplet</i>	7,000
Spanish mackerels	<i>Gore</i>	12,400
Tuna	<i>Dawan</i>	39,000
Marlins	<i>Ghora</i>	7,000
Shrimp	<i>Jheenga</i>	19,000
Lobster	<i>Kika</i>	1,100
Crabs	<i>Kekra</i>	6,000
Squid	<i>Sissimayyah</i>	4,000
Cuttlefish	<i>Dimrimayyah</i>	5,000
Miscellaneous		68,500
Total		355,813

offshore waters fish, such as snapper, croakers and catfish, are caught using trawl nets. For catching sardine, a seine net (locally known as katra) is used. This net is hanged vertically around a fish school and its bottom line is towed to form a pouch to trap fish, which are heaved in to the boat. Fish are also caught by hook and lines in Pakistan.

6.6 Fish Species

Although more than 1,500 types of finfish and shellfish are found along the Pakistan coast, about 200 species are commercially harvested. Shrimp is the most important commodity which is mainly exported. Among other shellfish, crab, lobster, squid, cuttlefish and mollusk are important. Among finfish, a large number of species are caught which includes sardines, croakers, snappers, pomfrets, sharks, catfish, barracudas, river shad and eels. A list of important fish and shellfish and their annual production is given in Table 2.

6.7 Types of Fishing

6.7.1 Subsistence Fishing

In most of the villages along the coast of Pakistan, fishermen are engaged in small scale subsistence fishing. These fishermen operate in shallow coastal waters near their villages using artisanal fishing gear. Subsistence fishing is a type of fishing in which the fishermen and their families consume the fish they catch whereas small quantities of commercially important species, such as shrimp, are marketed through middlemen and fish processors.

6.7.2 Commercial Fishing

A large part of the fishing fleet based in Karachi and other coastal towns, including Gaddani, Ormara, Pasni, Gwader and Jiwani, is engaged in commercial fishing. These vessels operate in coastal and offshore waters and catch large quantities of fish, shrimp and other shellfish. The fish is marketed and processed in fish factories located mainly in Karachi and Gwadar Districts. A major portion of the fish caught by commercial fishing boats is exported to other countries.

6.8 Fish Marketing

Fish is marketed through traditional channels in coastal areas. It is auctioned at the landing centers through dedicated auctioneers or middlemen who charge a commission of 6.25. The auctioneers and middlemen provide loans to the fishermen for the fishing operations which are paid back by



fisherman in installments from the value of their catch. Fish from the landing centers is transported to mainly Karachi through a series of middlemen. A major portion of fish is procured by fish processing plants; whereas that for domestic consumption is routed through middlemen to fish mongers or fish shop owners. Although marketing channels are adequately organized, the fish quality is not properly maintained. Usually, fish is not transported in insulated containers and fish boxes and icing or chilling is not adequately done, therefore, fish gets rotten during transportation.

6.9 Fish Processing

Fish processing is one of the oldest industries in the country, however, organized processing of seafood started in the country in the late 1960s when a number of seafood freezing and canning plants were established. Many types of processing is being practiced in Pakistan which includes curing/salted drying, freezing, canning, value added production and fish meal production.

6.9.1 Curing/Salted-Drying

This is probably the oldest form of processing done in Pakistan. Presently curing yards are established along the coastline especially at Karachi, Sonmiani (Damb), Ormara, Pasni, Gwader and Jiwani where low quality salted dried fish is preserved for export mainly to Sri Lanka. In these processing facilities, low quality salt is being used and hygienic conditions are not adequately maintained. Till 1970, almost all export consisted of salted dried product but presently salted dried products contribute only about 5 % of the total export from Pakistan.

6.9.2 Freezing

Freezing of seafood is now the most important form of processing being done in Pakistan consuming about 80 % of raw material being used for export. It is estimated that about 120,000 m. tons of seafood is annually processed in Pakistan in frozen form. Most of the seafood freezing plants are located in Karachi; however, during the last three years a number of seafood freezing plants have been established along the Balochistan coast. Shrimp, crab, lobster, cuttlefish, squid, ribbonfish, croakers, threadfin breams and Indian mackerels are the main products which are exported to about 60 countries of the world.

6.9.3 Canning

There used to be a large shrimp canning industry in Pakistan in the late 1960s which thrived till early the 1980s when all canning plants were closed down due to increase in the price of raw material. Presently there are two canning plants operating in Pakistan. One of these canning plants is in operation since 1985 and is producing pasteurized crab meat for the USA market. Another seafood canning plant is engaged in canning of sardines and Indian mackerel mainly in tomato sauce/paste for export to the USA market.

6.9.4 Fish Meal Processing

Small pelagic fishes (such as sardinellas, anchovies, etc.), by-catch of shrimp trawling and fish offal are used for production of fish meal in Pakistan. Most of the

fish meal processing plants use sun-dried fish and other raw materials, which are steamed (cooked under pressure), again sub-dried and pulverized. Protein content of fish meal produced by using this method is usually very low (between 40 to 55 %). Only a few fish meal processing plants have wet processing facilities. Major part of the fish meal is produced and consumed locally in the poultry industry; only small quantities are exported.

6.10 Fishing Vessels

In Pakistan, major fishing activities are primarily confined to shallow coastal waters, however, large fishing vessels venture deeper in the sea. There are many types of fishing boats used in Pakistan.

6.10.1 Small Size Boats

These include small fishing boats of 4 to 6 m to large fishing boats having an overall length of about 25 to 30 m. Smaller boats are known as “Katti” in Balochistan and “Tony” in Sindh. These boats are operated by 1 to 5 persons and are mainly engaged in gillnetting with monofilament nets, cast netting and hand-lining, for catching crab or other mollusks. These boats are mainly operated with a long tail outboard engine. They do not carry ice and operation is restricted to shallow coastal waters, bays and creeks. These fishing boats are engaged only in one day fishing operations.



Katti boat © Moazam Khan

6.10.2 Medium Size Boats

Medium type of fishing boats, ranging from 6 m to 12 m, are the most popular category of boats. They are locally called *Hora*. *Hora* boats are operated with a long-tail outboard engine or small horse power inboard engine. These fishing boats are engaged mainly in gillnetting and long lining. They are usually engaged in 5 to 10 day



Hora © Moazam Khan

long fishing trips. These boats carry ice in wooden fish holds. However, those engaged in a day trip do not carry any ice. For catching small pelagics (sardinellas, anchovies and scad), *Hora* boats have been made beamier. Most of these vessels are based in Sindh and operate in shallow coastal waters.

6.10.3 Trawlers

Shrimp is mostly caught by trawlers which range in size from 12 m to 25 m. There are two types of gear used in these boats i.e. shrimp trawl net and fish trawl net. Shrimp trawl net is a small bag net fitted with otter board. It operates up to a depth of about 40 m. Whereas, in comparatively deeper waters (20 to 100 m), a fish trawl net, which has a wider opening is used.

6.10.4 Large Gillnetters

Large gillnetters range from 25 m to 30 m. Most of these boats are fitted with net retrieval devices. These boats operate primarily in offshore waters and catch a variety of large pelagic and demersal fishes. These boats have a capacity of 20 to 100 tons. A few boats have freezing systems installed on board where the catch is frozen in blast freezers before storing in the fish holds.



It is estimated that 13,000 fishing vessels are in operation in Pakistan. Large gillnetters and trawlers operate from Karachi and other major towns along the Balochistan coast.

6.11 Fish Harbours

There are more than 65 population centers and villages along the coast of Pakistan where fish is landed on beaches without any facilities for offloading. Floating landing facilities have been established in creek areas including Keti Bundar, Kharo Chan and



Darya Pir which are being used by the local fishing fleet. However, there are only 5 operational fish harbours in Pakistan.

6.11.1 Karachi Fish Harbour

This is the largest landing center catering to about 7,000 fishing boats. It was constructed in 1958 and renovated and expanded in 1990. There are five auction halls and 10 pontoons (for parking) and a long quay wall and all other ancillary facilities at the port. A major part of the shrimp fleet is based in this harbour. The harbour also has 25 seafood processing plants.

6.11.2 Korangi Fish Harbour

It was built in 1993 mainly to cater to deep sea fishing vessels. It was also envisaged to handle about 500 fishing boats. It has a large auction hall, and all other ancillary facilities and has a quay wall of about 2 km. Four processing plants have recently started operations at the harbour. The harbour is not yet fully operational to its full capacity.

6.11.3 Pasni Fish Harbour

It is located along the Balochistan coast. Because of excessive siltation and inadequate dredging, the entrance is now partially blocked. The harbour is being used by the small artisanal boats and large gillnetters. Adequate onshore facilities are not available in this harbour.

6.11.4 Gwadar Fish Harbour and Miniport

It is used by large fishing boats especially gillnetters. For small artisanal boats, a floating pontoon has been constructed along the harbour which is connected with the main platform through bridges.

6.12 Fish Landing Jetties

There are five major landing jetties along the Balochistan coast located at Gaddani, Damb, Jiwani, Sur and Pishukan respectively. However, the work on Gaddani, Damb and Jiwani has been stopped mainly because of objection by fishermen on their design.

Ibrahim Hayderi Landing Jetty is the second largest fish landing center in Pakistan. Though this jetty is not properly designed and lacks basic amenities, a large number of artisanal fishing boats still use this landing center. This landing center is the main base of fishing boats that are engaged in one day fishing trips for shrimp using bottom set gillnetting (locally known as “thukri”). There are about 15 private jetties in the area where fishing boats are berthed, after landing their catch at Ibrahim Hayderi.

6.13 Factors Responsible for Degradation of Fisheries and other Marine Resources in Pakistan

6.13.1 Increase in Fishing Fleet

At the time of creation of Pakistan, there were only 800 small wind-driven fishing boats. Presently about 13,000 fishing vessels are being operated in Pakistan, some of which are more than 30 m long and fitted with all the necessary fishing gadgets, including onboard freezing facilities. Additionally, fishing technologies have improved, providing greater access to harvest resources in the deep sea. This has resulted in depleting fish and shellfish populations along the coast of Pakistan. Shrimp trawling was introduced in Pakistan in the 1950s and now the shrimping fleet consists of about 2,500 efficient fishing trawlers which have the capacity to fish in deeper waters. The operation of such a large fleet has resulted in depletion of shrimp stocks.

6.13.2 Use of Harmful Fishing Gears

Introduction of some of the exotic and harmful fishing gears has further aggravated the situation. It is feared that continuing to fish at this rate and use of harmful gear may soon result in a collapse of the fisheries stocks. Introduction of another exotic fishing gear i.e. seine gear (Katra) has resulted in overfishing of small fishes such as sardinellas, anchovies and scads. Use of this encircling gear is devastating, as it not only catches juveniles of other commercially important fishes but also results in scouring of the soft sea bottom. Bangladeshi fishermen introduced estuarine set bag net (ESBN-locally known as Bhulla) in the creek area of Sindh in the late 1970s. This is devastating fishing gear because of its mode of operation and small mesh size which catches juveniles as well as larvae of commercially important species. It

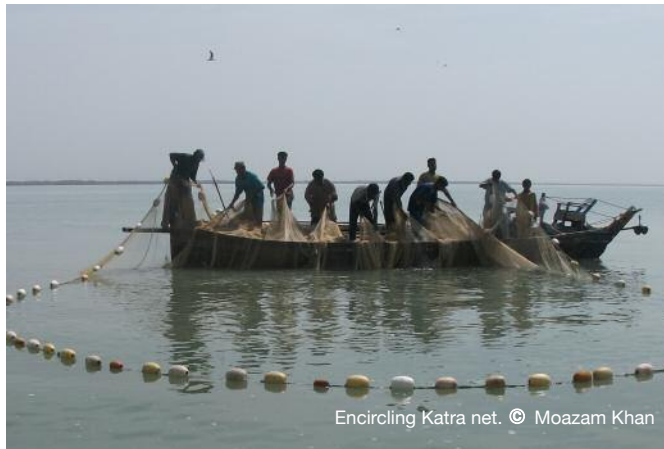


Bhulla net. © Moazam Khan

is estimated that about 8,000 ESNB are installed in almost all large and small creeks of the vast Indus estuarine system.

Use of gillnets of various types, small mesh and extended length is also considered to be a serious threat to fish and other marine biodiversity.

Gillnets are considered the “wall of death” because of high incidences of mortality of fish, as well as high by-catch of non-target species including whales, dolphins and sea turtles. In order to continue relying on the ocean as an important food source, there is a need to employ sustainable fishing practices.



6.13.3 Depletion of Mangroves

There is a very close link between the fisheries resources and the mangroves. Mangroves, and their associated tidal flats, provide a habitat for clams, crabs, oysters, and other species. Mangroves are known to be an important breeding, nursery and feeding ground for a large number of fish and shellfish species and other aquatic resources. The coastal mangrove creek systems are shallow and nutritionally rich, providing an ideal habitat for a variety of marine animals in addition to commercial fish and shrimp species. The shrimp industry largely depends upon the shrimp nurseries located in the mangroves of the Indus Delta. Although the shrimp are distributed along the entire coast, the main fishing grounds in the sea are usually located along the coastline adjacent to mangroves.

The reduction in freshwater flow into the Indus Delta has impacted mangrove growth and productivity of fish and shrimp and other marine resources. The Palla fish, which used to be caught in abundance, has reduced due to decline in freshwater flows in the Indus especially below the Kotri Barrage.

6.13.4 Coastal Pollution

Increasing levels of pollution also has serious bearing on the fish stocks in coastal as well as in the offshore waters. Disposal of untreated domestic and industrial sewage from coastal cities and towns has resulted in loss of fishing grounds in some highly polluted areas. It is



estimated that about 430 million gallons/day (MGD) of untreated sewage is dumped into the sea by the metropolis of Karachi alone through the Lyari and Malir Rivers as well as through a number of small drains. There is only about 15 % capacity of sewage treatment in Karachi. Because of the disposal of a huge quantity of sewage, the habitat in Manora Channel and Gizri Creek has been completely destroyed and most of the area in these two water bodies is devoid of any marine life. In addition, a major part of the creek system adjacent to Port Qasim is also heavily polluted because of thermal discharges from power plants, heavy metal discharge from the Steel Mill and tanneries, and organic discharge from cattle colony.

Solid waste discharged in the marine environment is also a serious threat to marine life. A substantially large quantity of solid waste from the coastal towns enters the sea on a regular basis which is accumulated on beaches as well as in the shallow coastal waters, making the coastal area polluted. Presence of solid waste in the marine environment is a major threat to some of the threatened species such as sea turtles, who try to engulf plastic bags considering them to be their favorite food, i.e. jellyfish.

Box 5: Key Issues in Fisheries Sector

- Over fishing / harvesting beyond sustainable limits.
- Use of destructive nets, including “Katra, Boolo and Gujjo”.
- Over population of the boats and trawlers.
- Degradation of mangroves.
- Pollution of the coastal fishing grounds.
- Decrease in the overall fish catch.
- Increased level of poverty among fishing communities.
- Lack of alternate livelihood options for fisher folk.
- Low priority to aquaculture development.

6.13.5 Fish By-catch

In Pakistan, most of the fishing is done through use of non-target fishing gears. As such, a number of other non-target animals including cetaceans (dolphin, porpoises and whales), sea turtles as well as fish and invertebrate species get entangled in these gears as by-catch. In most cases, these non-target by-catch species get seriously injured or killed, having a serious impact on their threatened population.

By-catch of trawl fisheries consists of juveniles and early stages of a large number of fish, sea turtles and invertebrates as well as benthic animals that inhabit soft substrates of the trawling grounds. It is estimated that for every one kg of shrimp caught through trawling, about 95 kg of by-catch is being caught by trawl fisheries in Pakistan. The ploughing action of trawl net and otter boards also causes severe damage to the fishing ground.

By-catch of gillnet fisheries consists of a large number of non-target species including endangered species like whale, dolphins and turtles. Studies have indicated that annually about 10,000 dolphins die in gillnet fisheries of Pakistan because of entanglement and drowning and a large number of sea turtles (annually about 30,000) get entangled in gillnets.

6.14 Measures for Conservation and Sustainable Fisheries Management in Pakistan

Sustainable management aims at practicing land stewardship ethics which integrate the growing, nurturing, and harvesting of resources sustainably with the conservation of soil, air, water quality, and biodiversity. The coastal zone of Pakistan is one of the significant fish producing zones. Fisheries and allied industrial activities are the most important economic activities along the coast and support the livelihoods of about one million fishermen and their families living in rural villages.

Some of the measures that have been taken to ensure sustainable use of fish and other marine resources are discussed as follows:

6.14.1 Enforcement of Fisheries Legislation

In order to ensure sustainable fishing and conservation of the fish stocks, a number of steps have been taken by the government agencies. A regular programme for assessment of fish stocks has been initiated which has revealed that most fish stocks have already been overfished in Pakistan.

The Government of Pakistan has enacted laws to control use of deleterious fishing gears. The Government of Sindh has imposed a ban on the use of trawl, seine and set bag nets in the creek areas of Sindh. A number of these gears have been confiscated and later on burnt by the Fisheries Department of Sindh.

There is a ban on the use of harmful gear in the waters of Balochistan. Both provincial governments undertake regular operations in their respective waters to take action against the violators of this legislation.

Fishermen communities and the Balochistan Fisheries Department, in collaboration with local NGOs, have taken steps to eliminate the use of harmful nets (ESBN) in Miani Hor lagoon with a good success rate. Karachi-based trawlers and seine (Katra) boats are known to poach heavily in the waters of Balochistan against which action has been taken by the local communities on some occasions.

In order to save sea turtles from being entangled in shrimp trawl nets, legislations have been enacted by the Marine Fisheries Department under which it is mandatory to install a Turtle Excluder Device (TED) in a shrimp trawl net. Installation of TED in trawl nets is also mandatory under United States regulations for export of shrimp from Pakistan and other countries into the US. The Marine Fisheries Department has taken measures to ensure that a TED is installed and used in all shrimp trawling operations.

6.14.2 Prohibition of Deep Sea Trawling

A greater threat to fisheries and marine life is posed by deep-sea trawling. These trawlers have been combing the territorial waters of Pakistan for a long time by indulging in poaching and under-reporting, besides polluting the sea by throwing by-

catch (unwanted species) into it. Deep-sea trawlers are supposed to operate beyond 35-miles of the coastline; however due to weak surveillance and enforcement, these trawlers often intrude in territorial waters.

6.14.3 Establishment of Marine Protected Areas

Marine Protected Areas are established to ensure that fisheries resources in these areas are fully protected against any human activities including unsustainable fishing practices. Marine Protected Areas act as “Refugia” for breeding of fish, shellfish and marine species.

Marine Protected Areas (MPAs) involve the protective management of natural areas so as to keep them in their natural state. MPAs can be conserved for a number of reasons including economic resources, biodiversity conservation, and species protection. They are created by delineating zones with permitted and non-permitted uses within that zone. Target 11 of the Aichi Biodiversity Targets agreed by all Parties to the CBD in 2010 specifies that each Party has to declare at least 10% of its coastal and marine areas as Marine Protected Area, especially the areas of biodiversity significance and ecosystem services. Further, the Sustainable Development Goals (SDGs) agreed by the UN General Assembly in September 2015 call for conservation and sustainable use of the oceans, seas and marine resources for sustainable development (SDG 14). IUCN under Mangroves for the Future Programme has taken steps in collaboration with Ministry of Climate Change to establish marine protected areas along the coast of Pakistan. Churna Island, Miani Hor, Astola Island and Gwatar Bay have been initially identified as the potential sites based on their ecological and socioeconomic significance.

The Government of Balochistan has decided to establish an artificial reef in Jiwani which will help in enhancing fish stocks in the area.

6.14.4 Maritime Stewardship Council Certification

Environmental certification such as the Maritime Stewardship Council (MSC) Certification, dolphin safe products and other similar initiatives are being encouraged throughout the world. The certification ensures that seafood products are harvested through sustainable methods to prevent depletion of fish stocks and prevent by-catch of endangered and protected species such as, dolphins, whales and sea turtles. A price premium is added to MSC certified products in the international market. Efforts are being made to get tuna troll fisheries of Balochistan and razor clam fisheries of Sindh certified by the MSC, which will pave the way for seeking certification for other major fisheries of Pakistan.



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7. CLIMATE CHANGE AND ITS IMPACTS

7.1 What is Climate Change?

Climate change is widely recognized as a key challenge to humankind in the twenty first century. Although the science is still being perfected, there is ample scientific evidence to suggest that climate change is a reality and will have far-reaching and direct impacts on economies, societies and ecosystems, especially on the lives of people throughout the world.

Climate change, also called global warming, refers to the rise in average surface temperatures on Earth. According to the International Panel on Climate Change (IPCC), the world has been warming at the rate of 0.128 ± 0.026 °C per year since the last 59 years (IPCC 2007).

Most of the warming of the past half-century is due to human activities. There is growing scientific consensus that climate change is primarily due to the burning of fossil fuels, such as oil and coal, which emits greenhouse gases into the atmosphere, mainly carbon dioxide. Other human activities, such as agriculture and deforestation, also contribute to the enhancement of greenhouse gases that cause global warming.

Global warming is the increase in Earth's average surface temperature due to the effect of greenhouse gases, such as carbon dioxide released from burning of fossil fuels or from deforestation. Green House Gases (GHGs) trap heat that would otherwise escape from Earth's atmosphere. It has been proved that due to the increase of the GHGs in our outer atmosphere, the Earth's temperature has warmed by 0.74 degree Celsius over the last 100 years.

Global warming is expected to have far-reaching, long-lasting and, in many cases, devastating consequences for planet Earth. Extreme weather events (floods, famines, droughts and cyclones), glacier melting and sea level rise are the most important consequences resulting from global warming. Rising temperatures can increase the rate of evapotranspiration. A warmer atmosphere can hold more water vapors. This increases the risk of extreme rainfall events. Changes in sea-surface temperatures may bring associated changes in atmospheric circulation and precipitation.

Agriculture is extremely vulnerable to climate change globally and in Pakistan. Water availability, food security and human health are most likely to be negatively affected by climate change. A report from the World Bank climate change experts has warned Pakistan of the existence of five major risks related to climate change. These include rise in sea level, glacial retreats, floods, higher average temperature and higher frequency of droughts.

7.2 Greenhouse Effect

The greenhouse effect is the name given to the process by which the Earth's atmosphere traps heat that is emitted by the Earth's surface and radiates it in all

directions. The process is caused by certain gases in the atmosphere, termed as “greenhouse gases”, which absorb and emit thermal radiation. The main greenhouse gases found in the Earth’s atmosphere are carbon dioxide, methane, water vapor, nitrous oxide, ozone and

chlorofluorocarbons. The

presence of many of these greenhouse gases has increased substantially because of emissions resulting from human activities. Greenhouse gases occur naturally in the Earth’s atmosphere but their concentration has been enhanced by human

activities. The

atmospheric

concentration of CO₂ did

not rise above 300 parts per million (ppm)

between the advent of

human civilization

roughly 10,000 years ago

and 1900. Today, CO₂

concentration in the

atmosphere has reached

to about 400 ppm, a level

not reached in more than

400,000 years.

The warming due to

greenhouse gases has

resulted in rising of sea

levels, melting of the

polar ice caps and

glaciers; warming ocean

temperatures resulting in

stronger and more

frequent storms; increase

in frequency of extreme

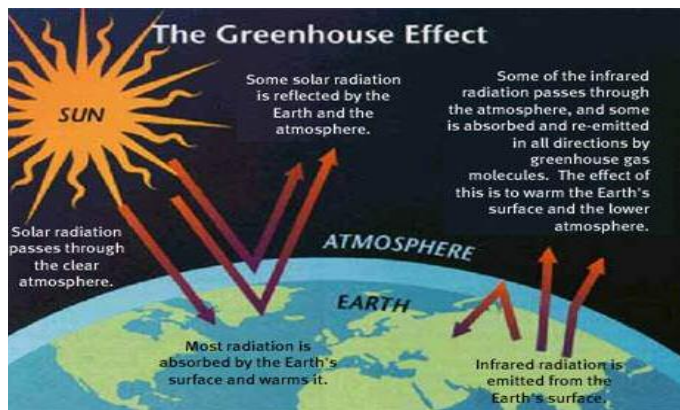
events such as floods,

droughts, and heat

waves contributing to

human deaths and other

consequences.



Source: University of Western Australia, 2014.

Box 6: Major Tropical Cyclones in Coastal Areas of Pakistan

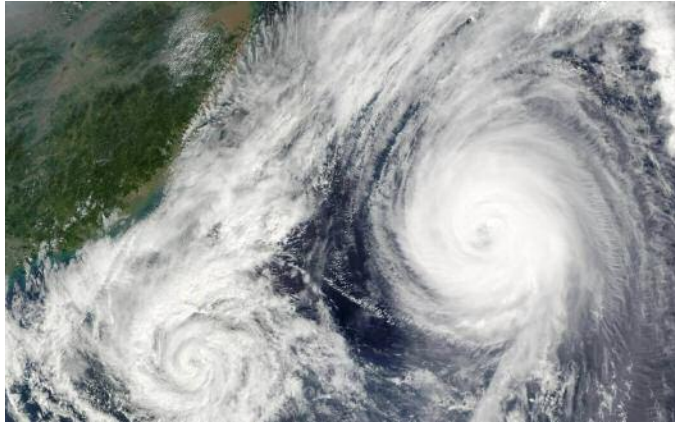
Tropical Cyclone (2-A) 1999: A tropical storm formed in the northern Arabian Sea developed into a severe tropical cyclone (2-A) and made landfall on 20th May, 1999 in the Indus delta area along the south-east coast of Sindh. Winds gusting up to 270 km per hour, impacted the coastal towns and villages of the districts of Badin and Thatta in Sindh province. At least 0.6 million people in 5,200 villages were affected. 82,181 houses were destroyed and 67,285 damaged. Some 400,000 acres of agricultural land were inundated with salt water, and 28,000 livestock perished. 675 fishing boats were destroyed and 191 people, mostly fishermen, were reported killed.

Tropical Cyclone YEMYIN 2007: This deadly tropical cyclone developed in the Arabian Sea on 22nd June, 2007 and made landfall along the Balochistan coast on 26th June, 2007. The cyclone affected at least 10 districts of Balochistan and four districts of Sindh. Around two million people were affected as a result of flash floods triggered by the cyclone and more than 2 million livestock perished.

Tropical Cyclone PHET 2010: A very severe cyclonic storm formed in the central Arabian Sea on 1st June, 2010 and made its first landfall along the coast of Oman on 4th June at peak intensity. Later it began re-curving towards the Pakistani coastal areas and weakened slightly before making its second landfall along the coast of Thatta on the evening of 6th June, 2010. Under its influence extremely heavy rainfall occurred over coastal areas of Balochistan (Gwadar 370 mm, Jiwani 208 mm) accompanied by strong gusty winds of 120 km/hour. PHET left thousands of people homeless.

7.3 Climate Change Consequences for Coastal Areas in Pakistan

Pakistan is not a significant contributor to greenhouse gases but it is facing the adverse effects of climate change. Increasing glacial melt, prolonged droughts, flash floods, cyclones, heat waves, warmer winters and early summers are some of the indicators of these impacts. According to the Maplecroft 2014 report, Pakistan is rated 16th on the list of countries most vulnerable to the impacts of climate change.



<http://all-free-download.com/free-photos/cyclone.html>

Pakistan's coastline stretches up to 990 km shared by the Sindh and Balochistan provinces. The rising temperatures may lead to sea level rise due to thermal expansion of the ocean waters, more acidic seawater, increase in heat waves and glacial melt. Sea level rise poses a great threat to coastal regions as it may lead to flooding and submergence of low lying areas resulting in displacement of local population, and an increase in sea intrusion and soil erosion processes. Sea intrusion will have adverse impacts on the productivity of coastal agriculture. The trend in sea level rise has been observed to be 1.1mm/year at the Karachi Harbour (Rabbani *et al*, 2014).¹²

According to the Intergovernmental Panel on Climate Change (IPCC), there has been 0.6 to 1.0°C rise in average temperatures since early 1900s in the coastal areas of Pakistan. 10 to 15% decrease in precipitation in the coastal belt and hyper arid plains over the last 40 years has been observed. It has been predicted that the Western Himalayan glaciers may retreat during the next 50 years, resulting in decrease in downstream river flows by 30% to 40% over the subsequent fifty years.

Coastal areas are also prone to tropical cyclones and storms and coastal flooding. Climate change has contributed to an increase in the frequency of occurrence of natural disasters, especially in coastal areas. During the period 1971-1998, around 13 cyclones formed in the Arabian Sea but did not affect Pakistan's coastal areas. However, during the last 12 years, three major tropical cyclones made landfall along our coastal areas. Coastal areas of Sindh are highly vulnerable to tropical cyclones and associated storm surges. Tropical cyclones have struck coastal areas of Pakistan in 1999, 2000 and 2010 causing damage to the lives and properties of coastal communities. The changing climate is resulting in increased frequency, intensity and changes in tracks of storms.

¹² Rabbani M.M, A. Inam, Tabrez A. R., Sayed N. A. and Tabrez S. M., 2014. The impact of sea level rise on Pakistan's coastal zones- in a climate change scenario.



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8. COASTAL EROSION AND ACCRETION

Coastal erosion is primarily a natural phenomenon, which has always existed and contributed throughout history to shaping coastal landscapes. Coastal landscapes are formed by a combination of erosion, transportation and deposition processes. Coastal erosion and accretion is the process of wearing away of land and removal of beach or dune sediments by



wave action, tidal currents and wave currents. Waves created by storms, wind or fast moving motor craft, cause coastal erosion which may take the form of long term losses of sediments and rocks, or merely the temporary re-distribution of coastal sediments. Erosion in one location may result in accretion nearby. Erosion is the product of an imbalance between sand inputs and outputs (the debits exceed the credits). A balance between inputs and outputs of sand produces no change, a condition termed "steady state."

Rainfall and oceanic waves are the principal eroding factors of the coastline. The combination of rain, wind and heavy surf tends to pick up and drag sand and earth from vulnerable beaches, washing it up and out into other areas. While the natural tides and waves perform similar movements, their impact is light compared to that of storms. Hurricanes especially provide enough water and force to erode coastlines, sometimes into unrecognizable shapes.

Coastal erosion is considered undesirable, not only because it threatens natural habitats found nowhere else in the world, but because it can change the nature of surrounding surf and tides, possibly making the area dangerous for boats and requiring constantly updated maps.

In Pakistan, coastal erosion, as well as soil erosion in water catchments of Indus, and other small rivers that empty at the coast, is the main process which provides terrestrial sediments to the coastal systems including beaches, dunes, mud flats, and marshes.

8.1 Factors Leading to Coastal Erosion

In Pakistan, the anthropogenic factors contributing to coastal erosion include drastic decline in the flows of the Indus River water into the delta, over exploitation of mangroves, dredging and channelization, multiple uses of coastal resources by different agencies and industries, and rise in sea level due to global warming. In

addition, coastal developments such as drainage infrastructure, construction jetties, and land reclamation also contribute to coastal erosion. Coastal erosion is often more pronounced in river deltas or coastlines with soft sediments and numerous beaches that can be easily affected by the movement of waves and tides.

The natural physical factors contributing to the coastal erosion process include earthquakes, wind, tides, waves, rainfall and cyclonic activities.

8.2 Hotspots of Coastal Erosion in Pakistan

The “erosion hotspots” i.e. areas that are affected by coastal erosion either by natural processes or human activities, are widespread along the entire coastal zone of Pakistan and display medium to severe erosion intensities.

In the Indus Delta, Ahmed Raju, Zero Point in Badin, Ketu Bundar, Shah Bundar, Jati and Kharo Chann are subject to a severe erosion problem which is mainly attributed to reduced fresh water flows down the Kotri Barrage and sea water intrusion.

Table 3: Intensity of Coastal Erosion along Pakistan’s Coast

Coastal Location and Degree of Erosion			
District	Location	Type of Coast	Erosion Intensity
Karachi	Phitti & Gizri Creeks	Mudflats/ Creek	Moderate
	Clifton	Beach	Low
	Hawksbay	Raised	Moderate
	DHA Phase-8	Creek and plain area	Moderate
	RasMurai	Raised	Low
Thatta	Kharo Chann	Estuarine mudflat	Severe
	Ketu Bunder	Estuarine mudflat	Moderate
	Mirpursakao	Creek/mudflat	Moderate
	Ghorabari	Creek/mudflat	Moderate
	Ghoro Creek	Creek/mudflat	Severe
Sujawal	Jati	Creek/mudflat	Severe
	Shah Bunder	Creek/mudflat	Severe
Badin	Badin	Creek/mudflat	Severe
	Shaheed Fazil Rahu	Creek/mudflat	Severe
Gwadar	Jiwani	Raised/flat	Very Severe
	Gwadar Bay	Raised/flat	Moderate
	Shadi Kor	Estuarine	Very Severe
	Kalimat Khor	Lagoon	Moderate
	Pasni	Raised/flat	Severe
	Ras Jaddi & Zarin	Raised	Moderate
	Ras Shaheed	Raised	Severe
	Ormara	Raised	Low
Lasbela	Damb	Sand dune	Very Severe
	Miani Hor	Lagoon	Moderate
	Sonmiani	Raised	Moderate
	Gaddani	Raised/flat	Moderate
	Hub	Estuarine	Moderate

Source: Adopted and modified from National Assessment Report on Coastal Erosion Management in Pakistan, WWF and IUCN, 2014

By comparing the historic datasets of 1962 with satellite images of the land in 2011, WWF Pakistan (2012) has estimated that erosion has engulfed approximately 9,065 ha of land in Keti Bundar and Kharo Chann whereas only 1,347 ha of land have been accreted.

Along the Balochistan coast, Damb, Pasni, Gwadar and Jiwani are the main hotspots of erosion. The coastal town of Pasni is slowly losing its distinctive beaches shaped as the roman symbol “zeta”. The northern side of the Pasni harbour, where lies the village of Sur Bundar, is severely hit by the erosion process. The village has a protection wall built to stop erosion but this has proved be ineffective. A fish harbour constructed in Damb village has resulted in massive erosion in nearby areas causing huge property loss. In Jiwani, erosion is mostly prevalent in the areas near the mouth of the Dasht River. The erosion problem in Solon Bazar is more severe and is attributed to the jetty construction in the town.

8.3 Management of Coastal Erosion

Coastal erosion management interventions or schemes are normally constrained by the following four factors; the scheme has to be technically viable, cost effective, and environmentally and socially acceptable. Further, we need to appreciate that the coast is a dynamic environment and each coastal zone has a unique natural system. Thus good knowledge and understanding of local coastal processes is a prerequisite for any coastal manager before proceeding to any hard or soft engineering solutions to the eroding coastal area.

In the management of coastal erosion, the eroding areas may not necessarily be called erosion hotspots, especially when the coastal erosion is not causing any immediate risk to human safety, economic assets or natural habitats of high value.

The strategic approach to manage coastal erosion comprises three components, as discussed below.

8.3.1 Monitoring actual change in erosion/recession rate in the coastal zone

This is a “do nothing” strategy, which would not take into account the increasing level of erosion risk due to sea level rise (climate change), and delta subsidence (or sinking of the Indus Delta). So this does not put emphasis on amending the legal or institutional tools to address the future risks posed by higher intensity of erosion. However, it generates information and knowledge on coastal erosion processes for designing appropriate management interventions.

This strategy is expected to address erosion risk through utilizing emergency risk management responses in particular to disasters such as cyclones, tsunamis, floods, etc.

8.3.2 Planned retreat or moving assets and infrastructure out of the high erosion risk zone or erosion hotspots

In some instances, public and private properties are located in areas which are erosion prone and eventually these assets are likely to be damaged due to coastal

processes. As such, a planned retreat is the preferred option to avoid risks associated with impacts of coastal erosion and recession on the local communities and coastal infrastructure. In this sense, this is a “hazard avoidance” strategy. The new development is placed outside of the risk zone and the built assets within the risk zone are gradually retreated or relocated.

8.3.3 Accommodate change and/or allow some interim protection of public and private assets in the immediate erosion risk zone

The strategy is often supported by coastal protection techniques such as hard, soft or hybrid measures to improve the adaptation chances of the ecological communities. For example, in eroded land areas with high salinity levels, salt tolerant vegetation has a better chance of success than a normal crop breed.

8.4 Hard Engineering Techniques

8.4.1 Sea Walls

These are the most obvious defensive methods. Sea walls are exactly that - giant walls that span entire coastlines and attempt to reduce erosion and prevent flooding in the process. They are big, ugly and very expensive, requiring constant maintenance so that they do not fail. They also produce a strong backwash in waves which undercuts the sea wall making their long term sustainability questionable. Traditionally, sea walls are large flat walls; however, more modern sea walls have a curved structure that reflects back the energy of the incoming waves, reducing the energy force and breaking them up, further reducing erosion.

8.4.2 Groynes

Groynes are relatively soft hard engineering techniques. They are low lying wooden walls or large boulders that are perpendicular to the beach and extend out to the sea. The idea of groynes is to capture sand that moves down the beach via longshore drift and help build up a larger section of beach in front of an area that's experiencing coastal erosion. The new beach will increase the distance that waves have to travel to reach the coast and, in the process, they will lose most of their energy, reducing their impact. Groynes are pretty



Sea Wall



Gabion



Rip Rap (Rock Armour)



Groyne

<http://croesy-gcse-geography.doomby.com/pages/unit-two-options/example.html>

effective but they remove a lot of the sand that is present down-drift of the beach which will result in a thinner beach at this area.

8.4.3 Gabions

Gabions are quite simply bundles of rocks in a metal mesh. They are placed at the base of a cliff in an attempt to reduce the impact of waves on the cliff and prevent the cliff from being undercut. They are not particularly effective and they are quite unsightly but they are a much cheaper option than some of the others.

8.4.4 Riprap

Ripraps are just rocks and stones that have been put against the base of a cliff. They are similar to gabions in their purpose but they are not bound together in a mesh. This makes them look slightly more appealing as they blend into the environment better, however the rocks are susceptible to being moved by the sea.

8.4.5 Breakwaters

Breakwaters are offshore concrete walls that break the energy of the incoming waves out at sea so that their erosive power is reduced when they reach the coast. Breakwaters are effective but they can be easily destroyed during a storm and they don't look particularly nice.

8.4.6 Tidal Barriers

These are big, retractable walls built across estuaries that can be used as a floodgate to prevent storm surges. They are hugely effective but they are also hugely expensive.

8.5 Soft Engineering Techniques

8.5.1 Beach Nourishment

This is where sand and shingle are added to a beach in order to make it wider. This increases the distance a wave has to travel to reach the cliffs and so the wave will



© UNEP-COBSEA 2013

lose more energy and have less erosive power when it reaches the cliffs. The sand and shingle has to be obtained from elsewhere and is normally obtained from dredging.

8.5.2 Land Management

Land management is often used to help protect and rebuild dunes. Sand dunes act as a good barrier against coastal flooding and erosion and they can be exploited as a natural defense against the sea. In order to do so though, the dunes must be left relatively undisturbed.

8.5.3 Marshland Creation

Marshland can be used to break up the waves and reduce their speed, reducing the wave's erosive power. The marshlands also limit the area which waves can reach, preventing flooding. The marshlands can be created by encouraging the growth of marshland vegetation such as glassworts.

8.5.4 Beach Stabilization

The goal of beach stabilization is the same as beach nourishment's goal, to widen the beach and dissipate as much wave energy as possible before it reaches the cliffs. Beach stabilization involves planting dead trees in the sand to stabilize it and lower the profile of the beach while widening the beach too.

8.5.5 Setting Setback Limits

Many coastal areas experience repeated shoreline erosion problem due to natural coastal process. It is recommended that a setback limit of 200 meters is established from the high water mark. People and communities must construct their homes and industries at least 200 meters away from the coast. Moving coastal communities and industries at a later stage to safer areas would be expensive and difficult.



9. COASTAL POLLUTION

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light. There are many types of pollution including: air, land, water and noise pollution.

9.1 Air Pollution

Air pollution is the contamination of natural air by mixing it up with many different contaminating particles including chemicals, harmful fumes, gases, etc. Sources of air pollution include automobiles, industry and burning of fossil fuels; examples of



contaminants released are compounds such as carbon dioxide, carbon monoxide and chlorofluorocarbons (CFCs). Air pollution is always a potential risk, leading to respiratory infections, heart diseases, strokes, etc. Other health effects due to air pollution include asthma and cardiac conditions.

9.2 Land Pollution

Land pollution refers to releasing waste onto land or soil, such as littering or dumping toxic industrial waste, waste dumping at landfill sites and quarries.

9.3 Water Pollution

Water pollution refers to the discharge of waste or other toxic material into the sea or other water bodies. Examples of water pollution include discharging untreated industrial effluent and municipal sewage into water bodies and oil spills. Municipal sewage includes domestic



wastewater originating from the kitchen, bathroom, laundry sources, from food preparation, dishwashing, garbage-grinding, toilets, baths, showers, and sinks. Domestic sewage contains a wide variety of dissolved and suspended impurities. The nutrient rich sewage water becomes a source of excessive algal growth. As algae die, decomposition of organic matter is enhanced through bacterial activity

which consumes dissolved oxygen in water, leading to depletion of oxygen in water, making it difficult for other aquatic organisms to survive. This state is commonly termed as 'eutrophication'.

Oil spills can be caused by releases of crude oil from tankers, offshore platforms, drilling rigs and wells, and spills of refined petroleum products (such as gasoline, diesel) and their by-products. The largest oil spill to date happened in 1991 in Kuwait, where about 42 million gallons of oil was spilled.

9.4 Noise Pollution

Noise pollution refers to the production of unwanted or unnecessary sound that becomes a nuisance and has a high pitch as compared to the hearing capabilities of humans. The buzzing sound of car engines, honking of horns, noise created by loud music



<https://www.emaze.com/@ATCIOIRW/Noise%C2%A0Pollution>

and use of heavy machinery at construction sites are all examples of noise pollution. Various studies have shown that long term exposure to high levels of industrial noise can cause a degree of hearing loss. Nearly 50 to 60 percent of the workers in a plant with a noise level of about 150 decibels (dB) have been reported to be losing hearing capacity. The acceptable noise level is 85 dB.

The other non-industrial sources of noise include vehicular traffic, loudspeakers, radios, television, music systems, construction work trains and aircrafts.

9.5 Radioactive Pollution

Radioactive pollution occurs mostly from the waste products that are left behind after the use of radioactive substances. Radioactive waste is usually the product of a nuclear process such as nuclear fission, which is extensively used in nuclear reactors, nuclear weapons and other nuclear fuel-cycles. A large amount of radioactive waste is generated from nuclear reactors used in nuclear power plants.

9.6 Sources of Coastal and Marine Pollution in Pakistan

9.6.1 Industrial Effluents

Industrial waste is produced by industrial activity; it is any material that is considered waste during a manufacturing process such as that of factories, industries, mills, and mining operations. Examples of industrial waste are chemical solvents, paints, sandpaper, paper products, industrial by-products, metals, and radioactive waste. Every year, thousands of tons of industrial waste is dumped into the ocean. In the

coastal areas of Karachi, this is a huge problem as Karachi happens to be the largest industrial hub of the country. According to official figures, 90 per cent of industrial effluent and sewage produced in the country's biggest city is poured into the sea either directly or via Lyari and Malir rivers. About 2,500 ships and 200 oil tankers visit Karachi harbour through the Manora Channel annually. There is large scale shipping traffic at Port Qasim. The sources of oil pollution in Manora channel are bilges, washings from engine rooms of vessels, discharges and leaks from bunkering point, and leaks and small spills occurring during loading and unloading at oil piers. Oily waste from city based sources including service stations also ends up in the harbour area.

9.6.2 Domestic Sewage

Perhaps the greatest contributor to marine pollution along Pakistan's coast is domestic sewage. About 550 million gallons per day (MGD) of mostly untreated wastewater is entering the coastal waters affecting the coastal areas; the problem would worsen if no remedial measures are undertaken.

9.6.3 Solid Waste

Global urbanization is increasing volumes of solid waste. A considerable amount of money goes into managing huge volumes of solid waste.

Approximately 12,000 tons of solid waste is generated daily in Karachi, excluding industrial and



hospital waste. Rapid establishment of new housing sectors, industrial estates and construction activities contribute to waste generation. The amount of solid wastes is expected to substantially increase with the rapid growth of population and economic activity. It is estimated that by the year 2020, solid waste generation in Karachi may approach 16,000 to 18,000 tons each day. The current poor solid waste management practices need to be made more efficient and modernised. Lack of planning, inappropriate technology and poor management are obviously the main areas of concern. This requires serious efforts from government authorities and other agencies for effective solid waste management.

9.7 Consequences of Coastal and Marine Pollution

Marine pollution has tremendous economic, health and biodiversity costs. Industrial waste, untreated sewage and oil spills contaminate the sea and pose a great threat to marine life. Oil is dangerous to marine life in several ways. For instance, if fur-bearing mammals or birds get oil on their fur or feathers, they may not be able to fly or move properly, maintain body temperature, or feed. The oil washes up on beaches and contaminates nesting areas and feeding grounds of birds and sea

turtles. Furthermore, pathogens entering the food chain through sewage will often be transmitted back to humans through seafood. Potentially fatal diseases such as typhoid and cholera are in fact highly prevalent in Pakistan. Another effect of marine pollution is that a lot of the waste and litter dumped in the ocean eventually washes up on beaches, and hence ruins beach aesthetic and tourism. Polluted beaches pose a higher risk of catching diseases.

9.7.1 Deterioration of Air and Water Quality

Environment is the first casualty for increase in pollution whether in air or water. The increase in the amount of CO₂ in the atmosphere leads to smog which can restrict sunlight from reaching the Earth and disruption of communication channels. The accumulation



of gases in the atmosphere may lead to an enhanced greenhouse effect, resulting in the warming of the Earth's surface. Gases like sulfur dioxide and nitrogen oxide can cause acid rain. Water pollution in terms of oil spill may lead to death of aquatic species. Use of pesticides and chemicals in agriculture induces harmful effects on nature in the form of loss of beneficial insects and pollution of water bodies.

9.7.2 Impacts on Human Health

The degradation in quality of air leads to several health related problems including asthma and lung cancer, chest pain, congestion, throat inflammation and cardiovascular diseases. Water pollution due to contamination may induce gastric and skin related problems including skin irritation and rashes. Similarly, noise pollution may lead to hearing loss, stress and sleep disturbance.

9.7.3 Global Warming

The emission of greenhouse gases, particularly CO₂ is leading to global warming. The burning of fossil fuels and industrial emissions are the main sources of increase in CO₂ in the atmosphere. The increase in greenhouse gases may result in global warming which may cause melting of polar ice caps and glaciers; induce rise in sea levels, affecting low lying coastal populations, and enhance frequency of extreme events.

9.7.4 Ozone Layer Depletion

The ozone layer is the thin shield high up in the upper atmosphere that stops ultra violet rays from reaching the Earth. As a result of human activities, chemicals termed as chlorofluorocarbons (CFCs) are released into the atmosphere, which contribute to the depletion of the ozone layer.

9.8 Coastal Pollution Management

9.8.1 Sewage Treatment

One way to combat coastal pollution is to treat sewage before discharging it into the

sea. Sewage treatment is the process of removal of contaminants from wastewater. It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater. A by-product of sewage treatment is usually a semi-solid waste, called sewage sludge that has to undergo further treatment before being suitable for disposal or land application. Karachi Water & Sewerage Board has established three sewage treatment plants. Of the total 472 MGD, these plants treat only 55 MGD of sewage and the rest finds its way to the sea untreated. For the industrial waste of 78 MGD, there is only one treatment plant with a designed capacity of treating 10 MGD. The city district government of Karachi has planned to set up six treatment plants at several sites for sewage water treatment.

9.8.2 Solid Waste Management

Solid waste collection by government owned and operated services in Pakistan's cities currently averages only 50 percent of waste quantities generated. Unfortunately, none of the cities in Pakistan has a proper solid waste management system right from collection of solid waste up to its proper disposal. Much of the uncollected waste poses serious risk to public health through clogging of drains and formation of stagnant ponds, providing breeding grounds for mosquitoes and flies with consequent risks of malaria and cholera. In addition, because of the lack of adequate disposal sites, much of the collected waste finds its way to dumping grounds, open pits, ponds, rivers and agricultural land. The Government of Pakistan enacted the Pakistan Environmental Protection Act (PEPA) in 1997 which provides a framework for establishing federal and provincial Environmental Protection Agencies (EPAs). One of the functions of EPA is to assist the local councils, local authorities, government agencies and other persons to implement schemes for the proper disposal of wastes so as to ensure compliance with the National Environmental Quality Standards (NEQS).

9.8.3 Reduction, Re-use and Recycling (3Rs)

One of the best ways to decrease pollution is to recycle, reuse and reduce our consumption of products. Lots of things (like cans, bottles, paper, and cardboard) can be remade into either the same kind of thing or new products through recycling.

9.8.4 Harbour Pollution Management

At Karachi Port environmental management system has been put in place which spells that Overboard Valves (OBV) may be locked, chained and sealed during stay of vessels at the port. No ship is allowed to pass its bilges through OBV in the harbour area. Moreover, shore reception facility according to MARPOL-73/78 Annex-I has been made available through private contractors.

9.8.5 Public Awareness

Creating public awareness on pollution and its threats is one of the important components of pollution management strategies. Awareness programmes run by the government and civil society organizations are necessary to promote recycling and sensitise the public towards pollution threats, changing their attitude towards environmentally responsible citizenship.



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10. INTEGRATED COASTAL MANAGEMENT

Coastal and marine ecosystems are among the world's most productive, economically valuable and biodiversity rich regions.

Coastal zones throughout the world have historically been among the most heavily exploited areas because of their rich resources. There is sharp conflict between the needs for immediate consumption or use of coastal resources and the needs to ensure the long-term supply of those resources. In many countries this conflict has resulted in the emergence of several issues, with large parts of the coastal zone polluted from local or upland sources, fisheries severely degraded or destroyed, wetlands drained, mangroves deforested for shrimp production, coral reef dynamited and beaches long since ruined for human recreation.

In order to address the wide range of issues and needs related to coastal and marine environments, a holistic approach towards their governance is essential. This involves adoption of dynamic and multidisciplinary systems like integrated coastal management (ICM) that converge ecosystem protection and sustainable development. ICM is now a widely recognized concept based on the belief that ecological integrity and economic growth should go hand in hand. This concept was born in 1992 during the Earth Summit of Rio de Janeiro. The European Commission defines the ICZM as follows.

ICZM is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. ICZM uses the informed participation and cooperation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. ICZM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics. 'Integrated' in ICZM refers to the integration of objectives and also to the integration of the many instruments needed to meet these objectives. It means integration of all relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory, in both time and space.

The 1992 United Nations Conference on Environment and Development (UNCED) provided significant support for integrated management of coastal zones. It sets out the objectives of integrated coastal zone management as follows:

1. provide for an integrated policy and decision-making process to promote compatibility and a balance of uses;
2. identify existing and projected uses of coastal zones and their interactions;
3. concentrate on well-defined issues;
4. apply preventive and precautionary approaches in planning and implementation;
5. promote the application and development of methods that reflect changes in value resulting from uses of marine and coastal zones, including pollution, marine erosion, loss of resources and habitat destruction;
6. provide access, as far as possible, for concerned individuals, groups and organizations to relevant information and opportunities for consultation and participation in planning and decision-making at appropriate levels.

The purpose of ICZM is to maximize the benefits provided by the coastal zone and minimize the conflicts and harmful effects of activities upon each other on resources and on the environment. It starts with an analytical process to set objectives for the development and management of the coastal zone. ICZM should ensure that the process of setting objectives, planning and implementation involves as broad a spectrum of interest group as possible, that the best possible compromise between the different interests is found and that a balance is achieved in the overall use of the country's coastal zones.

In Pakistan, there is a multitude of institutions concerned with the coastal zone. These include local, provincial or federal institutions, as well as ad hoc bodies, research institutions and the private sector. Often, there is a lack of coordination among these agencies who are responsible for the development and management of coastal areas. The presence of a multiplicity of agencies, institutions and organizations involved in management of coastal areas hinders the development of coordinated policies and plans for the coastal region because of overlap of policy and administrative jurisdictions of these agencies and their competing interest. This situation often leads to confusion and inefficient decision making with regards to the priorities and requirements of coastal zone management. The conflicting sectoral interests lead to a lack of coherent policies, plans and procedures regulating the development activities in the coastal zone resulting in unplanned development, encroachments and unsustainable land reclamation, pollution and degradation of coastal resources.

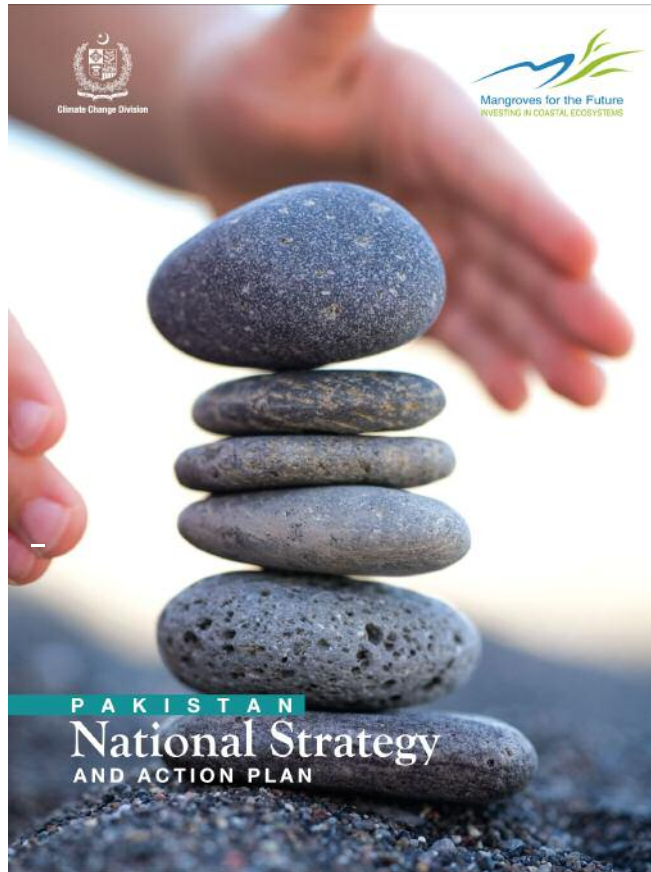
Many of these challenges could be effectively dealt with through strategic planning, effective coordination and improved communication between the relevant stakeholders working along the coast, and by networking at the regional level to promote learning and adoption of best management practices. At the same time, there is a need to create supportive institutional and policy frameworks and enhance awareness and capacities of coastal institutions, the private sector and local communities in sustainable management of the coastal resources.

Integrated Coastal Management provides a framework for formulation and implementation of coherent policies and practices by different coastal agencies which tends to avoid resource use conflicts, maximize societal benefits from use of coastal zone and ensure sustainability of coastal resources. Formulation of an integrated coastal zone management plan is a highly essential planning tool for sustainable management of coastal areas in Pakistan. An ICZM plan should focus on three operational objectives:

- i. Strengthening sectoral management, for instance through training, legislation and staffing.
- ii. Conserving and protecting the productivity and biological diversity of coastal ecosystems, mainly through prevention of habitat destruction from pollution and overexploitation.
- iii. Promoting national development and sustainable utilization of coastal resources.

The common principles set out a step by step process which can be adhered to¹³.

- i. Firstly, issues and problems need to be identified and assessments of these need to be quantified. This will include integration between government, sectoral entities and local residents.
- ii. Formulation of an effective management plan. The plan will be specific to the area in question.
- iii. Thirdly, the adoption of the plans as legally binding statutory plans, strategies or objectives which are generally quite powerful; or they can be non-statutory processes and can act as a guide for future development.
- iv. Implementation of the plan: this active phase includes law enforcement, education, development etc. The implementation activities will, of course, be as unique as their environments and can take many forms.
- v. Evaluation is last phase of the whole process. The principles of sustainability mean that there is no 'end state.' ICZM is an ongoing process which should constantly readjust the equilibrium between economic development and the protection of the environment. Feedback is a crucial part of the process and allows for continued effectiveness even when a situation may change. Public participation and stakeholder involvement is essential in ICZM processes, not only in terms of a democratic approach, but also from a technical-instrumental point of view, in order to reduce decisional conflicts.



An Integrated Coastal Management Plan for Pakistan was prepared by IUCN in June 2011 following extensive consultations with the relevant stakeholders. This work was supported the Royal Netherland Embassy (RNE) under the Balochistan Programme for Sustainable Development (BPSD). The ICM plan identifies a multitude of institutions concerned with the coastal zone. There are local, provincial or federal institutions, as well as ad hoc bodies, research institutions, management organizations and private parties. The involvement of all these institutions is

13 https://en.wikipedia.org/wiki/Integrated_coastal_zone_management#ICZM_Framework

presented in a comparative form in the plan, which also notes the nature of involvement of each body, as well as the inter-relationships between institutions.

The National Strategy and Action Plan (NSAP) of Pakistan developed under the Mangroves for the Future (MFF) Programme provides a good framework to promote integrated coastal management and is, in fact, a critical document that links local actions with global thinking. It is the key national document on coastal areas which suggests strategies and actions that support the implementation of the National Climate Change Policy 2012, approved by the Government of Pakistan and meeting Pakistan's obligations under various international environmental conventions.

