SINDH IRRIGATION AND DRAINAGE AUTHORITY

WATER SECTOR IMPROVEMENT PROJECT-I (WSIP-I)

PREPARATION OF REGIONAL PLAN FOR THE LEFT BANK INDUS, DELTA AND COASTAL ZONE

Rehabilitation of Coastal Wetlands

Feasibility Study




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In Association with
Indus Associated Consultants
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Acronyms

KPOD	Kadhan Pateji Outfall Drain
LBOD	Left Bank Outfall Drain
WAPDA	Water and Power Development Authority
SRS	Satellite Remote Sensing
DPOD	Dhoro Puran Outfall Drain
NIO	National Institute of Oceonography
CBD	Convention on Biodiversity
Dhands	Lakes
Sanhro	Name of one of the lakes of coastal wetlands
Mehro	Name of one of the lakes of coastal wetlands
TDS	Total Dissolved Solids

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Executive Summary

Rationale

Wetlands are among the world's most productive environments and are essential part of our landscape. They are the cradle of biodiversity and a vital component of the freshwater cycle. Wetlands are dynamic ecosystems with complex interrelationships of hydrology, soils and vegetation. Like other green areas the wetlands are also under tremendous environmental degradation. As a result, this important environmental source is depleting at an alarming rate. Therefore, an internationally acceptable up to date scientific technology is required to monitor wetlands effectively.

In Sindh there are more than 100 wetlands of which about 90% fall on the left bank of Indus and the rest are located on right bank (Fig-1). They range from coast, river, lake, marsh, pond and channels to lagoons. There are three wetland complexes namely Deh Akro II (32 dhands) located in district Benazirabad, Chotiari (22 dhands located in Sanghar district and Indus delta/coastal wetlands (15 wetlands) located in Badin and Thatta districts.

The wetlands are important natural resource base of economic importance. They provide livelihood opportunities, mainly fishing, for the local communities. The coastal wet lands, particularly Sanhro and Mehro dahnds - the Ramsar sites, were recharged by flows from storm water runoff and surface drainage system in the southern districts (Badin and Thatta). To avoid KPOD drainage effluent discharges into the above mentioned two dhand complexes, a 42 km long tidal link canal was built to detour the outfall into Shah Samando creek. In addition to this at Chotiari dhand, a weir was constructed to protect the *dhands* from excessive drainage flows and back flows into the tidal link during high tide.

Problem Statement

Since the 1960s, when the Kotri Basin drains were built to discharge into the coastal dhands they have become an important local fishery, and a waterfowl habitat of international importance. Portions of two of the Sindh dhands (Sanhro and Mehro) have been declared Ramsar sites, and the Rann of Kutch is included on the WWF list of the 200 globally most important biodiversity hot-spots. To avoid discharging LBOD through KPOD directly into this environmentally sensitive international wetland, a Tidal Link drain was built 42 km southwestward across the dhands and the Rann of Kutch from KPOD to the nearest active tidal creek, Shah Samando Creek. An 1800 ft weir, called the Cholri Weir, was built where the Tidal Link Canal passes through Cholri Dhand in order to attenuate high water levels in the Tidal Link drain during high tide by allowing water to flow into the dhands during this period, and to protect the dhands from excessive drainage during low tide when the water would flow back into the Tidal Link Canal.

1) With the collapse of Cholri weir and breaches in the tidal link due to cyclone 2 A in 1999, the salinity level of the *dhands* has been compromised due to back flows from the sea.
2) With the salinization of these *dhands*, the fish productivity capacity has been severely impaired. Also during the low tides, the *dhands* drain out into the tidal link, causing sedimentation and lowering the storage levels in the *dhands*.
3) Unsustainable methods of exploitation of these resources coupled with lack of sustainable and participatory policies and planning to conserve such resources have resulted degradation of such resources and threatened the very survival of the communities dependent on these resources.

4) Both tidal fluctuations and sea water intrude into the dhands and KPOD, and there is now an open connection between the dhands and the Tidal Link, exposing the dhands to tidal fluctuations, sea water intrusion, sedimentation, and excessive drainage during low tide. The LBOD can now be described as a "new river" that is forming an estuary and is an integral part of creek formation into the coastal area.

5) Severe erosion of the Tidal Link, breaches in the flanking embankments, and the collapse of Cholri Weir are the main problems and cause of degradation of coastal wetlands.

The Tidal Link has invited the sea to approach the land and now the tidal fluctuations are visible. This process will continue, and its progress is difficult to predict. Adapting to this new process requires continuous hydraulic and environmental monitoring in learning by doing approach. The IPOE suggested that LBOD Stage II & III in light of the present outfall conditions of LBOD Stage-I should be postponed until the existing problems at the outfall are adequately address and solved.

Present Status of Wetlands

The Tidal Link Canal bed and banks were constructed with the soil obtained from the canal excavation and consisted mainly of silty loam in which scour and erosion processes are highly sensitive to flow velocity. The analysis indicated that the sea water was not expected to penetrate more than 19 km upstream to an area about 5 km downstream of the Cholri Weir, the main connection between the Tidal Link and the dhands. Due to the sensitivity of the soil of the tidal link, the erosion of the bed and banks continued right from the inception of the tidal link canal and the process continues till today resulting in the breaches of the banks and erosion of the bed.

Master Plan Consultants visited tidal link to observe its morphological behavior and to suggest the possible structural / non-structural measures to improve outfall conditions for LBOD. Main objective of the visit was to identify and analyze the existing conditions of the tidal link, the process of creek development and the flow of tidal water from sea through tidal link to Dhand complex and back to sea. The design top width of the tidal link at the beginning was 152 ft and that at the outfall 233 ft. This width has increased manifold and has reached 3600 ft or more at some places in the vicinity of the outfall and near dhand complex.

Objectives of the Project

The main objectives are to:

i) revive the *dhands* as a source of livelihood

ii) restore and improve the ecosystem; through protecting the *dhands* from seawater

iii) promote the local fish in fish ponds filled with drain water and storm water

iv) grow salt tolerant crops for supplementing the farmers income

v) grow salt tolerant trees and shrubs for fuel wood and income generation

vi) develop fodder for livestock and reeds for migratory birds

Due Diligence

The present conditions of the outfall area are quite different from the ones observed when LBOD outfall system was in the stage of preparation and before it started operations. There is now an open connection between the dhands and the Tidal Link, exposing the dhands to large tidal fluctuations, sea water intrusion, sedimentation, and excessive drainage during low tide. A small tidal creek type system of drainage channels has now developed in Cholri Dhand, which is closest to the Tidal Link. The Tidal Link drain bed and banks were constructed with the soil obtained from the canal excavation and consisted mainly of silty loam in which scour and erosion processes are highly sensitive to flow velocity. At present both tidal fluctuations and sea water intrude into the dhands and KPOD, and the drainage and environmental functions of the Tidal Link portion of the LBOD outlet are impaired. The entire ecosystem of the dhands has been vanished and sea has occupied the area. This requires a wise decision to revive the ecosystem to bring back the conditions that existed before the LBOD.

Proposal to revive the dhand ecosystem through "Ecosystem Approach"

Presently the dhands receive water from Karo Ghungro and Guni Phuleli drains. The water of these drains is slightly brackish with <2000 ppm all the year round and is suitable for local fish, reed grass, salt tolerant crops and trees and migratory birds provided the sugar mill effluent is stopped in these drains. The area of dhands is over 60,000 acres. This area will be divided into suitable parcels after a detailed survey of the area using appropriate dykes and local fish will be reared in depressions together with growing salt tolerant crops, trees, grasses and fruit trees.

Project Outcome and Impacts

This intervention is expected to improve and revive to a larger extent the ecosystem of the *dhands* and would enhance the household income of the communities that are dependent for their livelihoods from these wetlands. The main outcome of the project includes production of local fish from 20,000 acres and production of crops from 10,000 acres, grasses from 10,000 acres and 10,000 acres of fruit and wood trees. The project will also provide employment to local communities, and would reduce the poverty incidence to 50 percent from the current estimated level of 75 percent.

Project Cost estimates

Management cost and cost of survey work, dykes, land development, hatchery, and capacity building etc of the project is estimated to the tune of Rs. million

Environmental and Social Safeguards

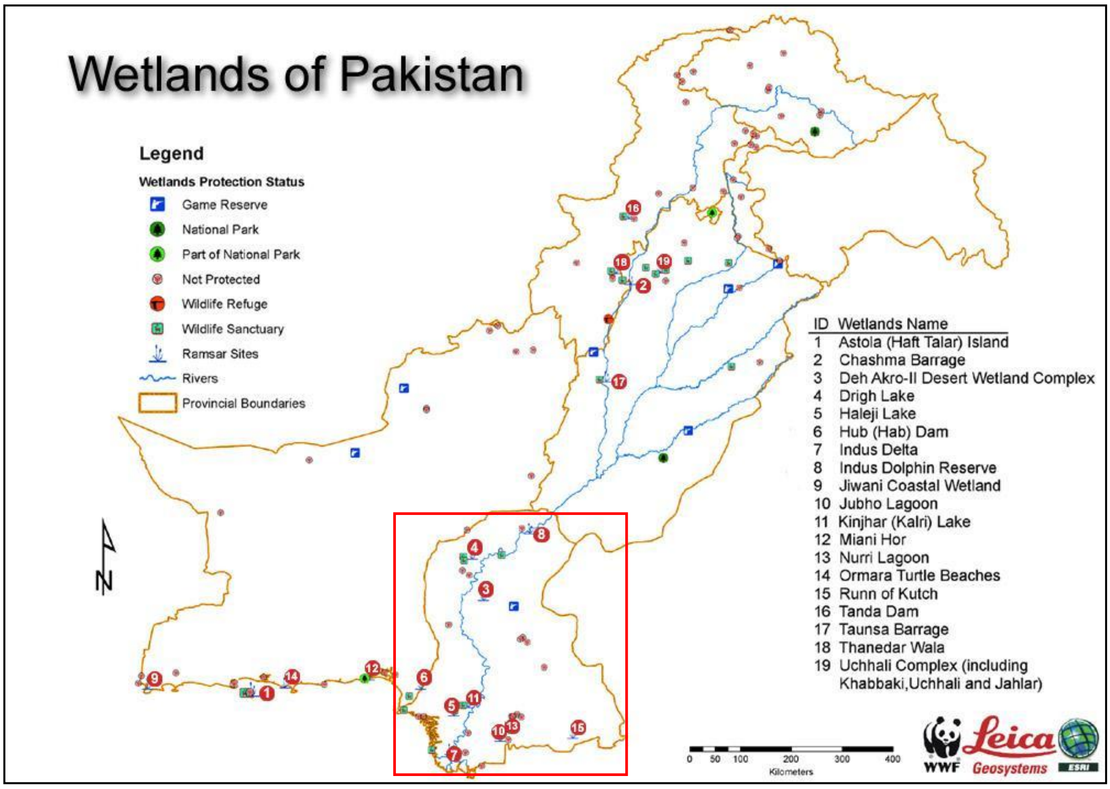
The intervention is environment friendly and will improve the ecosystem of dhands; will improve the salinity of *dhands* and will help conserve valuable water resource presently wasted to the sea through drainage. There are numerous social benefits including better livelihood opportunities, favorable environment for migratory birds and fodder for livestock thus raising the socio-economic wellbeing of the communities.

Rehabilitation of Coastal Wetlands

1 Introduction

Wetlands in Pakistan cover an area of 780,000 ha which is 9.7% of the total land area, with 225 nationally significant wetlands and 19 among them have been recognized as Ramsar sites of global significance. Wetlands extend along the Indus River from the glaciers and lakes, through riverine and freshwater lakes to the coastal wetlands of the Indus Delta. These wetlands provide numerous benefits and services, such as provisioning food and fiber production, regulating services such as water balance, groundwater recharge, flood mitigation, storm protection, cultural and social functions such as sacred and religious importance; providing recreation and tourism opportunities; and supporting functions such as soil formation and sediment retention. Major threats to wetlands include shortages of water to maintain the wetlands, poor water quality from increasing pollution, change in land use, encroachment, and overexploitation of natural resources, such as fish and wildlife. Most often the overexploitation is driven by the lack of alternative livelihoods so that poor communities may have no option.

Management of the natural resources is usually ineffective and penalties for illegal or inappropriate resource use are often not significant enough to be prohibitive. These practices generally stem from policy shortcomings, legal gaps and inconsistencies, failure to enforce regulations, and institutional overlap of responsibilities for management of wetlands and lack of coordination. Lack of awareness both amongst the general public and more importantly amongst key policy and decision makers at national and provincial levels undermine most efforts at wetland conservation and sustainable use.



Source: WWF Pakistan

Figure 1: Wetlands of Pakistan

Wetlands are among the world's most productive environments and are essential part of our landscape. They are the cradle of biodiversity and a vital component of the freshwater cycle. Wetlands provide numerous benefits that include rich floral and faunal habitat, improved water quality, flood abatement, water storage and groundwater recharge, support for fisheries, and opportunities for education and recreation. Wetlands are dynamic ecosystems with complex interrelationships of hydrology, soils and vegetation. Like other green areas, these wetlands are also under tremendous environmental degradation. As a result, this important environmental source is depleting at an alarming rate. Therefore, an internationally acceptable up to date scientific technology is required to monitor wetlands effectively. It has established that the satellite remote sensing (SRS) and geographical information systems (GIS) are the state-of-the-art technologies for mapping, monitoring, and management of huge wetlands.

Wetlands are key natural resources providing livelihood opportunities for the local communities. However, unsustainable methods of exploitation of these resources coupled with lack of sustainable and participatory policies and planning to conserve such resources have resulted in degradation of such resources and threatened the very survival of the communities dependent on such resources (Sangatsindh.org). Wetlands have actually a high economic value while decision makers often have insufficient understanding of the values of wetlands, including the economic value, so the protection of wetlands does not appear to be a serious alternative. Analyzing the existing valuation studies, WWF estimated that the Ramsar Convention's global wetland area of about 12.8 million km², would have an annual global value of US$70 billion. Recognizing the economic importance of wetlands in addition to their biodiversity, scientific value, climate regulation, potential tourism, socio-cultural and other important wetland values (that were not included in WWF's calculations) is yet another good reason to reverse global wetland loss.

In Sindh there are more than 100 wetlands of which about 90% fall on the left bank of Indus and the rest are located on right bank of Indus. They range from coast, river, lake, marsh, pond and channels to lagoons. There are three wetland complexes namely Deh Akro II (32 dhandhs) located in district Benazirabad, Chotiari (22 dhandhs located in Sanghar district and Indus delta/coastal wetlands (15 wetlands) located in Badin and Thatta districts. Rest of the wetlands are located in other districts of Sindh. Wetlands of Sindh declared as Ramsar Sites are i) Haleji lake ii) Keenjhar lake iii) Drigh lake iv) Indus dolphin Reserve v) Deh Akro II wetlands complex vi) Indus delta vii) Rann of Kutch viii) Nureri lagoon ix) Jabbo lagoon x) Hub dam. All wetlands are storehouses of biodiversity and sources of livelihood of majority of population. Biodiversity found in these wetlands are wetland vegetation, plants fish, birds, wildlife, and other aquatic life.

1.1 Major Issues and Problems

Major issues causing threats to wetlands are; droughts, eutrophication, bad agricultural practices and agricultural runoff. Release of untreated industrial effluents, coastal and estuarine habitat loss due to sea intrusion, shortage of freshwater in Indus, species loss, habitat shrinkage, disposal of saline drainage water of drainage systems, increase in salinity levels, extraction of groundwater and development projects are also among the causes of wetland degradation (Rahat Jabeen, 2004).

All these factors individually and collectively have emerged in significant degradation of wetland ecosystems in Sindh. There is urgent need to take steps to revive wetlands by preparing wetland management plan focusing on development, conservation, structural and non-structural interventions and strict protection through participatory approaches involving stakeholders' especially local communities.

Some of the uses that threaten wetlands are:

- drainage for irrigation and agriculture
- as a source of drinking water
- using the wetlands waters for electricity generation
- human settlements
- dredging sediments and exploiting mineral resources
- intensive harvesting of wetland goods

1.2 Problem Statement

Since the 1960s, when the Kotri Basin drains were built to discharge into the dhands, they have become an important local fishery, and a waterfowl habitat of international importance. Portions of two of the Sindh dhands (Sanhro and Mehro) have been declared Ramsar sites, and the Rann of Kutch is included on the WWF list of the 200 globally most important biodiversity hot-spots. The natural pattern of surface drainage and overland flow, especially of storm runoff, from this coastal and near-coastal zone in Badin District is south and southeastward towards the Rann of Kutch. To avoid discharging LBOD through KPOD directly into this environmentally sensitive international wetland, a Tidal Link drain was built 42 km southwestward across the dhands and the Rann of Kutch from KPOD to the nearest active tidal creek, Shah Samando Creek. The Tidal Link drain was isolated from the Rann of Kutch and the dhands by high embankments. An 1800 ft weir, called the Cholri Weir, was built where the Tidal Link Canal passes through Cholri Dhand in order to attenuate high water levels in the Tidal Link drain during high tide by allowing water to flow into the dhands during this period, and to protect the dhands from excessive drainage during low tide when the water would flow back into the Tidal Link Canal.

The present conditions of the outfall area are quite different from the ones observed when LBOD outfall system was in the stage of preparation and before it started operations. There is now an open connection between the dhands and the Tidal Link, exposing the dhands to large tidal fluctuations, sea water intrusion, sedimentation, and excessive drainage during low tide. A small tidal creek type system of drainage channels has now developed in Cholri Dhand, which is closest to the Tidal Link. No tidal fluctuations are evident in Sanhro and Mehro dhands. The Tidal Link drain bed and banks were constructed with the soil obtained from the canal excavation and consisted mainly of silty loam in which scour and erosion processes are highly sensitive to flow velocity. These analyses determined that tidal fluctuations would be felt all the way up to the Tidal Link Canal from Shah Samando Creek to a point somewhere near the terminus of KPOD, but sea water was not expected to penetrate more than 19 km upstream to an area about 5 km downstream of the Cholri Weir, the main connection between the Tidal Link and the dhands. At present both tidal fluctuations and sea water intrude into the dhands and KPOD, and the drainage and environmental functions of the Tidal Link portion of the LBOD outlet are impaired.

The stakeholders pointed out that the main cause of the entire problem is the tidal link. This structure if plugged may stop the seawater intrusion into the area. The NESPAK report of 2009 following the demands of the stakeholders suggested that the tidal link is required to be plugged at RD (-140) and at RD (-110) near the Shah Samando creek. The report further supported the idea of constructing a road on the northern side of the tidal link from the end of

KPOD up to Shah Samando Creek. The National Institute of Oceanography (NIO, NESPAK, 2009) conducted hydrological investigations and tidal behavior in the tidal link area and submitted a desk study in 2012. The findings of the report are as under:

i. Due to extensive damage the seawater influence has increased manifold within the Tidal Link Drain and Dhands. The marked seawater influence can now be traced up to RD +2 and beyond instead of RD -50 / RD –55 within the Tidal Link Drain during pre-cyclone period.

ii. The effective length of the Tidal Link Drain for discharges from LBOD has now been reduced to RD -38 due to several breaches in the embankments during most part of the year particularly during Southwest monsoon. Most of the drain water discharges from LBOD through KPOD into the Tidal Link Drain at RD -38 does not reach its logical end at the Sir Creek (i.e. RD –155).

iii. The presence of a number of breaches in the Tidal link drain has resulted in complex and slightly abnormal behavior of the Tidal currents in the area particularly during southwest monsoon period.

iv. During the winter season (November through February) the LBOD is still functioning to carry the saline drain waters to the end of Tidal Link Drain (RD –93 and RD –125) for final disposal to the Arabian Sea. This is due to the reduced hydraulic pressures / resistance from Tidal inflows during the winter season (i.e. November through February period).

v. During Southwest Monsoon (Mid April to June) there is overall residual water inflow to dhands and to KPOD instead of the residual flow to sea. However, the situation is restored back to normal during most part of the year with natural flow towards the creeks with the arrival of run-off from the land in the rainy season (July-August).

vi. Between RD -55 and RD -95 the embankments of the drain were found breached at a number of points at both sides of the Tidal Link Drain. The water was seen flowing out of the embankments through these breaches. The depths within the Tidal Link Drain have changed drastically. Huge quantity of silt and mud appear to have been deposited at many places within the drain due to accretion along with erosion at different nearby points. This situation has changed the entire depth profile of the Tidal Link Drain, which now stands altered drastically with reference to its designed depth.

vii. The effective length of the Tidal Link has been reduced up to the point at the first breach in its embankments (RD –38) and it is still functioning up to that point. Beyond RD –38 there is an exchange of water over a Tidal Cycle between various dhands, water from KPOD and seawater from Shah Samando Creek and also from Rann of Kutch. The complex water exchange at RD –93 with discharge from KPOD and water from adjacent dhands and from Rann of Kutch does not represent the discharge from LBOD at this point. Therefore water discharge values at RD –00, RD –22 and RD –38 represent the actual situation.

viii. Drainage from the dhands to the tidal link at Ebb tide is strong, and a visible drainage network (having the appearance of a typical tidal creek) has formed in Cholri Dhand and to a lesser extent in Pateji Dhand.

ix. It is therefore concluded on the basis of the available data that the hydraulic performance of the Tidal Link Drain has been reduced considerably and its effective length to carry Agriculture Saline Discharges to Shah Samando Creek have reduced upto RD –22 and RD -38 instead of RD –125 and RD -155 as per original design.

x. On the basis of observations and existing hydraulic regime appropriate recommendations have been made by the NIO (NESPAK Report 2009) to restore the LBOD flow upto RD -65.

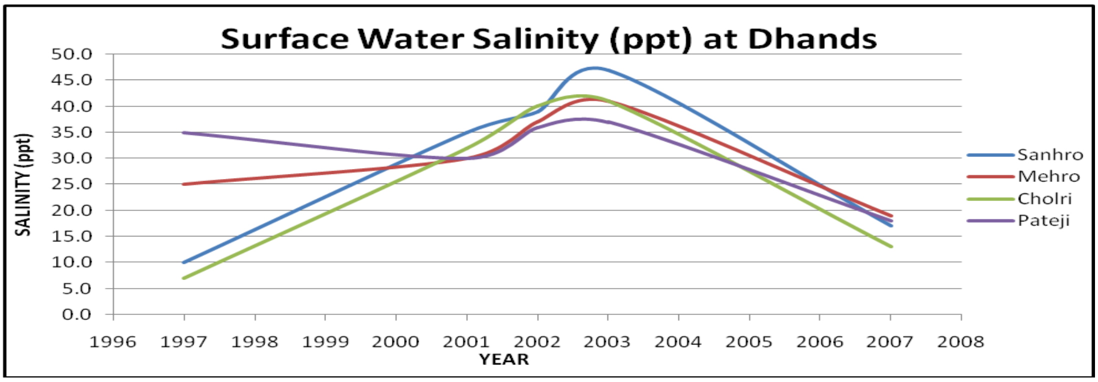
a) Reinforcement of the LBOD right embankment, and the construction of escapes from the left bank of the Spinal Drain and KPOD in the direction of the Thar using to the extent possible the ancient Dhoro Puran river bed. Install flap-gates in the drains discharging into LBOD drain.
b) Diversion of the Serani drain and other Kotri drains into the dhands.
c) Possible connection of the Pateji and Mehro dhands
d) Construct a gated structure at the DPOD and KPOD to control the flows in both directions.
e) Analyze the location of the tidal control structure in the KPOD and possible control structures in the drains.

After the failure of Cholri weir, the sea water is continuously flowing into the dhands (twice a day on the rise of tide) since last more than 14 years. This water has changed the hydrologic conditions of the dhands. The dhands have lost the local fish, the fauna and flora, the migratory birds and the natural ecosystem. To and fro movement of tidal water into and out of dhand complex have developed a creek system on its own owing to the erosion due to fast evacuating sea water from the dhands when tide recedes.

To stop seawater entry into the dhands, there is need to restrict the entry of tidal water into the dhands. The cyclone 2A of May 1999 and subsequent rains of 2003, 2006 and in 2011 as well as the fast moving tidal water that continuously eroded the soil from within the creeks deepening and widening them progressively. Various experts including the visiting International Panel of Experts have pointed out that it would be practically impossible to stop the seawater entry into the dhands through the major creek that had developed at the place of the Cholri weir that completely failed in 1999 cyclone giving twice a day entry to the tidal water to roam around the dhand complex and return back on tide recetion.

1.3 Salinity status of Wetlands

The salinity in the tidal link as well as the dhands after the collapse of Cholri weir started increasing gradually with the passage of time till 2003-04 then gradually decreased Figure-1 and Table-1.This occurred because seawater intrusion into the dhands took place right from the time the weir was damaged and tidal water got intruded into dhands through this opening (weir). The salinity recorded in dhands in 2012 was also in the range of 64 to 70 dS/m almost same as of 2003-04. This showed that the salinity of dhands has become almost stable at this range due to continued back and forth movement of the tidal waters in dhand complex.



(Source: NIO, NESPAK 2009)

Figure 2: Surface Water salinity of Coastal Dhands from 1996-2007

Table 1: Surface Water Salinity of Dhands

RD's	YEAR									
	1997 (Before Cyclone 2A)		2001		2002		2003		2007	
	Salinity (ppt)	Depth (m)	Salinity (ppt)	Depth (m)	Salinity (ppt)	Depth (m)	Salinity (ppt)	Depth (m)	Salinity (ppt)	Depth (m)
Sanhro	10.00	0.80	35.00	0.70	39.00	0.50	47.00	0.40	17.00	0.40
Sanhro Mehro	25.00	0.60	30.00	0.60	37.00	0.30	41.00	0.30	19.00	0.30
Cholri	7.00	1.00	32.00	0.80	40.00	0.80	41.00	0.70	13.00	0.60
Pateji	35.00	0.50	30.00	0.60	36.00	0.60	37.00	0.60	18.00	0.50

(Source: NIO, NESPAK 2009)

1.4 Expert Views on the Dhand Complex

The World Bank organized a mission of International Panel of Experts in March 2005 to review the conditions at the outfall and identify the possible alternatives to mitigate the damages. They reported that both tidal fluctuations and sea water intrude into the dhands and KPOD, and there is now an open connection between the dhands and the Tidal Link, exposing the dhands to tidal fluctuations, sea water intrusion, sedimentation, and excessive drainage during low tide. The LBOD can now be described as a “new river” that is forming an estuary and is an integral part of creek formation into the coastal area. The Tidal Link has invited the sea to approach the land and now the tidal fluctuations are visible. This process will continue, and its progress is difficult to predict. Adapting to this new process requires continuous hydraulic and environmental monitoring in a learning by doing approach. The IPOE suggested that LBOD Stage II & III in light of the present outfall conditions of LBOD Stage I should be postponed until the existing problems at the outfall are adequately address and solved.

John Field Farmington, WAPDA (2011) in his report "Geomorphology Review of Redesign of LBQD Stage-1 Badin Area Drainage System" reported after analyzing the existing conditions of the LBOD outfall that severe erosion of the Tidal Link, breaches in the flanking embankments, and the collapse of Cholri Weir are ongoing problems with the LBOD drainage system caused by several natural and anthropogenic processes. The structural plans to limit further enlargement of the Tidal Link, seawater intrusion into KPOD and smaller branch drains, and degradation of water quality in the dhands need to be built with far more reinforcement than the initial Tidal Link in order to survive in an environment facing earthquakes and the specter of global climate change where the effects of tides, cyclones, and sea level rise are likely to worsen over time. Therefore the structures such as tidal plugs should have sheet piles 100 feet or more below the bed of the tidal link as the risk of failure will be too high and the potential for rapid repairs to damaged structures low given the remoteness of most areas.

1.5 Experts visit of Tidal link and Dhands in 2012

Master Plan Consultants made a visit of tidal link and dhand complex in 2012 to observe the morphology of the area to suggest the possible structural/non-structural measures to improve outfall conditions for LBOD. Main objective of the visit was to identify and analyze the existing conditions of the tidal link, the process of creek development and the flow of tidal water from sea through tidal link to Dhand complex and back to sea. The depth of the creek developed at the failed Cholri weir was determined and water samples at four different locations of the creek were collected for analysis to know the salinity status of the water in the creek

Table 2: Water quality of the samples collected from creek at four different locations

Location	Coordinates	Depth of water (ft)	Altitude (ft)	TDS (ppm)	pH	Salinity EC(mS/cm)
At Cholri Weir	24 15.5478 N 68 40.4230 E	37	3.25	41216	8.3	64.4
Creek in dhand	24 16.0502 N 68 37.1513 E	26	4.93	44352	8.4	69.3
Creek at zero point	24 15.3603 N 68 40.7705 E	18	10.22	44800	8.3	70.0
Tidal link RD (-53)	24 15.3640 N 68 40.7542 E	20.5	9.02	41336	8.3	65.0

Following observations were made during the visit of the tidal link and suggestions are also offered about proposed structural / non-structural measures:

1. The design top width of the tidal link at the beginning was 152 ft and that at the outfall 233 ft. This width has increased manifold and has reached 3600 ft or more at some places in the vicinity of the outfall and near dhand complex
2. Pronounced scouring of the tidal link banks was noticed with mixing of the eroded soil in the tidal link waters making it muddy and highly turbid. The creek developed at the location of damaged Cholri weir kept deepening and widening with the passage of time due to erosion by high velocity tidal waters at the time of tide recession.
3. Flow of tidal water to and from the dhand complex together with wave wash has tremendously eroded the tidal link banks and the process appears to continue that may result in width wise expansion of tidal link for quite some time.

4. Presently the tidal link has been converted to a sea creek due to non existence of protected bunds.
5. Due to erosion, the coastal lands of Badin and Thatta districts are progressively under severe threat of washing away into the sea by tidal waves.
6. Stopping seawater intrusion is therefore, the need of the day because the tidal influence is adding to the environmental degradation causing severe scouring of soil and adding to the salinity of soils in dhands area.
7. The coastal wetlands are an important ecosystem and a predominant source of livelihood for coastal communities. The revival of the coastal wetlands has therefore become a dream unless some viable solution to check sea water intrusion is made effective and is sustainable
8. Apparently the structural solutions does not seem workable in this area, therefore, ecosystem approach for the revival of dhand ecosystem is proposed taking start from the northern end of dhand complex and moving gradually towards south and southeast.
9. The team has already proposed a biological solution i.e plantation of mangroves in the area. This solution is to be extended and implemented on the potential sites so as to ensure their protective role.
10. The interventions of Zulfikarabad Project which is being actively executed in the coastal areas of Jati, Shahbander, Kharochan and Keti bunder are also of worth consideration.
11. If the option of any structural solution is considered, the cost of the intervention would surpass the benefits to accrued. Secondly, the prevailing conditions at tidal link do not warrant to take risk of possible failure of structure either at the tail end of the tidal link or the place where the cholri weir failed.

NIO was entrusted to recommend most appropriate option for the restoration of the coastal dhand complex. The recommendations extended by the NIO in 2012 are reproduced below in the following paragraphs.

1.6 Possible options to conserve and improve the dhand ecosystems

First step should be to construct a low embankment or bund separating Cholri Dhand from Sanhro Dhand. The viability of this option might be questioned because of the likelihood of severe wave erosion, but low cost measures might be formulated to adequately protect the embankment. However, this option should be viewed as a serious step because it cuts off all opportunity for water to circulate between the dhands and it prevents the recruitment of juvenile fish, shrimp and other fauna. Moreover this option should not be chosen until the dynamic water balance and patterns of water movement within the dhand system are well known and a verified model of these dynamics can be used to assess the feasibility and impact of this option.

ii) increased flow of brackish, relatively low salinity water into the dhands is the best restoration strategy assuming this would shift the water and salt balance toward a lower salinity environment, something that can be determined by a comprehensive monitoring program designed to provide the data needed to analyze the dynamic water quantity and quality balance in the dhands. At present, studies have begun to provide data and analysis to support ongoing negotiations concerning the allocation of Indus River flow to the Indus River and delta below Kotri Barrage. Should these negotiations prove successful from Sindh's perspective, a percentage of the flow available should be diverted into the Kotri canals and drains to the dhands. This would likely have a significant impact on the restoration process.

iii) a number of non-structural natural measures that might attenuate the influence of the Tidal Link on the dhands and in particular slow or stop its progression beyond Cho lri Dhand. A belt of mangroves generally along in the alignment where Cholri Dhand joins Sanhro Dhand has been suggested as a way of trapping sediment and attenuating any tidal pulses or effects that might enter Sanhro Dhand. However, past attempts to establish extensive mangrove belts or forests in this area of the coastal zone have not been successful probably because of the soils (they are reported to be flourishing in the area of Shah Samando Creek though over harvested by local people). *A third possibility is to try to establish appropriate specie of reeds and other grasses that are well adapted to the prevailing salinities in the shallow silted area between Cholri and Sanhro Dhands. Such a reed and grass belt would behave much like a constructed wetland filtering both sediments, pollutants and nutrients moving from Cholri Dhand to Sanhro Dhand.* Care would have to be taken to not prevent the recruitment of fish and young shrimps from the Tidal Link or the movement of breeding fishes toward the delta and the marine environment. If the dhands were to begin a slow recovery initiatives would have to be undertaken to organize fisherman and provide training and awareness to stimulate their management of the fishery by preventing over- fishing and use of fine mesh nets that take excessive quantities of young fish and shrimp.

For the time being the best strategy is to ensure increased flow of brackish water into the dhands from the Kotri drains including the diversion of those drains that currently flow into KPOD, and to intensify the monitoring of water levels, tides, sediment, bathymetry , salinity and drain flows in the Dhands to improve the understanding of the water balance and to find out any negative trends that emerge in order to formulate mitigation measures.

A wide range of interventions have been suggested by both the affected people in the region and District authorities. Most of these proposals are well understood and typical of interventions being implemented elsewhere in many areas of Sindh today. But the context of these interventions in the Sindh coastal zone, and most particularly in the area of the Badin dhands is unique. This is an area of high risk from natural disasters, especially cyclones and heavy monsoon season storms that cause extensive and damaging floods, in which narrowly conceived, piecemeal interventions appear to have made the risks even greater. Moreover, success depends to a significant degree on managing a highly productive and economically important ecosystem, something with which Sindh has had little experience and even less success in the past. This is so despite the availability of necessary scientific and technical expertise within the Sindh community.

1.7 Proposed solution for the revival of the coastal wetlands

Coastal wetlands of the coastal area are highly protected areas both at national and international levels. They are the pool of biodiversity and source of livelihood of coastal communities providing all types of ecosystem services but have been degraded primarily due to failure of drainage infrastructure at the tail end, sea intrusion and associated factors. Being protected areas of high degree, the major structures or activities are not allowed as these will disturb the ecosystem and its services on the one hand and will be against the provisions of national and international agreements.

As pointed out by the experts in the above paragraphs, the structural solution for stopping the seawater into the dhand complex is risky and would require huge investments. Under present circumstances with higher frequency of storms and cyclones on Sindh cost, the structural interventions are supposed to be vulnerable and risky. The only workable solution would be tackling the problem through *"Ecosystem Approach"* "a strategy for the integrated management of land, water and living resources that promote conservation and sustainable use in an equitable way". Thus the management approach will focus on the land resources, water resources, biological resources and human resources to the extent that all are managed with an integrated approach without compromising on the sustainability and the benefit to the concerned communities. The approach would be to revive original ecosystem of the dhands step by step without harming a particular entity.

1.8 Due Diligence & Technical approach

The main activities to achieve the anticipated targets include: i) survey of the entire coastal wetlands and water resources of the area ii) identification of potential sites for local fish culture, agriculture, grasses for livestock and better environment and habitat for migratory birds iii) Soil and water testing for establishing the conditions of soils and water resources; and iv) selection of suitable crop, grasses, fruit and or wood trees for specific soil and water conditions.

2 Ecosystem Approach for Restoration of Coastal Wetlands

In the light of the recommendations of the NIO, a workable solution is proposed on the "Ecosystem approach for the revival of the coastal wetlands. Under this approach a gradual development of the area is proposed starting from the north western side of the dhands progressively going to south east developing the entire area covering the selected parcels of the land under various interventions including fish ponds, salt tolerant crops, salt tolerant fruit and wood trees, salt tolerant grasses etc.

Ecosystem is a community of organisms and their physical environment interacting as an ecological unit. It is a complex of living organisms and their non-living environment. Thus it is "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit". Furthermore, ecosystem is an interconnected community of living things, including humans, and physical environment within which they interact. There are three major types of ecosystems in the project area i.e freshwater ecosystems, terrestrial ecosystems and deltaic/coastal ecosystems.

Almost all the ecosystems designated as Protected Areas where large scale development activities that create disturbance for the biotic components of that area, are not carried out. These ecosystems are managed under an approach called as **Ecosystem Approach**. The Convention on Biological Diversity (CBD) describes the ecosystem approach as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way". It encompasses the importance of maintaining ecosystem functions for both biodiversity and human livelihoods. In order to achieve these goals, the ecosystem approach promotes management of natural resources at the landscape level recognizing the need for engaging with a variety of stakeholders.

Ecosystem approach places the human needs at the centre of biodiversity management. It aims to manage the ecosystem, based on the multiple functions that ecosystems perform and the multiple uses that are made for these functions. The ecosystem approach does not aim for short-term economic gains, but aims to optimize the use of an ecosystem without damaging it.

There are considerable similarities between the Sustainable Livelihoods and Ecosystem approaches. A combination of these two approaches has been used to bridge the gulf between exclusively conservation-oriented approaches and exclusively development-oriented approaches. Ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It encompasses the importance of maintaining ecosystem functions for both biodiversity and human livelihoods. Therefore, an integrated management-approach components i.e the land, water and living resources are proposed to be managed and developed through community participatory approach.

2.1 Ecosystem services

Ecosystem services are usually defined as the aspects of ecosystems used (actively or passively) to produce human wellbeing. Four categories are include ***provisioning services*** such as food and water, ***regulatory services*** such as flood and disease control; ***cultural services*** such as spiritual and recreational benefits; and ***supporting services*** such as soil formation and photosynthesis that maintain the conditions for life. Ecosystem services are the link between ecosystems and human wellbeing, with ecosystem service transformed by other forms of capital to provide benefits.

2.2 Degradation of the dhands

Historically, freshwater entered the dhands through distributary channels connected to the Indus River, although some, if not most, of these channels were flowing only during flood stage. Given the variable timing of freshwater inputs from the drainage canals and marine inputs, the salinity in the dhands ranged from 15-45 dS/m before construction of the Tidal Link (NESPAK, 2009). By 2004 salinity had increased with measurements of 60-70 dS/m in Pateji Dhand.

Construction of the Tidal Link cutoff the exchange of waters between the dhands to the north and south such that those from the south no longer had significant freshwater inputs. The collapse of Cholri Weir, the widening of the breaches through the embankments, and the growth of tidal channels into the dhands has led to a twice-daily tidal fluctuation into Pateji Dhand. The resulting changes towards a more marine environment have had a dramatic impact on fish production and the livelihoods of 200 local fishermen. As the tidal channels grow further into the dhands, both to the north and south of the Tidal Link, the brackish water lakes are increasingly exposed to large tidal fluctuations, sea water intrusion, sedimentation, and excessive drainage during low tide. In addition to the impacts the Tidal Link has had on the dhands, dhand degradation already begun before 1995, because freshwater inputs from the Indus River had been severely curtailed by the completion of the Kotri Barrage. While some freshwater continues to reach the northern dhands through the drainage canals, sugar factories and other sources often pollute this water, further degrading water quality.

2.3 Land status of coastal wetlands

The Tidal Link Canal bed and banks were constructed with the soil obtained from the canal excavation and consisted mainly of silty loam in which scour and erosion processes are highly sensitive to flow velocity. The analysis indicated that the sea water was not expected to penetrate more than 19 km upstream to an area about 5 km downstream of the Cholri Weir, the main connection between the Tidal Link and the dhands. Due to the sensitivity of the soil of the tidal link, the erosion of the bed and banks continued right from the inception of the tidal link canal and the process continues till today resulting in the breaches of the banks and erosion of the bed.

2.4 Biodiversity

Wetlands are the most productive environments essential part of our landscape. They are the cradle of biodiversity and an important component of the freshwater cycle. Wetlands provide numerous benefits that include rich floral and faunal habitat, improved water quality, flood abatement, water storage and groundwater recharge, support for fisheries, and opportunities for landscape and recreation. Wetlands are dynamic ecosystems with complex interrelationships of hydrology, soils and vegetation. Like other green areas, these wetlands are also under tremendous environmental degradation.

a. **Vegetation**
At present all the vegetation in the coastal wetlands have been vanished due to increase in the salinity of the dhands

b. **Fish**
Local fish that used to be the source of livelihood of the local communities have completely disappeared / destroyed due to salinity status of the dhands. Only shrimps and small size fish is available that cannot provide sufficient livelihood for people

c. **Agriculture Crops**
There were no agriculture crops but reed grasses were growing in the dhand complex on which the livestock of the communities depended but all the reed grass did not survive due to high salinity in the dhands after the collapse of the Cholri weir.

d. **Livestock**
The people living around the dhand complex used to have livestock for their families that depended on the reed grasses. Since there is no fodder, people have either sold their livestock or handed over their cattle to their relatives in other areas

e. **Marshy vegetation**
There are marshy lands in the dhand complex area. These lands could be utilized for grasses or arable cropping. Marshy lands historically have been converted to use for arable farming by the use of various practices that drain the water from the subsurface of the soil. When the soil is saturated with water, it is devoid of oxygen. Crops used in arable farming need this oxygen in the soil that can be made available through proper drainage.

2.5 People and their livelihood

People of the coastal area are poor and depend for their livelihood on fishing. The change of dhand ecosystem due to failure of Cholri weir has adversely affected the livelihood opportunities of these people. Local fish cannot survive in marine environment while the marine fish is not the priority of the local people. Thus the local communities are not earning their livelihood to the extent they used to earn in pre-LBOD time.

2.6 Site identification and selection

Site selection is an important step for this intervention. The exact areas to be earmarked for local fish culture, for various crops, grasses and trees will be identified through field visits / surveys, and in coordination and counseling with stakeholders and by observing technical details. It is estimated that about 20,235 hectares will be brought under project interventions selecting 8,094 hectares for local fish, 4,047 hectares for various crops and 4,047 hectares for suitable grasses for livestock and 4,047 acres for trees.

2.7 Proposed Activities

Following activities are proposed for the rehabilitation of coastal wetlands to get profitable use of these natural resources that have badly been degraded seriously affecting the livelihood of the communities that depended on these wetland resources.

2.7.1 Land Fragmentation

The available land in the wetlands will be earmarked for different management options i.e salt resistant crops, salt resistant trees/shrubs, planting of mangroves on potential sites within the wetland area and adjacent areas, management of water resource from inland area and seaside, identification of sites for establishing open area fish ponds, areas where no activity could be proposed. The outcome of this activity will provide a base for planning other interventions in the proposed project area.

2.7.2 Water Management

There are two sources of water entering in the proposed project area i) drainage water from Kotri surface drainage through different drains such as Mir Western drain, Karo Ghunghro drain and Guni Phuleli drain and ii) sea water through tidal effect.

The management of both the waters sources is an important intervention for restoration of wetland ecosystem. It is essential that the type of activities should be environment friendly without creating major disturbance on each component of biotic life and the local stakeholders' acceptance.

2.7.3 Water diversion interventions

Under extreme storm flood conditions the KPOD runs at its full capacity carrying storm water. This water can be diverted through some diversion structure proposed to be built upstream of the tidal control structure on KPOD. This good quality water when diverted to dhand complex will add to the dhand water thereby reducing the salinity of the dhands as well to attract the migratory birds and the grasses will flourish. This will reduce the effluent flow in the KPOD that may help reducing the back water flow effect in the sub-drains falling directly in the KPOD system.

2.7.4 Open-ended water retention interventions

Under ecosystem approach, the rainwater could be retained in dhands by open ended water retention technique. With this, some quantity of rain water could be retained by constructing open ended retention bunds that will collect water in depressions but will allow extra water to flow to the other places. This way, some rain water will be retained in depressions for fish or birds or for the vegetation to grow for livestock.

2.7.5 Water harvesting interventions

Efforts will be focused to collect and retain rain water and water from other sources including the drainage water from adjacent fields in the depressions for use when the there is water scarcity in dhands with an aim to keep the dhands always wet with sufficient water.

2.7.6 Activities for management of tidal water

Tidal water at present circulates throughout the dhands twice in 24 hours. This process adds to the salinity of the dhands as well as creates a marine environment that that drastically changed the ecosystem of the complex. The local Sindhi fish has altogether disappeared; the reed grasses have been burnt due to salinity and migratory birds do not stay due to continuous to and fro movement of water in dhands. Therefore, there is dire need to stop the tidal water entering the dhands from creek developed at the collapse of cholri weir that keeps deepening and widening due to increased velocity of flow of tidal water when tide recedes. The consultants in principle agree that the flow of tidal water in dhand complex must be stopped. A study is awarded to the NIO for monitoring the morphology of the tidal link and tidal behavior to suggest suitable alternatives for stopping seawater intrusion into vast areas of the coastal wetlands now under the grip of the sea. The proposed ecosystem approach shall however deliver fruitful results when a sound and viable proposal is suggested by the NIO to stop seawater towards dhands.

2.7.7 Biological / Green infrastructure

Vegetation in the wetlands will certainly improve the ecosystem and ecology of the dhands. Vegetation in the form of grasses, salt tolerant trees, and salt tolerant crops will certainly bring back the condition that existed before the LBOD. The objective of enhancement of biological infrastructure is to incorporate various biological activities to improve the wetland ecosystem and its services. The proposed interventions are:

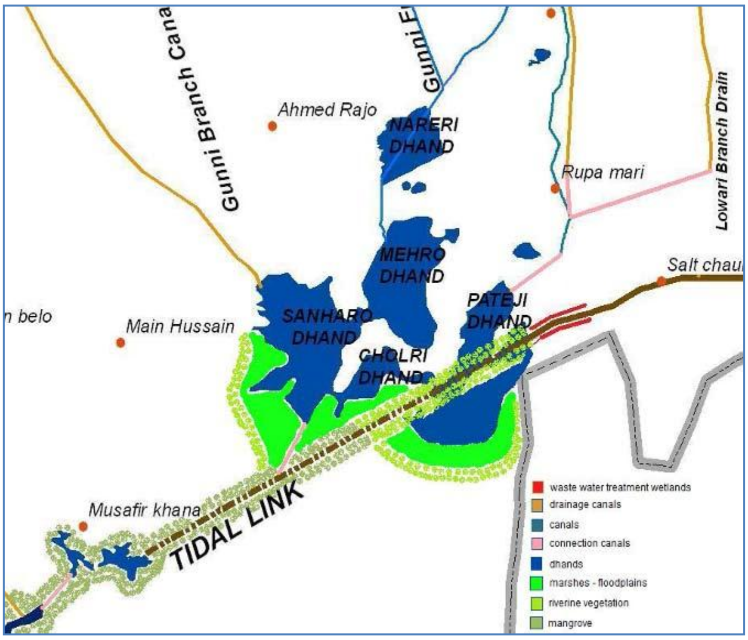


Figure 3: Salt Tolerant Trees on the berms of the Tidal link

2.7.8 Mangrove planting on potential sites

The survey teams will identify the potential areas in the coastal belt for growing various mangroves species that suit to the prevailing environmental conditions.

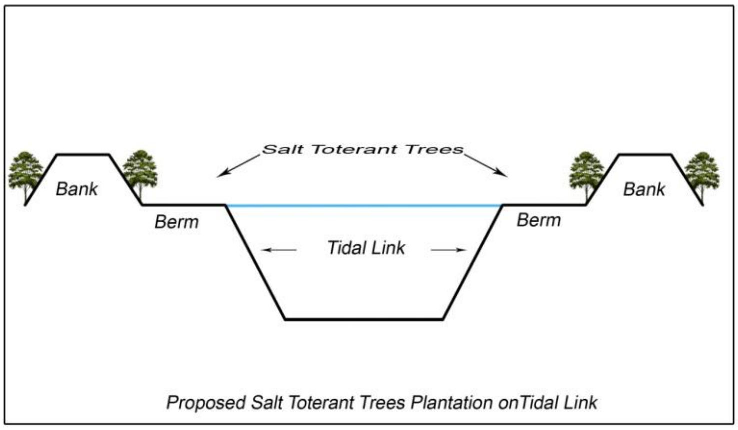


Figure 4: Growing of Salt tolerant trees on the banks of Tidal Link

2.8 Growing mangroves in the vicinity of tidal link

There are two main objectives of planting mangroves in the vicinity of the Tidal link particularly in most potential areas are i) to stop seawater intrusion into the dhands and ii) to revive the dhand ecosystem as of pre-LBOD period. The stakeholders perceive that by reviving the dhand ecosystem, the natural environment shall be revived back. This will open the livelihood opportunities for the communities living in the

vicinity of dhands. Furthermore, the local fish culture in the dhands will come back when the dhands will be provided either fresh storm water or brackish drain water from Kotri surface drains having a very slight salinity <2000 ppm. Local fish would certainly survive and flourish in this water that will stay in dhands for long.

2.9 Plantation of salt –tolerant trees/shrubs

Salt tolerant shrubs and trees of promising species that could generate income for the communities as well as improve the ecosystem shall be selected and grown in the selected potential areas of the dhands and around the tidal link banks.

2.9.1 Growing of salt tolerant grasses and crops

Grasses as fodder for the animals as well as salt tolerant crops shall be grown in the potential areas with sufficient water availability to promote the interest of the people in the development of the dhand ecosystem.

2.9.2 Establishment of freshwater and brackish water fish areas

Depending upon the location and salinity of the water available in the depressions, suitable freshwater fish species will be developed to support the fishermen families to earn their livelihood easily.

2.9.3 Promotion of livestock hay and breeding and marketing arrangements

When the grasses in the dhand complex will flourish, naturally the livestock will thrive on these fodders. The communities will have the opportunity to enhance their incomes with rearing the livestock.

These all activities will improve ecosystem, protect environment, provide livelihood sources, address the problem of erosion and sea intrusion, reduce the adverse impacts of tidal effect, and use drainage and sea water for some productive and protective functions.

2.9.4 Stakeholder’s participation

The activities include:

- Promotion of Participatory Approach
- Stakeholders’ Capacity Building
- Workshops and Trainings
- Exchange visits
- Constitution COs’, VOs’, and their roles and responsibilities
- Institutional Strengthening
- Marketing of products

3 Project Objectives

The coastal dhands were natural depressions receiving water from Kotri Drainage Basin and the runoff water from monsoon rains. Rising salinity in the dhands in particular, is compromising their biological integrity: birds and waterfowl are suffering, distinctive vegetation is being lost, and there has been a major decrease in yields and species composition of the fishery. By rehabilitation, the dhand ecosystem shall be revived with stoppage of seawater.

3.1 Phase II Tasks covered by this project

Sub Tasks II.10 *Sea Water Intrusion - determine extent, nature and intensity*

The Consultant will further develop existing WAPDA studies to determine the extent, nature and intensity of high sea levels and surges that may be caused by anticipated high storms and that may block the direct discharge of the water and raised the levels in the KPOD and LBOD and propose the physical measures to prevent sea water entering into these main drains systems. Study the anticipated limits of sea intrusion and tidal effects. Using the field data investigate intrusion of marine ecosystem and model its effects. Also evaluate and propose measures to reduce the deterioration of wetlands through seawater intrusion.

Sub Tasks II.11 *Assess the conditions of dhands, water bodies, wetlands, ecosystems and mangroves in coastal zone*

To address the critical environmental concerns of this project, the Consultant will assess in detail the condition of dhands, wetlands, water bodies and other ecosystems and mangroves in the coastal zone and the socio-economic role they play in the area. The Consultant will determine management options, drawing upon international experiences, develop a strategy for their sustainable use recognizing the environmental importance of the region and its considerable economic potential in particular for the local communities depending on these resources. Drawing from the findings of the assessment the Consultant will develop recommendations on ecologically acceptable alternatives for conserving and sustaining the prevailing ecosystem.

3.2 Issues developed due to sea intrusion in dhands

i. The arrangement to maintain the Dhands ecosystem adjacent to the Tidal link as envisaged in the LBOD project proposal have failed due to the failure of the cholri weir and breaches in the bunds. The seawater moves into the dhands due to tidal effect and when tide recedes, the dhands get vacated with little sea water left in depressions.

ii. The seawater has deserted the dhands. The brackish water dhands have turned into saline and the reed grasses, the water fowl, and the freshwater fish have disappeared.

iii. The entire ecosystem has changed affecting the fauna and flora of the dhand complex.

iv. The livelihood opportunities have dwindled and the villagers settled around the dhand complex have either migrated or passing a miserable life due to scarcity of livelihood opportunities

v. The fertile lands around the dhands have severely been degraded and the production from these lands has gone down.

vi. The livestock population has declined due to non availability of fodder for animals.

vii. The marine fish species have replaced the freshwater fish. The price of the marine fish is just Rs. 15-20 per kg as such the people have almost lost their livelihood resources.

3.3 Dhands revival is expected to revive the following facilities

a) Freshwater fish have preference over the marine fish by the local people. There is enough market for the local fish species in villages and towns of Sindh. The expected fish production as estimated taking a thumb rule of 50 kg per acre shall be 1 million kg /year. Assuming the rate of fish as Rs. 100/- per kg would yield an income of Rs.100 million annually.

b) The population of migratory birds and local water fowl in the dhand complex has significantly decreased due to loss of habitat; that is expected to revive with the revival of the habitat.

c) The salinity of dhands will improve that will reduce the chances of soil salinization of the lands near the dhands.

d) Salt tolerant grasses will grow in dhands that would be utilized as fodder for livestock. This will motivate livestock farming

e) Livelihood opportunities for the people residing in the vicinity of dhands will be develop

f) Ecosystem of the area will improve creating a better environment for the wild life and biodiversity.

g) Dhand water in excess could be used for farming under water scarcity conditions.

h) Construction of tidal control gate across the KPOD will create heading up of storm water in KPOD upstream. This good quality water if diverted to dhands through a weir upstream of the gated structure will conserve water in dhands that could be used for cropping of the adjacent lands in water scarcity conditions.

3.4 Options and solutions to be offered by the project

i. The project will focus on the revival of the ecosystem of dhand complex to the status it was before the LBOD intervention

ii. The stakeholders of the area and the communities will work as partners in the ecosystem approach as they will be the major beneficiaries

iii. The dhand complex shall get water only from Kotri basin drainage system but without the sugar mill wastes plus the storm water runoff during monsoons

iv. Revival of local fish in dhands will open avenues of livelihood for the fishermen community of the area.

v. The grasses will be grown in the area that will support the livestock of the communities adding additional income to the communities as well as food for the families.

vi. The degraded lands around the dhand complex may improve due to lowering the salinity in the dhands thereby improving the production and socio-economic status of the farmers / owners of the lands.

vii. The fear among the stakeholders regarding the decline in resource base shall get addressed. People will feel secure with regard to their livelihood opportunities.

viii. Good quality storm water could be conserved into the depressions in the dhand complex. It is estimated that on 8094 hectares of the land specified for fish can hold a maximum of 140,000 acre ft of water up to a depth of 7 ft. This is substantial volume of water that can be utilized for multifarious purposes including irrigation of agricultural lands, forestry, fish culture etc.

ix. During monsoons there will be high pressure on the LBOD that could be offloaded to release pressure on the system by diverting substantial quantity of water from KPOD to dhands. This water will be used for fish development and agriculture.

4 Outcome and Impacts

Presently the dhands receive water from Karo Ghungro and Guni Phuleli drains. The water of these drains is slightly brackish with TDS less than 2000 ppm all the year round and is suitable for local fish, reed grass, salt tolerant crops and trees and migratory birds provided the sugar mill effluent is stopped in these drains. The area of dhands is over 60,000 acres. This area will be divided into suitable parcels after a detailed survey of the area using appropriate dykes and the following interventions shall be practiced depending upon the location, status of soil salinity and surface elevation:

a) Fish ponds in Sanhro and Mahro dhands
b) Reed grass areas
c) Salt tolerant trees and bushes (on the tidal link banks wherever possible figure-3)
d) Salt tolerant crops and grasses for livestock fodder
e) High value Oil seed crops like castor and linseed etc.
f) Mangroves

4.1 Water storage for fish and agriculture

The dhands spread over an area of more than 24282 hectares. This huge area can conserve substantial storm water for the development of local fish. The local fish has enough local market so a better livelihood for fishermen. Also this water may also be used to cultivate adjoining uncultivated lands.

The storage of water in dhands with the storm water coming from the LBOD catchments will be fresh and useable. The water conservation step will not only conserve valuable water resource presently being wasted flowing to the sea but will offload the drainage infrastructure now under severe pressure due to high monsoons. So diverting the storm water and drain water to the dhands will have multifarious uses and objectives in long run.

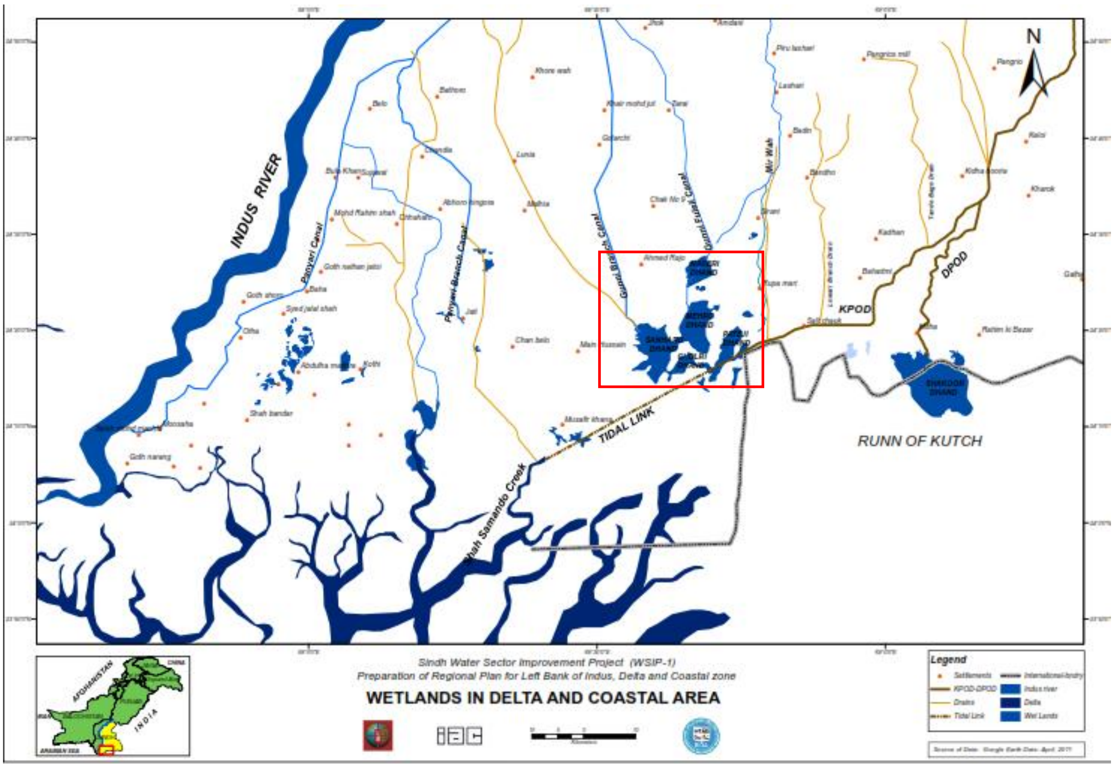


Figure 5: The map of coastal wetlands

A gated cross regulator at suitable location is proposed on KPOD that will stop the tidal influx at high tide. During heavy monsoons, storm water headed up above the gated structure could be diverted to dhands through a weir on the upstream side of the gate through a diversion channel to the dhands to a manageable capacity.

The dhands shall have fresh / brackish water mix (estuarine) condition comprising of the water from the Kotri barrage surface drains and the storm water from the KPOD. These waters shall change the salinity status of dhands from marine to brackish. The seed of good local species of fish shall be delivered in the dhands to flourish. The reed grasses will be encouraged to grow creating an environment /habitat for the waterfowl / migratory birds as well as fodder for the livestock for the neighboring farming community. This will improve and revive to a larger extent the ecosystem of the dhands and the following benefits shall be accrued.

5 Expected project benefits

With these arrangements, it is expected that the dhand ecosystem shall be revived. The dhands shall have fresh / brackish water of the local drains and the storm water from the KPOD. This water shall change the salinity status of dhands from saline to brackish. The seed of good species of fish shall be loaded to flourish. The trees, fruit trees, crops and grasses will grow and the waterfowl / migratory birds shall be attracted. This will improve that ecosystem and the following benefits shall be acrewed.

a) As estimated, about 1000 tons of local fish will be produced annually creating ample livelihood opportunities for local fishermen of the area.

b) Better habitat for migratory birds and local water fowl will attract the bird community to settle in the dhands as in pre-LBOD period.

c) The salinity of dhands will improve that will reduce the chances of soil salinization of the lands near the dhands.

d) Grasses on about 4,047 hectares will be grown in the area that would support for fodder for the Livestock. This will motivate livestock farming

e) Better and sustainable livelihood opportunities for the people residing in the vicinity of dhands will be developed

f) Ecosystem of the area shall improve creating a better environment for the wild life and biodiversity.

g) Dhand water in excess could be used for farming under water scarcity conditions

5.1 Quantifiable Economic benefits

The intervention will generate significant quantifiable and non quantifiable benefits. A preliminary assessment of the anticipated benefits is presented in with and without intervention analytical framework.

The preliminary indicative rate of return of the intervention (IERR) is 1.2%. The details of the economic analysis are presented in Tables 4 and 5.

5.2 Non Quantifiable Benefits

The environment of the area will be improved. The land degradation process will minimize. Wherever, there is likelihood of increase in soil salinity, efforts will be made to rectify by draining the accumulated rain water in monsoon season to wash away the salts into the nearby drainage structures. The livestock will be reared on the grasses and forage thus benefiting the stakeholders.

The proposed project will have positive impacts on the social aspects of the society such as poverty, income distribution, employment generation, livelihood opportunities and gender mainstreaming. With the development of this project and its execution through integrated and participatory approaches the coastal people will be mobilized, organized and act as executing team will get direct and indirect employment and sources of livelihood which will ultimately alleviate poverty and distribute benefits equitably. Due to participatory approach the local communities will be involved from initial stages of project development, survey, selection of sites, land development and water distribution system installation activities. Furthermore, the communities will own the project. Women will also be involved in all the processes of the project.

5.3 Stakeholder Involvement

Stakeholders' involvement shall be encouraged. They will be involved in the management of the dhands by formulating a code of conduct for their participation in management interventions. Success of the plan shall depend upon the involvement of local communities in streamlining the management options. The communities will also be involved in regulating the flow of storm water to the dhands by timely closing or opening the gated structures whenever needed.

6 Project impacts

6.1 Environmental impacts

The proposed project is environment friendly as:

a) It will not have any adverse impacts on land.

b) It will utilize the drainage and storm water for dhands.
c) It will improve the ecosystem of the area that will favour the fauna and flora.
d) It will improve the water quality and improve the salinity level.

The proposed project will not create any environmental issue in the project area but will address the existing environmental issues pertaining to land degradation, soil and water quality, productivity of lands, soil and water pollution and overall environment of the area. The project shall generate additional livelihood opportunities for the communities.

This intervention shall help to revive the degraded ecosystem of the coastal dhands. The fish, reed grasses wild life and the migratory birds will occupy the dhands and improve the overall ecology of the area. The salinity of dhands will improve and the storm water will be stored in large quantity that would be used for fish development and agriculture for the neighbouring lands in droughts. The project is environment friendly.

6.2 Social impacts

The proposed project will have several socio-economic benefits for the society as under:

- Enhance the livelihood opportunities.
- The wild life will get better environment to flourish.
- The local fish will increase that will boost the earning of the fishermen of the area.
- Livestock and wildlife will get improved grazing areas and habitats, respectively.
- Livestock outputs and local fish species will improve socio-economic status of community and associated stakeholders.
- The pressure on the LBOD will be reduced by diversion of storm water to dhands, thus the vulnerability of the communities to flood water will reduce.
- Water conservation will benefit the farmers during water scarcity.

6.3 Re-settlement impacts

The proposed project will not warrant any resettlement issue

7 Investment and Financing Plans

The preliminary year wise cost estimates and detailed breakups are presented in Table-4. Efforts will be made to solicit funding support from international donors and development partners. The project aim is multidimensional having positive impacts on overall environment of the region, support of the communities in enhancing their livelihood opportunities and increase in agriculture produce with support for the livestock. The dhand ecosystem that existed in pre-LBOD period has seriously degraded due to continuous flow of seawater into and out of the dhands twice a day after complete collapse of the cholri weir. The banks of the tidal link at the place of cholri weir have seriously eroded and a creek of about 700-800 ft wide and about 40-50 feet deep is developed across the dhand complex creating an open seawater passage to dhands. This had badly degraded the original ecosystem of dhands. There were estuarine conditions in dhands where local fish, reed grasses and staging, nesting, breeding places for the migratory birds existed. Now local fish has altogether disappeared, reed grass was burnet in salinity and to and fro movement of seawater in dhands do not favour peaceful staging of migratory birds.

8 Implementation Arrangements

8.1 Time Frame

The implementation period for the proposed intervention is five years.

8.2 Executing and Implementing Agencies

The executing agency will be Forest Department Government of Sindh for implementation of the project intervention. The project will be implemented through community based participatory approach. The Forest Department will be responsible for all operational and management aspects, under public-private-partnership arrangements. NGOs will arrange the capacity building tasks to motivate and train the local community stakeholders to participate and benefit from the intervention. All the technical support will be provided by the project staff including the selection of sites for development of local fish, growing various crops, grasses, fruit and other trees keeping in view the condition of the salinity of the soil and the quality of the available water resource. In addition the project staff will also inform the stakeholders about the impact of using the marginal quality water on their lands and crop yields.

The experience so far gained reveals that due to ecological, environmental, social and economic importance the project will be supportive for the communities and overall environment of the region. The implementation of the project is proposed to be participatory including government department, NGOs and local communities. These efforts will mainly focus on the revival of the original ecosystem that prevailed prior to the construction of the LBOD infrastructure.

8.3 Monitoring and Evaluation Mechanism

The purpose of monitoring and evaluation will be to provide timely feedback and analysis to the program partners for making management decisions. This information will be used to facilitate problem-solving at the local level; identify trends requiring corrective actions, evaluate program performance, undertake impact assessment, and to document successful approaches and lessons learned and support strategic planning efforts. Monitoring indicators will be as under:

1. Total number of acres planted under crops grasses fruit and other trees and the livestock reared.
2. Anticipated yields and yields obtained from various interventions
3. The resources (Land and water) were beneficially utilized or under-utilized
4. Development of local fish culture and its impact on livelihood
5. The increase in the farmers income
6. Increase in the environmental outlook
7. Satisfaction of the stakeholders
8. The overall project benefits
9. Cost-benefit analysis on yearly basis

8.4 Monitoring roles and responsibilities

It is essential to define the roles and responsibilities of monitoring and evaluation of participatory M & E. Since the process of project identification and preparation has been participatory in which all the stakeholders have been involved, the monitoring shall also have to be participatory. The tools described above for participatory monitoring also describes the roles and responsibilities for monitoring and review of the plan. In addition, committees comprising of the project management, NGOs and stakeholders should be formulated for monitoring of the project.

8.5 Review process of participatory approach

Like monitoring, the review process shall have to be participatory involving representatives of all stakeholders. The success of Project will be judged from the achievements of indicators set during investigation exercises of project. Communities taking the responsibilities of participatory management in collaboration and participation of other stakeholders shall also set review process. Review process shall be continuous, critical and result oriented. Initially the project area shall be reviewed frequently and the corrective measures taken accordingly but the period of review could be increased as the participating actors gain experience and expertise of participatory management.

8.6 Project Limitations

It is intended to use the drain water for the proposed intervention. At present, Karo Ghungro and Guni Phuleli drains carry sugar mills effluent including effluent from distilleries. This effluent is highly polluted with organic materials that heavily consume the oxygen present in drain water resulting in depletion of oxygen that may cause death of fish and other living creatures using this water. This water is equally hazardous for the crops, trees, grasses to be grown under this intervention. It is therefore extremely important that before going to implement this project, it may be ensured that the sugar mill effluents are stopped entering into these drains. EPA Sindh should invoke the relevant legislation regarding prohibition of disposing the industrial effluents into water bodies and must enforce the EPA act to stop this illegal practice in vogue.

9 References

1. Edward B Barbier, Mike Acreman and Duncan Knowler. 1997. Economic valuation of wetlands. Ramsar Convention Bureau, Gland, Switzerland.

2. IUCN. The lower indus river: balancing development and maintenance of wetland ecosystems. The Water and Nature Initiatives.

3. IUCN 2007. Valuing Coastal Ecosystems. Issue 4 April 2007.

4. Chaudhry A.A. 2010. Wetlands of Pakistan. What is happening to Them? World Environment Day 2010.

5. WWF Pakistan 2007. Pakistan Wetlands Program. Pakistan Wetlands GIS, Integrated Database.

6. Muhammad Ahmad and M. Ishaque. 2011. Wetlands of Pakistan Management and Conservation. http://www.agrihunt.com/pak-agri-outlook/994-wetlands-of-pakistan-management-and-conservation.html

7. IWMI. 2006. Working Wetlands. a new approach to balancing agricultural development with environmental protection.

8. Pakistan National Wetland Policy Final Draft 2009. Ministry of Environment's Pakistan Wetland Program.

Table 3: Detailed Quantities of Rehabilitation of Coastal Wetland Complex

	Unit	Quantities						
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
I. Investment Costs								
A. Machinery, Equipment, Vehicles, and Office furniture & Fixtures								
Double Cab Pickup	#	1	-	-	-	-	-	1
Single Cab Pickup	#	1	-	-	-	-	-	1
Office Equipment	ls							
Office Furniture & Fixtures	#	1	-	-	-	-	-	1
Subtotal								
B. Survey & Investigations								
Survey and Mapping	ls							
C. Civil Works								
Fish Ponds	acre	4,000	4,000	4,000	4,000	4,000	-	20,000
Office Block	#							
Hatchery	#							
Subtotal								
D. Land Acquisition and Resettlement	0							
E. Plantation Cost								
1. Land Development (Tree Planting)	acre	2,000	2,000	2,000	2,000	2,000	-	10,000
2. Land Development (Crops)	acre	2,000	2,000	2,000	2,000	2,000	-	10,000
3. Land Development (Grasses)	acre	2,000	2,000	2,000	2,000	2,000	-	10,000
4. Soil Tolerant Tree Planting	ha	-	1,500	1,500	1,500	500	-	5,000
5. Fingerlings	ls							
Subtotal								
F. Capacity Building								
Farmer Training Cost	ls							
G. Consultancies, Studies, and Services								
1. Soil & Water Testing Contract	per ha	10,000	10,000	10,000	10,000	10,000	-	50,000
2. Capacity building NGO	ls							
Subtotal								
H. Operations Cost								
1. Project Staff Cost								
Project Manager	pm	12	12	12	12	12	-	60
Project Officer	2 pm	12	12	12	12	12	-	60
Fisheries Inspector	pm	12	12	12	12	12	-	60
Fisheries Assistant	4 pm	12	12	12	12	12	-	60
Superintendent	2 pm	12	12	12	12	12	-	60
Office Assistant	4 pm	12	12	12	12	12	-	60
Accountant	pm	12	12	12	12	12	-	60
Computer Operator	2 pm	12	12	12	12	12	-	60
Chowkidars	10 pm	12	12	12	12	12	-	60
Drivers	2 pm	12	12	12	12	12	-	60
Field Assistants	5 pm	12	12	12	12	12	-	60
Beldars	10 pm	12	12	12	12	12	-	60
Labor	50 pm	12	12	12	12	12	-	60
Subtotal								
2. Travel Cost (TA/DA)	ls							
3. Vehicle Operating Cost	ls	2	2	2	2	2	-	10
4. Expendables & Utilities	ls							
5. Hatchery O&M	ls							
Subtotal								
Total Investment Costs								
II. Recurrent Costs								

Table 4: Detailed Base Costs Rehabilitation of Coastal Wetland Complex

	Unit Cost (PRs)	Base Cost (PRs Million) Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
I. Investment Costs								
A. Machinery, Equipment, Vehicles, and Office furniture & Fixtures								
Double Cab Pickup	2,700,000	2.7	-	-	-	-	-	2.7
Single Cab Pickup	2,000,000	2.0	-	-	-	-	-	2.0
Office Equipment		2.0	-	-	-	-	-	2.0
Office Furniture & Fixtures	1,000,000	1.0	-	-	-	-	-	1.0
Subtotal		7.7	-	-	-	-	-	7.7
B. Survey & Investigations								
Survey and Mapping		5.0	-	-	-	-	-	5.0
C. Civil Works								
Fish Ponds	20,000	80.0	80.0	80.0	80.0	80.0	-	400.0
Office Block		2.5	-	-	-	-	-	2.5
Hatchery		1.0	-	-	-	-	-	1.0
Subtotal		83.5	80.0	80.0	80.0	80.0	-	403.5
D. Land Acquisition and Resettlement		-	-	-	-	-	-	-
E. Plantation Cost								
1. Land Development (Tree Planting)	15,000	30.0	30.0	30.0	30.0	30.0	-	150.0
2. Land Development (Crops)	10,000	20.0	20.0	20.0	20.0	20.0	-	100.0
3. Land Development (Grasses)	10,000	20.0	20.0	20.0	20.0	20.0	-	100.0
4. Soil Tolerant Tree Planting	14,000	-	21.0	21.0	21.0	7.0	-	70.0
5. Fingerlings		0.3	0.3	0.3	0.3	0.3	-	1.5
Subtotal		70.3	91.3	91.3	91.3	77.3	-	421.5
F. Capacity Building								
Farmer Training Cost		1.0	3.5	4.0	3.0	2.0	-	13.5
G. Consultancies, Studies, and Services								
1. Soil & Water Testing Contract	5,000	50.0	50.0	50.0	50.0	50.0	-	250.0
2. Capacity building NGO		5.0	5.0	5.0	5.0	5.0	-	25.0
Subtotal		55.0	55.0	55.0	55.0	55.0	-	275.0
H. Operations Cost								
1. Project Staff Cost								
Project Manager	150,000	1.8	1.8	1.8	1.8	1.8	-	9.0
Project Officer	75,000/pm	1.8	1.8	1.8	1.8	1.8	-	9.0
Fisheries Inspector	30,000	0.4	0.4	0.4	0.4	0.4	-	1.8
Fisheries Assistant	20,000/pm	1.0	1.0	1.0	1.0	1.0	-	4.8
Superintendent	35,000/pm	0.8	0.8	0.8	0.8	0.8	-	4.2
Office Assistant	20,000/pm	1.0	1.0	1.0	1.0	1.0	-	4.8
Accountant	25,000	0.3	0.3	0.3	0.3	0.3	-	1.5
Computer Operator	20,000/pm	0.5	0.5	0.5	0.5	0.5	-	2.4
Chowkidars	20,000/pm	2.4	2.4	2.4	2.4	2.4	-	12.0
Drivers	15,000/pm	0.4	0.4	0.4	0.4	0.4	-	1.8
Field Assistants	15,000/pm	0.9	0.9	0.9	0.9	0.9	-	4.5
Beldars	20,000/pm	2.4	2.4	2.4	2.4	2.4	-	12.0
Labor	20,000/pm	12.0	12.0	12.0	12.0	12.0	-	60.0
Subtotal		25.6	25.6	25.6	25.6	25.6	-	127.8
2. Travel Cost (TA/DA)		0.1	0.1	0.1	0.1	0.1	-	0.5
3. Vehicle Operating Cost	240,000	0.5	0.5	0.5	0.5	0.5	-	2.4
4. Expendables & Utilities		0.3	0.3	0.3	0.3	0.3	-	1.5
5. Hatchery O&M		0.1	0.1	0.1	0.1	0.1	-	0.6
Subtotal		26.6	26.6	26.6	26.6	26.6	-	132.8
Total Investment Costs		249.1	256.4	256.9	255.9	240.9	-	1,259.0
II. Recurrent Costs								
		249.1	256.4	256.9	255.9	240.9	-	1,259.0

Table 5: Detailed Contingency Costs of Rehabilitation of Coastal Wetland Complex

	Totals Including Contingencies (PRs Million)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
I. Investment Costs							
A. Machinery, Equipment, Vehicles, and Office furniture & Fixtures							
Double Cab Pickup	2.9	-	-	-	-	-	2.9
Single Cab Pickup	2.1	-	-	-	-	-	2.1
Office Equipment	2.1	-	-	-	-	-	2.1
Office Furniture & Fixtures	1.1	-	-	-	-	-	1.1
Subtotal	8.3	-	-	-	-	-	8.3
B. Survey & Investigations							
Survey and Mapping	5.8	-	-	-	-	-	5.8
C. Civil Works							
Fish Ponds	93.6	98.2	103.2	108.3	113.7	-	517.0
Office Block	2.9	-	-	-	-	-	2.9
Hatchery	1.2	-	-	-	-	-	1.2
Subtotal	97.7	98.2	103.2	108.3	113.7	-	521.1
D. Land Acquisition and Resettlement	-	-	-	-	-	-	-
E. Plantation Cost							
1. Land Development (Tree Planting)	35.1	36.8	38.7	40.6	42.7	-	193.9
2. Land Development (Crops)	23.4	24.6	25.8	27.1	28.4	-	129.3
3. Land Development (Grasses)	23.4	24.6	25.8	27.1	28.4	-	129.3
4. Soil Tolerant Tree Planting	-	25.8	27.1	28.4	10.0	-	91.3
5. Fingerlings	0.4	0.4	0.4	0.4	0.4	-	1.9
Subtotal	82.2	112.1	117.7	123.6	109.9	-	545.6
F. Capacity Building							
Farmer Training Cost	1.2	4.3	5.2	4.1	2.8	-	17.5
G. Consultancies, Studies, and Services							
1. Soil & Water Testing Contract	58.5	61.4	64.5	67.7	71.1	-	323.1
2. Capacity building NGO	5.8	6.1	6.4	6.8	7.1	-	32.3
Subtotal	64.3	67.5	70.9	74.5	78.2	-	355.5
H. Operations Cost							
1. Project Staff Cost							
Project Manager	1.9	2.0	2.1	2.1	2.2	-	10.3
Project Officer	1.9	2.0	2.1	2.1	2.2	-	10.3
Fisheries Inspector	0.4	0.4	0.4	0.4	0.4	-	2.1
Fisheries Assistant	1.0	1.1	1.1	1.1	1.2	-	5.5
Superintendent	0.9	0.9	1.0	1.0	1.0	-	4.8
Office Assistant	1.0	1.1	1.1	1.1	1.2	-	5.5
Accountant	0.3	0.3	0.3	0.4	0.4	-	1.7
Computer Operator	0.5	0.5	0.5	0.6	0.6	-	2.7
Chowkidars	2.6	2.7	2.7	2.8	2.9	-	13.7
Drivers	0.4	0.4	0.4	0.4	0.4	-	2.1
Field Assistants	1.0	1.0	1.0	1.1	1.1	-	5.1
Beldars	2.6	2.7	2.7	2.8	2.9	-	13.7
Labor	12.9	13.3	13.7	14.1	14.5	-	68.6
Subtotal	27.5	28.3	29.2	30.1	31.0	-	146.1
2. Travel Cost (TA/DA)	0.1	0.1	0.1	0.1	0.1	-	0.6
3. Vehicle Operating Cost	0.5	0.5	0.6	0.6	0.6	-	2.8
4. Expendables & Utilities	0.3	0.3	0.4	0.4	0.4	-	1.8
5. Hatchery O&M	0.1	0.1	0.2	0.2	0.2	-	0.8
Subtotal	28.6	29.5	30.4	31.3	32.3	-	152.2
Total Investment Costs	288.2	311.7	327.4	341.8	336.9	-	1,606.0
II. Recurrent Costs							
	288.2	311.7	327.4	341.8	336.9	-	1,606.0

Table 6: Economic Analysis of Coastal Wetlands

The estimated IERR has been computed at 2.1 %, hence the project is not economically viable. The NPV at 12% is Rs.-444.3 million is presented in the table below. Hence the sensitivity analysis is not required as the IERR is very low (2.1%).

A	**Without Project**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**
1	Area in Acres (Shrimps)	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
2	Production of Shrimps in (mt)	2,000	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0
3	Value of production in (M.Rs.)	27.00	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
B	**With Project**												
1	Area in Acres (Shrimps)	20000	16000	12000	8000	4000							
2	Production of Shrimps in (mt)	2,000	1,600	1,200	800	400	-	-	-	-	-	-	-
3	Value of production in (M.Rs.)	27.00	21.60	16.20	10.80	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	Area converted for Fish production (ac)	0.0	4,000.0	8,000.0	12,000.0	16,000.0	20,000.0						
2	Value of Fish catch (M. Rs.)	0.0	0.0	7.2	14.4	21.6	28.8	29.1	29.4	29.7	30.0	31.5	33.1
3	Trees Area (Acres)	0.0	2,000.0	2,000.0	2,000.0	2,000.0	2,000.0						
4	Value of Trees (M.Rs.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.0	0.0
5	Grass Area (Acres)	0.0	2,000.0	4,000.0	6,000.0	8,000.0	10,000.0	10,000.0	10,000.0	10,000.0	10,000.0	10,000.0	10,000.0
6	Value of Grass (M.Rs.)	0.0	0.0	5.4	10.8	16.2	21.6	22.0	22.5	22.9	23.4	25.8	28.5
7	Crops Area (Acres)	0.0	2,000.0	4,000.0	6,000.0	8,000.0	10,000.0	10,000.0	10,000.0	10,000.0	10,000.0	10,000.0	10,000.0
8	Value of Crops (M. Rs.)	0.0	5.4	10.8	16.2	21.6	27.0	27.0	27.0	27.0	27.0	27.0	27.0
9	Total Inflow (Rs. M)	27.0	5.4	23.4	41.4	59.4	77.4	78.1	78.9	79.6	80.3	174.3	88.6
1	Incremental Benefits	-	-22	-4	14	32	50	51	52	53	53	147	62
2	Cost of Intervention (Rs M)	210.2	215.7	216.1	215.4	203.8							
3	Incremental Cash Flow (Rs. M)	-210.2	-237.3	-219.7	-201.0	-171.4	50.4	51.1	51.9	52.6	53.3	147.3	61.6
F	NPV @ 12% (Rs. M)	-444.3											
	IERR	2.1%											