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Pakistan

Environmental Degradation and Impacts on Livelihoods

Sea Intrusion – A Case Study

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Acknowledgements

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ACRONYMS & ABBREVIATIONS

cusec	Cubic feet per second
DFI	Development Finance Institutions
FAO	Food and Agriculture Organisation
GoS	Government of Sindh
ha.	Hectare
HMIS	Health Management Information System
IPCC	Inter-governmental Panel on Climate Change
IUCN	World Conservation Union
MAF	Million Acre-Feet
MT	Metric Tonnes
PHED	Public Health Engineering Department
ppt	Parts per thousand
Rs.	Pakistani Rupees
TDS	Total Dissolved Solids
UNDP	United Nations Development Programme
USD	United States Dollars
WFP	World Food Programme
WHO	World Health Organisation

Preface

The linkages between environmental degradation and poverty have been the topic of extensive debates in the recent past. Previously assumptions such as “poverty necessarily leads to environmental degradation” and “the poor degrade the environment more than the affluent” were taken as accepted facts. Today however, environmental degradation and poverty have been shown to be components of a complex cycle in which both are interdependent and the linkages between them are complicated and multi-dimensional. This case study is an attempt to document how environmental degradation caused by sea intrusion in the coastal and deltaic tracts of lower Sindh has been instrumental in impacting and destroying the livelihoods of the local population, thereby exacerbating their poverty.

The gradual encroachment of the sea into the Indus Delta and up the main course of River Indus in lower Sindh is increasingly being brought to the forefront of recent policy debates as one of the worst cases of large-scale environmental degradation to have occurred in Sindh. For some people sea intrusion is the main cause of the destruction of several thousand hectares of land in the coastal districts of Thatta and Badin, rendering prime agricultural land barren, contaminating aquifers and causing the degradation of coastal, deltaic and riverine ecosystems. Many believe that the degeneration of land and water resources has seriously affected fishing and agriculture, which constitute the two principal vocations of the local population leading to loss of livelihoods, migration to the hinterland and an ensuing rise in poverty levels.

According to observation by IUCNP experts, the sea has intruded 54km upstream along the main course of the River Indus. That this incursion is taking place against the gradient of the riverbed indicates that there might be an absence of any retarding factor such as a considerable volume of fresh water in the riverbed. Hence the sea surges have driven seawater into the river channel. This is an uncommon phenomenon for a perennial river. Many are of the view that the fundamental cause may be the progressive upstream diversion of Indus waters and the gradual depletion of freshwater discharges downstream of the Kotri Barrage – the last in a series of barrages and dams on the Indus River. Adequate freshwater flows flush the coastal and deltaic environments of seawater and salt deposits. Further, the silt load carried by the flow physically prevents the sea from intruding up the river channel. In the absence of a considerable volume of such flows there is no decelerating factor to check sea intrusion. The prolonged drought and water shortages in the country during the recent past have further aggravated the detrimental impacts of the phenomenon.

The ecology and physiology of richly productive but delicately balanced riverine and deltaic ecosystems are undergoing adverse changes, and many experts are of the opinion that this is due to a lack of freshwater flow in their environment, depleting the biodiversity of these areas. Productivity is on the decline and, in some cases, extinction of species has occurred. The mangrove forests of the Indus Delta, one of the most extensive arid coast mangroves in the world, are a case in point. Of the eight species of mangroves recorded to be growing in the Indus Delta in 1950s only three continue to flourish. While the exact reason for this disappearance is not known, experts working in this area consider the lack of downstream flows in addition to pollution, to be one of the prime reasons. Recently IUCNP has successfully reintroduced a fourth salt tolerant species, *Rhizophora mucronata*, in the region.

In addition a sharp decline in the landing of anadromous fish species, in particular the valuable Pallah (*Tenualosa ilisha*) and Barramundi (*Lates calcifer*) has been observed. The volume and quality of shrimp catch that represents a major segment of seafood exports has also fallen. Marine fish such as the Dumbra (*Labeo spp*.) have been sighted several kilometers up the course of the river. These developments point towards the persistent degradation of the ecosystems, their inevitable collapse, and the associated environmental and economic costs that will consequently be incurred.

As mentioned earlier, the livelihoods of the coastal population are mostly dependent on fisheries, agriculture and forestry. With the degradation of the natural resource base, there has been a persistent decline in the socio-economic conditions of the local communities. The loss of livelihoods has caused a rise in poverty levels, malnutrition, and the deterioration of people's health in general. The scarcity of potable and uncontaminated water is a significant factor that contributes to the increasing incidence of diseases of the skin, eyes and the digestive tract.

In the current global environmental scenario, global warming and climate change are causing sea levels to rise worldwide, posing a threat to coastal environments. The rise in sea level along the coast of Pakistan has been estimated at 1.1mm per annum, which is not very significant in itself, since the average rate of global sea level rise is about 2.5mm. However, any additional contributing factor, such as water scarcity in river channels, can be instrumental in hastening the intrusion of the sea in the deltaic channels and eventually up the main course of the Indus.

This report has been prepared with the financial assistance of the Norwegian Agency for Development (NORAD) and presents a study of the estimated ecological and socio-economic impacts of sea intrusion on the coastal and riverine ecosystem and the population of the affected area, as well as the concurrent losses sustained by the provincial and national exchequers, which may have been perpetuated by this phenomenon. The objective of this report is to present a case study of the impacts, ***and not a detailed scientific analysis*** of various environmental sectors being influenced. For this reason the report is largely based on secondary research, literature reviews, community interviews etc., though some primary research has also been conducted.

A few parameters have been selected for each of the chosen environmental sectors, for which costs have been calculated and extrapolations made to predict future trends. Since the objective of the study is to present a general estimate of environmental loss in terms of economic costs, interest and inflation rates have not been considered for the cost analysis.

Advocacy on the issue of environmental degradation caused by sea intrusion has been a major focus of the Sindh Programme Office of IUCNP. On February 14, 2002 a presentation on the condition of the Indus Delta was made by the Sindh Programme Office at the Sindh Development Forum organized by the Planning & Development Department, Government of Sindh and the World Bank at the Governor House, Karachi. Sea intrusion and its impact on the Indus Delta remained a central issue at this event and was followed by a visit to the affected areas (Annex 1). Since then several initiatives have been taken by the Sindh Programme Office to actively pursue advocacy on the subject. During the course of the study a wide range of stakeholders from the government departments to community organizations and media were contacted. During the last one year period approximately 40 news items have been printed in daily newspapers and various seminars have been organized by different governmental and non-governmental

organizations on the issue. This report will serve to take the issue further and contribute to the delineation of a strategy for the mitigation of the impacts of sea intrusion.

We are very thankful to all the people who provided their valuable input in the preparation of this case study. The list is very long, and though we have tried to acknowledge all the persons, some names might have been missed. We apologize for any such oversight and thank them for their cooperation.

Environmental Degradation and Impacts on Livelihoods
Sea Intrusion - A Case Study

1. Introduction

Many environmental disasters such as droughts, floods etc. may be precipitated by the degradation of natural resources, and cause widespread damage and destruction. Sea intrusion may be classified as one such phenomenon. It constitutes the encroachment of saline seawater inland and up the channels of rivers as a result of sea level rise, depletion of fresh water flows in the river channel or, both.

Globally, sea levels are rising. The planet is undergoing a global warming that is altering climatic trends worldwide. Higher global temperatures are causing ocean waters to expand and glaciers and polar ice sheets to melt. It is estimated that the global mean temperature will increase by 1°C above the present value by the year 2025 and by 3°C before the end of the next century. The IPCC – Working Group I [1]projects a rise in global sea level of 30 – 110 cm by the year 2100 due principally to thermal expansion of ocean water and melting of polar ice sheets and glaciers.

Sea intrusion is affected by topographic, climatic, and hydrologic conditions such as:

- slope of river channel;
- tidal magnitude;
- wind velocity and direction;
- river flow and duration; and
- water temperature.

Of these parameters, river flow is the dominant parameter determining the phenomenon[2]. Human activities such as hydroelectric, irrigation, and water diversion projects may change the hydrologic conditions including flows and their duration and exaggerate sea intrusion.

In the delta of a river the difference in density between seawater (approximately 1.5 g/cm^3) and freshwater (approximately 1.0 g/cm^3) causes the heavier seawater to move upstream along the river bottom under floating freshwater. Typically, a highly stratified wedge may be formed in deep rivers with high freshwater flows. The leading edge of the saltwater wedge is well defined; however, some mixing occurs to form a brackish water region along the freshwater-saltwater interface. If the volume of freshwater is large enough, it can push seawater away from the river mouth. Hence, in rivers with a long duration of high flows, freshwater is able to prevent seawater from intruding into the river

[1] The Intergovernmental Panel on Climate Change (IPCC) was jointly established by World Meteorological Organization (WMO) and United Nations Environment Program (UNEP) in 1988. The Panel's charge was to assess scientific information related to various components of the climate change issue and to formulate realistic response strategies for the management of this issue. Of the three Working Groups of IPCC, Working Group I has been assigned the task to assess available scientific information on climate change.

[2] (A) American Association for the Advancement of Science, 1967
(B) The US Army Corps of Engineers, New Orleans District, September 1997

channel. The reverse is also true: seawater can intrude easily into rivers with a long duration of low flows. In rivers without adequate freshwater flows, saltwater may intrude into the river channel rendering the brackish estuarine environment marine[3].

The intrusion of the sea in the Indus Delta and up the course of the Indus River is being termed as one of the most disastrous cases of environmental degradation that the province of Sindh has had to experience. The Indus Delta, located on the western coast of Pakistan near the Indian border, is a typical fan-shaped delta covering an area of 600,000 ha. The Indus River outfalls into the sea through 17 major creeks of the delta, which is also characterized by several minor creeks, mudflats and mangrove vegetation. The mangroves serve as nursery and feeding grounds for many varieties of fish and shrimp. The coastal communities depend upon the mangroves for their fuel and fodder requirements.

Though the Sindh coast is generally affected by global sea level rise, it is believed that the dominant element responsible for sea intrusion into the Indus Delta and up the Indus River channel might be the diminished freshwater discharge downstream of the Kotri Barrage that has resulted in the degradation of deltaic and riverine ecosystems. Drought conditions over the past few years have further aggravated the impacts of depleted water flows. Due to the absence of water in the river channel, seawater has intruded almost 54 kilometers upstream in the river channel till village Darwesh in *Taluka*[4] Ghorabari, District Thatta. The upstream salinity data measured at this location ranged between 25-35ppt.

The data presented in this study indicate a steady decrease in freshwater flows into the Indus Delta. Some people believe that it is the inevitable consequence of drought and imperatives of economic development upstream. To them, the negative impacts downstream are not as obvious or important. The critics in the lower riparian areas see the reduced flow as a grave concern in terms of loss of income, displacements of large number of people and economic activity. The issue is not who is right or wrong. What is obvious, is a lack of communication and informed debate.

[3] Nguyen, P.E., 1999
[4] Sub-unit of district

2. Background

Freshwater flows are affected by the irrigation system developed under the British and further developments after 1947. After independence, the sharing of the water of the Indus came under dispute between India and Pakistan. Through the mediation of the World Bank, an agreement was arrived at and Pakistan and India signed the Indus Water Treaty in 1960. Under this treaty India has the right to use the water of Punjab's three eastern rivers, the Ravi, Beas and Sutlej, whilst the waters of the three western rivers, the Chenab, Jhelum and Indus were left for Pakistan's use. To compensate the diverted flows, the Indus Basin Project was conceived and implemented in Pakistan, which entailed the construction of two gigantic dams (on the rivers Indus and Jhelum), five barrages and one gated-siphon. The purpose was to link canals for the mass transfer of irrigation water from the western rivers to the areas falling under the command of the eastern rivers. The present irrigation system comprises of three storage reservoirs at Tarbela, Mangla and Chashma, 16 barrages, 12 inter-river link canals, two siphons and 43 main canals.

In March 1991, the Governments of the four provinces of Pakistan came to an agreement about distribution of the water of the Indus under the Indus Water Accord.

Table 1 – 1991 Water Accord Apportionment

Province	Kharif	Rabi	Total in MAF
Punjab	37.07	18.87	55.94
Sindh	33.94	14.82	48.76 including urban & industrial uses for Karachi
NWFP a)	3.48	2.30	5.78
b)Civil Canals*	1.80	1.20	3.00
Balochistan	2.85	1.02	3.87
Total	77.34	37.01	114.35

* - Ungauged civil canals above the rim stations

Balance flows from the river during flood and future storage schemes will be apportioned as follows:

Punjab	37%
Sindh	37%
NWFP	14%
Balochistan	12%

The Indus Water Accord recognizes that flows of fresh water to the delta are vital to the maintenance of the mangrove ecosystem (a minimum of 10 MAF was agreed upon). However, it is clear that the extra water apportioned over and above the current usage will be taken from the water discharged to the delta.

Data from the Irrigation and Power Department, GoS, indicate that over the 16 years from 1976 to 1992, the total average inflow was 146 MAF and canal withdrawals amounted to about 104 MAF (129 billion m^3) per year. Only 35 MAF (43 billion m^3) is being released below the farthest downstream barrage, Kotri (see Table 2). Thus the total flow of the Indus has been reduced to about 24% of the original available flow. Even below the Kotri Barrage, the waters are used for irrigation and are subject to evaporation, so that only 20 MAF (25 billion m^3) actually reaches the Indus Delta. In some dry years, the discharge

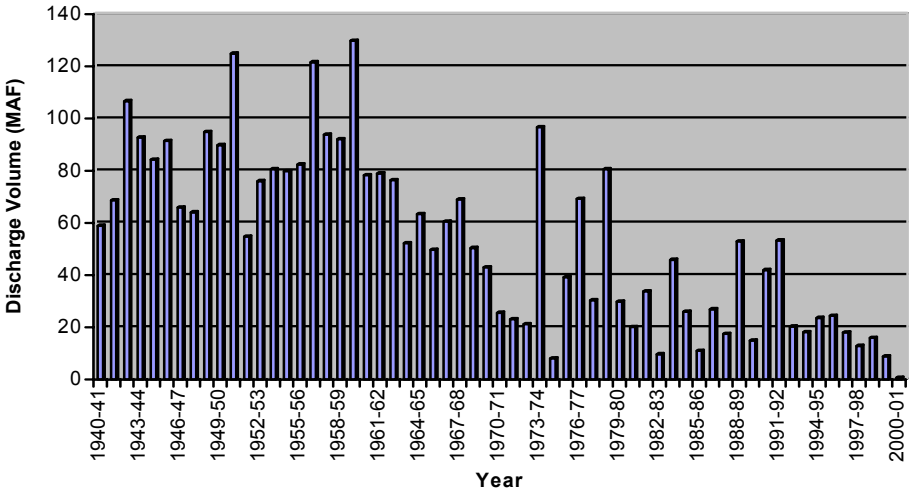
falls below 10 MAF (12.5 billion m^3); in these years it can be assumed that virtually no fresh water reaches the sea, and even in wet years the Indus will only reach the sea for three months per year.

Table 2 – Average Annual and Seasonal Discharge Volume Downstream of Kotri Barrage

Period	Discharge Volume (MAF)			Reduction (%)	Construction with Year	Silt Load (mill. Tons)
	Annual	Kharif	Rabi			
1880-92	150.0	-	-	-	Canal System	400
1940-54	84.7	73.8	10.9	10.0	Sukkur Barrage 1932	225
1955-65	79.9	69.7	10.2	12.9	Barrages ▪ Kalabagh (Jinnah) 1955 ▪ Kotri 1955 ▪ Marala 1956 ▪ Taunsa 1958 ▪ Guddu 1962 ▪ Warsak Dam 1965	213
1966-76	46.0	44.4	1.6	45.7	▪ Mangla Dam 1967 ▪ Chashma Barrage 1971 ▪ Tarbela Dam 1975	122
1977-92	35.2	33.1	2.1	58.4		100
1992 onwards, after Water Accord between provinces	-	-	10.0	88.19		30

Source: Irrigation and Power Department, Govt. of Sindh

Figure 1
Discharge Volumes Downstream of Kotri Barrage



According to some, not even the 10 MAF promised under the 1991 Water Accord has been released below the Kotri Barrage in recent years and in 2000-01 the flows were reported to reach the lowest level in Sindh's recorded irrigation history i.e. 0.72 MAF.

Recently the Irrigation and Power Department of Sindh has formally announced statistics of the impact of sea intrusion in the Indus Delta. Tidal infringement has inundated over 486,000 hectares representing 33% of the land in the two coastal districts of Sindh province, namely Thatta and Badin. Almost a quarter million population has been dislocated causing financial losses of over Rs.100 billion to date[5]. The *taluka* wise loss of land is depicted in the table below.

Table 3 – Taluka-wise Land Losses in Indus Riverine and Deltaic Region

Taluka	District	Land Loss (ha.)
Keti Bunder	Thatta	46,137
Ghorabari	Thatta	12,749
Kharo Chan	Thatta	47,701
Mirpur Sakro	Thatta	24,363
Shah Bunder	Thatta	2,38,866
Jati	Thatta	91,766
Badin	Badin	19,910
Golarchi	Badin	12,398

Source: Board of Revenue, GoS

[5] Board of Revenue, Govt. of Sindh

The degradation of land, biodiversity, environment and the resultant loss of livelihoods and increase in poverty of the people that seems to be taking place in the area, could be the result of the intrusion of the sea. The global aspect of the phenomenon cannot be controlled locally but much can be done to curtail the domestically generated contributing factors.

3. Methodology and Rationale

3.1 Criteria of Taluka Selection

It seems that the area directly or indirectly influenced by flows of freshwater released downstream from Kotri Barrage has been most impacted by sea intrusion. This area includes the riverine area, the active delta zone and the river itself including the branches and channels it forms as it outfalls into the sea.

Though the area of land impacted by sea intrusion is apparently quite extensive encompassing both the right and left banks of the Indus, only three of the six coastal *talukas*[6] of District Thatta have been chosen for this study (see Annex -). These are Keti Bunder, Kharo Chan, and Ghorabari *Talukas*. The reasoning behind the selection is as follows.

These *talukas* are all located along the right bank of River Indus and form a contiguous belt. Hence they can be studied in their entirety as a sizable affected area and further studies in other affected *talukas* may be undertaken diverging outwards from the present area.

The geographical location of these *talukas* has apparently rendered them most susceptible to sea intrusion amongst the *talukas* on the right bank. Hence the ecological and socio economic impacts of the phenomenon and resultantly the variation in parameters chosen for this study have been most evident here.

The area represents several topographic and ecosystem types. Keti Bunder is situated in the Indus Delta and Kharo Chan and Ghorabari form part of the riverine tract of the Indus. Hence it is possible to study impacts on various ecosystems during a single initiative.

3.2 System of Investigation

This study has been based on both primary and secondary research. A team of consultants representing various sectors, hired by IUCNP, undertook the task of collecting primary data from the field. However, IUCNP experts maintained oversight and the draft documents were also reviewed by them.

Community perceptions were investigated through on-site individual interviews and focus group discussions. Detailed consultations were conducted with relevant government line department representatives and public sector organisations. Background data for the study was obtained through an extensive literature review. Secondary data used was based on published statistics provided by federal and provincial agencies and has been referenced within the text. Relevant government departments and NGOs were also consulted where required (attached as List of Individuals/ Institutions Contacted pg. 53).

[6] Sub-unit of district

3.3 General Parameters of Study

The study analyzes data for the period 1995-2000 to predict future trends in the sectors of agriculture, fisheries and forestry. A few parameters for each of the sectors were selected for an in-depth and focussed analysis. These are:

Agriculture

- Loss of geographic area
- Loss of area under cultivation
- Impact on economic returns from agriculture

Fisheries

- Change in freshwater fish catch composition

Forestry

- Loss of forest cover/ productivity
- Loss of forest land

3.4 Problems and Constraints

Several constraints were faced during the data collection process, which have resulted in the inability to generate the level of detail desired in analysis. These include:

- Non availability of updated documented statistics;
- Deficiencies in time-series data;
- General reluctance of individuals to provide information due to a variety of reasons, including but not limited to cultural values and general suspicion;
- The limited time period that is not sufficient to take into consideration the seasonal variation of the river flow;
- The expectations of the local population become very high as they see outsiders as problem shooters who will solve all their problems.

4. Description of Study Area

4.1 Location and Setting

The study area comprises of three *talukas* of district Thatta. The Thatta District lies in the province of Sindh, at the southern border of Pakistan where the River Indus enters the Arabian Sea. It is situated at 23°43' to 25° 26' north latitudes and 67°05' to 68°45' east longitudes and is bound by Dadu District to the north, Hyderabad and Badin Districts to the east, Karachi Division to the west and Rann of Kutch and Arabian Sea to the south. The total geographic area of the district is 17,355 km^2, which represents 12.32% of the total geographic area of Sindh. There is some rocky tract in the northwestern part while the rest of the district mainly consists of old and active flood plain.

Thatta District is divided into nine *talukas,* which are further divided into 48 Union Councils, 8 Town Committees, 648 *dehs*[7] and 6,614 villages. Of the nine *talukas*, six are considered to be coastal namely Mirpur Sakro, Ghorabari, Keti Bunder, Kharo Chan, Shah Bunder and Jati. These *talukas* constitute the region directly or indirectly influenced by flows of freshwater released downstream from the Kotri Barrage (see Annex – for map of Thatta District).

The study area embodies several topographic types including riverine tract, the active delta zone and the river itself, together with the branches and channels it forms as it outfalls into the sea.

4.2 Socio-economic Profile

4.2.1. Demography

District Thatta has a total population of 1,113,194[8], out of which 156,848 (14.08%) is concentrated in the three *talukas* covered in this study.

Table 4 - Demographic Information of Studied Talukas

Taluka	Area (km^2)	Male Population	Female Population	Total Population
Ghorabari	1,018	55,527	49,955	105,482
Keti Bunder	771	13,553	12,147	25,700
Kharo Chan	778	13,794	11,872	25,666
Total	***2,567***	***82,874***	***73,974***	***156,848***

Most of the area of the coastal *talukas* lies within the Indus Delta. The majority of settlements are concentrated on islands located in the creeks of the delta.

The population of the study area belongs to a number of clans and tribes such as the Jats, Khaskhalis and Dablas. Traditionally they followed occupations inherited from their forefathers; for example, the Khaskhalis were agriculturists; the Jats were pastoral people, breeders of camels and suppliers of timber for fuel; the Memons and Shedis were merchants and traders; the Dablas were fishermen. In addition, there were artisans such as carpenters, barbers and potters. The artisans were supported by the community (given residences, expenses and seasonal share in agricultural and fish produce) in lieu

[7] Administrative unit below sub-district
[8] 1998 Census Report

of their services.

4.2.2 Poverty and Livelihoods

Traditionally agriculture, fishing and livestock were the three main sources of livelihood till 1960. High quality red rice was extensively cultivated and exported, to the extent that labourers from other areas of Sindh would come to work here during the harvesting season. Fishing was not a major income generating activity and was mainly engaged in as a part-time occupation for subsistence purposes. As such it did not require much organisation or infrastructural maintenance[9].

Today the market and cash economy has broken down the traditional social and economic interdependence previously existing within clans and tribes. This change has been precipitated by the deterioration of agriculture due to water logging and salinity of lands rendering a large number of peasants jobless, hence economically independent of the community structure. Resultantly a massive outward migration of population in search of alternate livelihoods took place. The second factor contributing to the change in the socio-economic structure was the rapid development of the fisheries sector, especially inland fisheries, in the 1960s. Incentives were given to entrepreneurship and people whose lands had turned barren developed fish ponds on them. Social mobility was enhanced by the construction of roads, proliferation of mechanised transport, populist political movements, and accessibility to the media. Easier access to urban areas due to the above mentioned factors have also played their role in opening up these areas to outside influences.

Currently the dominant occupations in the study area can be categorised as follows: fishing and related activities that employ an estimated 90% of the population; agriculture and forestry, in which 8% of the population is involved; and the services sector that engages a mere 2% of the population.

Eveready Pictures Pvt. Ltd/IUCN-Pakistan

A Fishing Village, Keti Bunder

The fisheries sector employs the majority of the population of the coastal *talukas* in a number of ways - as fishermen, boat owners, helpers (*khalasis),* boat captain *(nakho),* workers in ice factories, transporters and drivers of fish carrier vehicles[10]. The incidence of poverty is very high among the fishing communities. Firstly the unsustainable exploitation of fisheries (including overfishing and use of harmful fishing techniques) has depleted stocks. Secondly, in the absence of institutional credit facilities, the fishermen depend upon an informal and exploitative system of credit that keeps them forever indebted to the middle-men. They are bound to supply fish to the middle-men at rates lower than the market price.

Transportation is the main support activity, which employs the largest number of people. Local transport involves the carting of fish from the creek shores to the high ground for sorting, drying, weighing and transfer to trucks and pick-ups for their journey to Karachi.

[9] Coastal Environmental Management Plan for Pakistan: UNESCAP, 1996
[10] Shoro Jamal: Poverty Analysis of Coastal Areas, Center for Information & Research SZABIST

Any other type of profession or business is rare in the area, except for a few government employees such as school teachers and other government functionaries. Over ninety percent of the population of the area depends on fishing, which results in greater than sustainable fish catch and lower nursery life of the fish. The diminishing fish catch reduces the income, which directly affects the economic stability of fishermen.

The mechanisation of the fishing industry has radically impacted the traditional social structure of coastal areas. Fishing has become an increasingly export-oriented industry, with the greatest profiteers being the outside entrepreneurs who can afford and sustain the level of investment required by commercial fishing. The next in the hierarchy come the crew labourers who work regularly on trawler boats and the owners of motorised boats, while the traditional fishermen occupy the lowest tier. The major impact of this change in the traditional economy is the dominant role of fish merchants and middlemen, who extend loans to the fishermen against the commitment of future delivery of catch on prices lower than the market rate.

4.2.3. Status of Women

The women belonging to fishing communities have more freedom as compared to other agricultural and pastoral communities. They play a greater role in family matters because the fishermen spend most of their time in fishing. The women have to look after the house and deal with other problems of the family. Due to such status, a number of fisherwomen are so vocal that they have developed the reputation of being the chief of not only the family but also of the sub-caste or locality. There are instances in which women have also played the role of arbitrators. As opposed to the agricultural and pastoral communities, the women of the fishing communities do not observe *purdah* (veiling).

Previously, the major activity of fisherwomen was the making and selling of cotton fishing nets. However, since the nets now used are ready-made nylon ones, the fisherwomen no longer have this source of income generation. But they are still responsible for the repair of fishing nets. The fisherwomen also used to earn income through cleaning of shrimp and small scale fishing in the creeks. Today both these activities have declined due to a reduction in fish catch caused by overfishing and unsustainable fishing methods practised by commercial fishermen. Overpopulation, partially caused by an influx of migrants such as Bengalis, Burmese and Afghanis has placed enormous stress on the fisheries and other resources of the coastal areas. These immigrants have settled along the Karachi coast but operate along the coastline up to Sir Creek near the Indian border.

Today the major responsibilities of the fisherwomen include household chores and taking care of the animals. The gathering of firewood and fetching water also consumes much of their time, especially since potable water is not readily available. They also repair the fishing nets and help the men in processing and selling the fish catch.

4.2.4. Sources of Fuel and Fodder

Tamarix (local name *lai*) constituted the traditional fuel in the riverine region. The Jats bartered it for fish, agricultural produce or cash. People who did not have a commodity to offer in exchange collected their own firewood from the forests. The change in the old social order and the decline in *tamarix* forests have brought about several changes. Firewood is now sold for cash and *tamarix* wood is not easily available everywhere. Hence the people are using *Prosopis juliflora* (local name *devi*) instead.

In the mangrove areas *Avicennia* has remained the main species for firewood and fodder. In Keti Bunder and Kharo Chan, its wood is being used for the construction of houses and boats.

The delta supports some grasses and shrubs, which are grazed upon by buffaloes, cows and camels. The *sohand* grass is found in the saline creeks and *pal* grass and the *lana* shrubs grow where fresh water is available. The quantity and quality of *pal* and *lana* have decreased with the diminishing availability of fresh water in the delta. Resultantly the livestock population of the deltaic areas has also declined. Only camels that require little fresh water and no supplementary feed continue to flourish.

Eveready Pictures Pvt. Ltd/IUCN-Pakistan

A Herd of Camels, Keti Bunder

5. Findings and Analysis

The sectors chosen for assessment of impacts of sea intrusion are:

- Agriculture
- Fisheries
- Forestry

They have been selected because they constitute the main sources of livelihood of the coastal people, although the productivity of some has declined due to various factors including unsustainable use.

The study considers data from the year 1995 to 2000, where available and relevant. We have tried to conform to these cut-off dates but for certain parameters (such as the social) this has not been possible.

5.1 Agriculture

Thatta is predominantly an agricultural district with 372,065 hectares of land under cultivation.

Table 5 - Land Use in District Thatta

Classification	Percentage of Total Area
Cultivated	21.4%
Fallow	13.4%
Cultivable Waste	10.1%
Forests	5.8%

Development Statistics Sindh, 1994

Major crops include wheat, rice, maize, sugarcane, vegetables and fruit. The soil is mainly clay loam or sandy loam in the Indus Basin area and loamy and saline in the deltaic and coastal region. Fresh water resources include the Indus River, canals and inundation channels.

The riverine and deltaic tracts of the River Indus once constituted rich agricultural land in which livestock breeding formed an integral part of agriculture. The delta was criss-crossed by the distributaries of the Indus. The out of bank flooding of the river and the deposition of the nutrient rich alluvium on the land enhanced its fertility. Irrigation water was readily available from the Indus. Agriculture was seasonal and yields were high. Among others, red rice represented a major crop and export of the region.

After the damming of the river, fresh water ceased to flow in the delta channels altogether, except for a few weeks in the monsoon season.

Box 1

VARIATION IN WATER QUALITY OF RIVER INDUS FROM KOTRI BARRAGE TO ARABIAN SEA

A study by M.Y. Khuhawar, S.M. Leghari, R.B. Bozdar, G.M. Mastoi, T.M. Jahangir, S.N. Chandio, A. Leghari; University of Sindh, Hyderabdad (1997-2000)

Adequate freshwater flows in the Indus River restrict the back flow of seawater in the river channel. In the absence of such flows seawater has been observed up to 60 km* upstream in the main course of the river. This four-year study conducted from 1997 to 2000 aimed to examine the water quantity and quality downstream from the Kotri Barrage and the impact of seawater on the quality of River Indus water in the delta region.

Water samples were collected from Kotri Barrage to Keti Bunder and from Kotri Barrage to Shah Bunder, a stretch of about 200 km, during various phases of water discharge in the river. Seven to eight samples were collected from the middle of the flow in each sampling scheme. Two to four sub-samples were collected from the vertical section. These were then analysed for about twenty physico-chemical parameters including conductivity, total dissolved solids (TDS), pH, chlorides, alkalinity, hardness, nutrients and metal contents.

The results of the sampling scheme carried out on 27.7.1997 with a water discharge of 68,939 cusecs downstream of the Kotri Barrage indicated that conductivity, chloride, TDS and hardness remained nearly constant up to Gharo and a significant effect of seawater was not observed. The results of the sampling scheme carried out on 27.4.1997 with some water discharge downstream of Kotri Barrage, the results of chemical analysis remained constant up to Sijawal Bridge and some effects were observed at Darwesh and Uderolal about 60km from the mouth of the river.

However, when the sampling scheme was carried out on 23.4.2000 with zero discharge down the Kotri Barrage for several days the chemical analysis indicated interesting results. Total dissolved solids (TDS) in water upstream from the Kotri Barrage were within the safe limits of 500 ppm as recommended by WHO for drinking water. But downstream the Kotri Barrage the TDS levels rose sharply and reached the limits of 3200 ppm at Sijawal Bridge. The international guidelines for irrigation water quality suggest severe impacts on land for water with TDS above 2000 ppm.

The Indus below Sijawal Bridge comes increasingly under the influence of sea water. It was surprising to note the channel of the river full of water near the villages of Abdullah Jat and Mohmood Jat on the left bank about 20 – 30 km from the mouth of the river. However water quality tests indicated pure sea water with a TDS of 42240 ppm.

It is therefore suggested that some water be allowed to flow downstream from the Kotri Barrage in order to control the back flow of seawater into the main river channel. The extensive back flow of sea water into the Indus would affect the salinity in the delta region and underground water resources that are used as a source of drinking water by the local population.

* - The intrusion of seawater in the Indus has been reported as 60 km in this study. IUCN has observed it to be 54 km upstream till village Darwesh in Taluka Ghorabari.

Continuing low releases of freshwater downstream of Kotri Barrage accompanied by four consecutive years of drought have caused a progressive intrusion of the sea inland and a degradation of land and water resources. Fertile mud plains have been transformed into saline marshes unfit for cultivation[11]. Today the underground water is mainly saline and water logging has affected 17% of the total arable land[12]. Box 1 describes a study exploring the variation in water quality undertaken by Sindh University, Hyderabad.

The parameters being used to assess the impact of sea intrusion on agriculture in the study area are:

- Loss of geographic area
- Loss of area under cultivation
- Impact on economic returns from agriculture

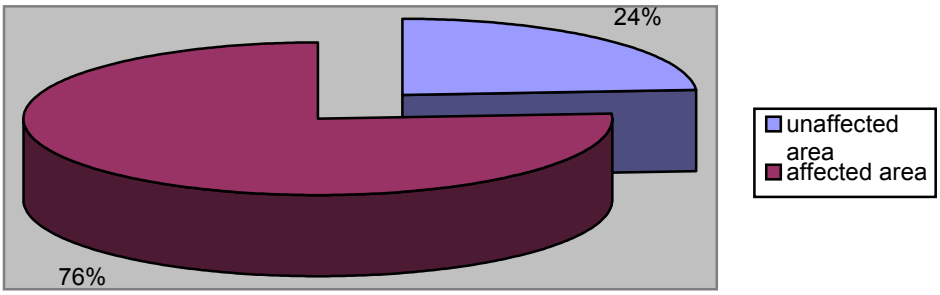
5.1.1. Loss of Geographic Area

Sea intrusion seems to have caused direct land losses in low-lying *talukas* of District Thatta by inundation of extensive land areas. This process has been gradual but unrelenting and has taken place over a period of four decades. *For this parameter the time period of 1995-2000 has not been considered since it is too short a duration for a phenomenon of this nature to register a significant impact.* Rather, loss of geographic area has been employed to depict an overview of the emerging scenario. Based on information obtained from Board of Revenue, Govt. of Sindh (Annex 3), *taluka* wise land losses have been graphically depicted below.

Taluka Keti Bunder

Taluka Keti Bunder (map attached as Annex -) incorporates a total of 42 *dehs* spread over a total area of 60,969 hectares. The sea has completely engulfed 28 *dehs* and 1 has been partially damaged. The total affected area in the taluka is 46,137 hectares.

Figure 2
Inundation of Land - Taluka Keti Bunder



One of the most crucial impacts of sea intrusion here has been the reduction in the extensive cultivation of red rice that constituted a cash crop and staple food of the area. Recent estimates however indicate that the area under this crop in the whole *taluka* has

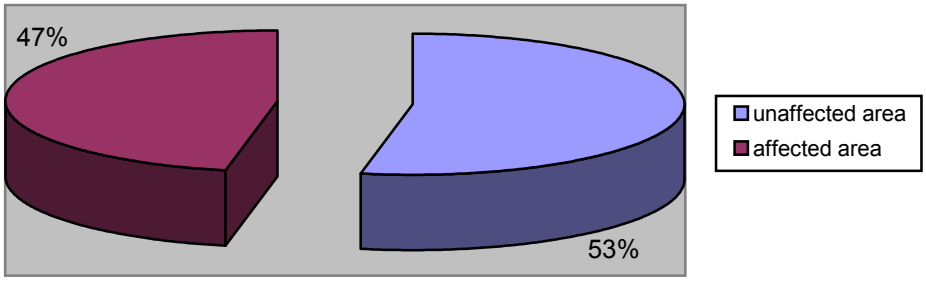
[11] Benchmark Survey and Social Analysis of Forestry Sector in Sindh, May 1997
[12] Agriculture Census 1990, District Thatta

been reduced to barely 200 hectares. Previously this crop had been cultivated over an area of thousands of hectares.

Taluka Kharo Chan

This *taluka* comprised of 41 *dehs* with a total area of 102,069 hectares. So far 47,702 hectares have been affected by sea intrusion. This constitutes 47% of the total land area of the *taluka*. (See Annex – for map of *taluka*).

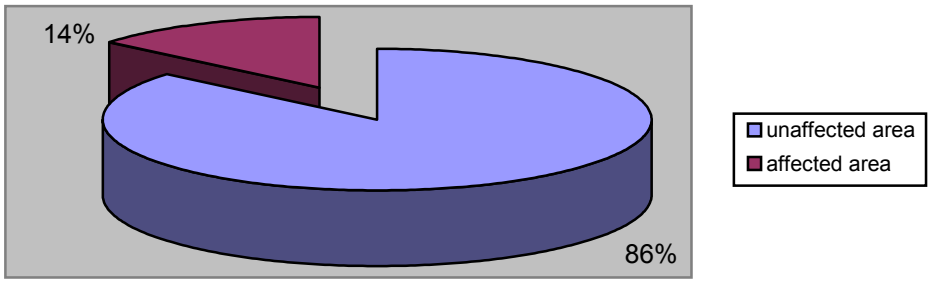
Figure 3
Inundation of Land - Taluka Kharo Chan



Taluka Ghorabari

Ghorabari (see Annex – for map) is the least damaged *taluka* studied. It comprises of a total of 59 *dehs* covering an area of 93,919 hectares. Of the total, 10 *dehs* have been damaged by sea intrusion resulting in a land loss of 12,749 hectares that represents 14% of the total area.

Figure 4
Inundation of Land - Taluka Ghorabari



5.1.2. Loss of Area under Cultivation

District level information indicative of trends in yield per unit area and area under cultivation of different crops, vegetables and fruits was contrary to what was observed by our area findings. The information provided by the office of Deputy Director Agriculture, Thatta indicated a very interesting trend viz. increment in cultivated area and yield despite considerable loss of geographic area and land degradation by intruding sea. For

this reason *taluka* level revenue offices were consulted to get relevant information. This data portrays a very different scenario.

Table 6 contains information that was obtained from the offices of *Mukhtiar Kars*[13] of the concerned *talukas* and the office of the District Revenue Officer, Thatta. It shows the area (in hectares) under cultivation of selected crops from 1995 – 2000.

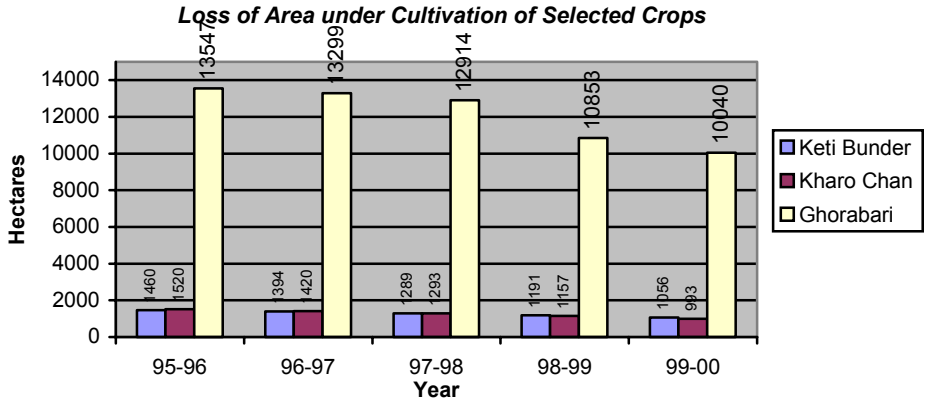
Table 6 - Area under Cultivation of Selected Crops (in hectares)

	1995-96	1996-97	1997-98	1998-99	1999-2000
Taluka Keti Bunder					
Rice	486	441	409	399	379
Wheat	130	121	126	91	118
Maize	372	383	329	286	194
Banana	472	449	425	415	365
Total	1,460	1,394	1,289	1,191	1,056
Taluka Kharo Chan					
Rice	156	140	126	123	105
Wheat	140	126	123	113	118
Maize	126	133	109	87	50
Banana	1,098	1,021	935	834	720
Total	1,520	1,420	1,293	1,157	993
Taluka Ghorabari					
Rice	7,500	7,374	7,247	7,131	6,968
Wheat	910	917	913	928	934
Maize	690	657	654	651	655
Banana	1,579	1,555	1,539	1,524	1,494
Total	10,679	10,503	10,353	10,234	10,051

Source: Offices of Mukhtiar Kars of relative talukas

This data reveals a steady decline in the acreage under cultivation of all these crops. In the absence of other adverse conditions such as disease and pest attacks, this could be both due to loss of geographical area as well as the scarcity of fresh water for irrigation. Figure 5 depicts the gradual decrease in the area under cultivation in the study area. (Complete table attached as Annex -)

Figure 5
Loss of Area under Cultivation of Selected Crops



[13] *Taluka* Revenue Officer

Table 7 presents the percentage loss in the cultivated area for the selected crops.

Table 7 - Loss of Area under Cultivation of Selected Crops

Crop	Taluka Keti Bunder		Taluka Kharo Chan		Taluka Ghorabari	
	Loss of Area (ha.)	% Loss	Loss of Area (ha.)	% Loss	Loss of Area (ha.)	% Loss
Rice	107	22	51	33	532	7
Wheat	12	9.2	22	16	24+	2.6+
Maize	178	48	76	60	35	5
Banana	107	23	378	34	85	5.4
Total	394		527		628	

Based on these figures it is obvious that there has been a gradual decrease of cultivated area, which may be due to inundation of land as well as soil and water degradation resulting from sea intrusion.

To gauge the economic impact of the loss of area under cultivation, an estimated average cost of Rs. 60,000 per hectare of agricultural land has been applied. This cost has been calculated by taking an average of land prices that range between Rs. 50,000 to above Rs. 70,000 per hectare depending upon the availability of fresh water. However, it is an approximate value. ***The total loss of 4428 hectares under cultivation of these selected crops (rice, wheat, maize and banana) translates into an economic loss of Rs. 265.7 million over a period of five years (1995-2000). In the next 25 years this loss would amount to an approximate total of Rs. 1.3 billion.*** It is reiterated that this is an estimated figure and not an exact calculation of the economic loss since several factors such as the yearly fluctuation in prices of land have not been taken into account due to unavailability of data.

5.1.3. Impact on Economic Returns from Agriculture

The sea intrusion phenomenon is accompanied by many costs manifest in the benefits foregone due to environmental degradation. One such cost is the impact on the economic returns from agriculture, which is a direct consequence of soil and water resource degradation. This is an extremely important parameter since it directly impacts the income of the local population.

In the ensuing data analysis the ecological impact has been collected and converted into economic costs. Data used to investigate this aspect of the study is attached as Annex 4.

The following table has been derived by converting the area under cultivation into hectares, and then multiplying that figure with average yields as per specific crop. It shows a general decline in all agricultural crops, except wheat, which seems to have recovered in 1999-00.

Table 8 - Aggregate Production in Metric Tonnes of Selected Crops in Study Area, 1995/96-1999/00

Agricultural Crop	1995-96	1996-97	1997-98	1998-99	1999-00
Rice	16,281.78	15,909.35	15,562.82	15,305.36	14,902.97
Wheat	1,736.93	1,715.47	1,711.29	1,667.77	1,723.82
Maize	422.65	416.75	388.12	363.94	319.47
Bananas	6,680.55	6,419.44	6,149.75	5,883.49	5,472.07

Table 9 provides essential raw data to convert the data in Table 8 into economic costs.

Table 9 - Prices of Selected Crops 2000/01

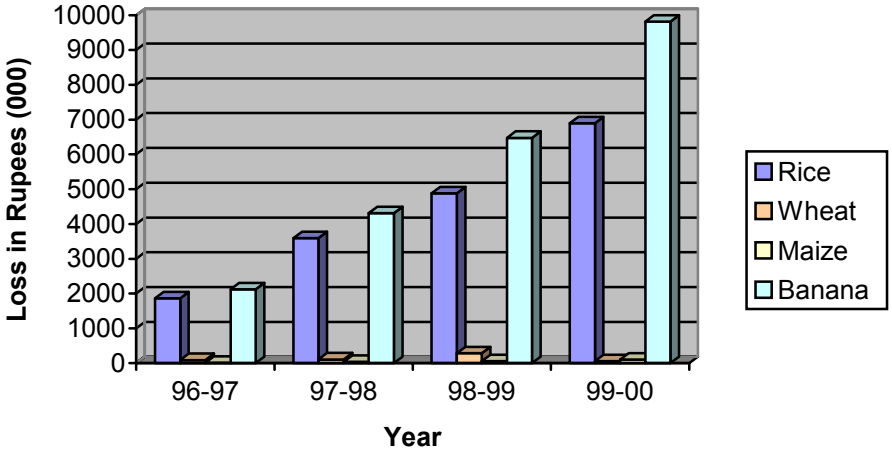
Crop	**Price (Rs./kg)**				
	1st Quarter	**2nd Quarter**	**3rd Quarter**	**4th Quarter**	**Average**
Rice	5.00	5.00	5.00	5.00	5.00
Wheat	4.07	4.07	4.07	4.07	4.07
Maize	0.63	0.63	0.88	1.63	0.94
Bananas	6.25	7.50	8.75	10.00	8.13

Analyzing the above data (Annex 2), Table 10 has been created to demonstrate the economic losses in agricultural production 1995/96-1999/00.

Table 10 - Losses on Agricultural Produce at 2000/01 Prices for the Period of 1995/96-1999/00

Name of Agricultural Crop	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**
Rice Losses*		-1,862,163	-3,594,784	-4,882,105	-6,894,051
Wheat Losses		-87,258	-104,225	-281,165	-53,324
Maize Losses		-5,561	-32,552	-55,338	-97,248
Banana Losses		-2,121,491	-4,312,769	-6,476,132	-9,818,876
Absolute Losses		**-4,076,473**	**-8,044,329**	**-11,694,740**	**-16,863,500**
Relative Losses		**4,076,464**	**3,967,857**	**3,650,361**	**5,168,807**
% Change Annually		*2.848%*	*2.853%*	*2.702%*	*3.932%*

Figure 6
Losses on Agricultural Produce



The statistics reveal the following:

- Crop production has declined overall, as well as for individual crops over this period (the small recovery in wheat production in 1999/2000 is not very significant, as wheat has not fallen drastically anyway).

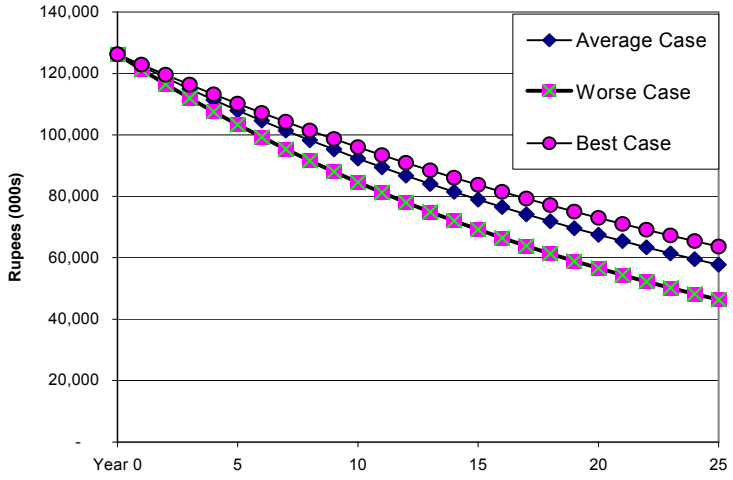
- The average annual loss, in relative terms, is Rs. 4.2 million. The analysis of annual loss shows a clear pattern. Over the study period, annual loss is an average of 3%, varying between 2.7% and 3.9%.

- Absolute losses neared Rs. 17 million in 1999/00; while for the 5 year period absolute losses neared a staggering Rs. 40.7 million.

- These figures indicate substantial losses to the local economy, which is intrinsically dependent on agriculture. It may be safe to assume that the number of the poor has been increasingly pushed below the poverty line.

Figure 7 illustrates the analysis of data for the past 5 years in order to predict trends, as future scenarios, relating to agricultural losses 25 years into the future. The data over the study period shows that crop production is declining at an average of 3%, between a maximum of 3.9% and a minimum of 2.7%. By using these numbers, average rate of decline (3%), worst-case rate of decline (3.9%), best-case rate of decline (2.7%), indicative trends and figures in terms of losses are provided.

Figure 7
Future Trends in Agriculture: Best Case, Average Case and Worse Case Scenarios



The analysis reveals that

- The variation observed is fairly consistent between the three cases, pointing to a clear trend/pattern
- The Average Case: total costs in absolute terms over the next 25 years will amount to about 1 billion rupees, or a net present cost of 227.55 million rupees.
- ***The Worst Case Scenario***: total costs in absolute terms over the next 25 years will exceed 1.2 billion rupees, or a net present cost of 277.26 million rupees
- The Best Case: total costs in absolute terms over the next 25 years of 902 million rupees, or a net present cost of 203.59 million rupees

It is crucial to recognize that at some point in the future, if such degradation of the ecosystem is allowed to continue for whatever reasons, the ecosystem will probably reach a critical point and then collapse, which is simply saying that no more economic output will be possible from the area.

5.2 Fisheries

The Sindh province holds a premier position in the fisheries sector of the country. It commands almost 90% of brackish water and 71% of the marine resources of the total fisheries resources of Pakistan[14]. Export of fisheries products constitutes 2% of national exports and contributes significantly to the national income. The average annual income from export of this commodity amounts to Rs. 2.2 billion, of which 60% is attributable to shrimp and 40% to fish. The total production of the fisheries sector in the year 2000 was estimated at 665,000 MT of which Sindh produced 318,770 MT (48% of the total)[15]. Besides providing valuable export earnings to the country, it is the primary livelihood of a vast majority of coastal population and also a source of cheap protein in the diet of the local communities.

Box 2

Year-wise Shrimp Landings showing decline in Larger Shrimp (in MT)

Year	Jaira (Large)	Kalri (Medium)	Kiddi (Small)	Total
1971	10,000	6,080	3,741	19,821
1992	5,397	8,238	12,693	26,328
1993	6,820	9,468	18,632	34,920
1994	6,021	7,120	16,023	29,164
1995	5,723	6,981	12,919	25,623
1996	6,123	7,602	14,047	27,772
1997	6,115	6,801	16,722	29,638
1998	5,311	6,204	14,689	26,204

Source: Marine Fisheries Department

The propagation and recruitment of seed of important fish species have always been correlated to the timings and intensity of monsoon floods as well as the continuous flow of floodwaters down to the sea. The reduction in flow intensity has disturbed this cycle, resulting in the deterioration of freshwater and marine fisheries both in terms of quantity and diversity. These fisheries constitute a notable reservoir of foreign exchange earnings for the country. The pallah fish (*Tenualosa ilisha)* that is essentially a marine migratory species is also caught on the river when it ascends upstream for breeding purposes. Catch landings of this species alone were reduced from about 10,000MT per annum in the 1970s to 400-600MT per annum in the late 1990s. Furthermore the size of individual fish has also declined. Likewise, the catch of baramundi (*Lates calcarifer*) has declined from 1000-3000MT per annum in the 1980s to about 200MT per annum in the 1990s. A somewhat similar trend has been observed in the larger variety of shrimp catches. There are 23 species of shrimp in the inshore and the offshore waters of Pakistan of which 15 are exploited commercially. They are classified into three categories according to size: *jaira, kalri* and *kiddi*, with *jaira* being the largest and *kiddi* the smallest. A notable decrease has occurred in the catches of the *jaira* variety of shrimp that has been the greatest foreign exchange earner in the fisheries sector[16] (see Box 2).

The discharge of fresh water into the sea plays a major role in the formation of an extended delta and a fertile estuary for the breeding and growth of juvenile fish, shrimp and shell fish that require low salinity (12ppt-15ppt) water during this phase of their life cycles. At present the salinity of the creek waters has increased to 50ppt, which is detrimental to the breeding of fish and shrimp species. The decline in this flow is the

[14] Effect & Economic Losses on Marine Life and Aquaculture due to Shortage of Fresh Water in Downstream Kotri Barrage up to Sea and Encroachment of Sea in Coastal Areas, Fisheries Wing, Agriculture, Livestock and Fisheries Department, Government of Sindh.
[15] Economic Survey of Pakistan, 2000-2001
[16] Agriculture, Livestock and Fisheries Department, Government of Sindh

fundamental factor responsible for the reduced productivity of fisheries, which is manifest in the declining catch of some valuable species. For example, the catch per unit effort of the *kalri* and *jaira* varieties of shrimp has declined by 25% and the shrimp catch per trawler has also declined from 25 MT in 1971 to less than 5 MT in 2000[17].

The Sindh coastline, though of a shorter length than the Balochistan coastline, is much more productive in terms of coastal resources as shown in the table below.

Table 11 - Comparative Analysis of Sindh and Balochistan Coastlines

Province	Length of Coastline (km)	Shrimp Catch (MT)	Fish Catch (MT)
Sindh	330	83	770
Balochistan	645	1.3	202

Source: Agriculture, Livestock and Fisheries Department, Govt. of Sindh

Though the catch is also dependent upon the per unit effort, the higher productivity of the Sindh coast may to a great extent be attributed to the fact that the Indus and other smaller rivers outflow into the sea here. These channels bring with them the nutrient rich silt that has over the centuries built up the deltaic region and the exceptionally wide continental shelf, the seat of coastal productivity. The Balochistan coast lacks this feature due to the absence of rivers outflowing into the sea. But with diminishing freshwater outflows the productivity of the Sindh coast will also decline.

According to an IUCN Study[18], a freshwater flow of at least 27 MAF is required for the maintenance of a sustainable estuary and mangrove ecosystem in the delta. However, according to experts the flow has fallen to an alarming level of a bare minimum of 0.72-2MAF during 2000-2001 out of the 10 MAF promised under the 1991 Water Accord.

The parameter being employed to assess the impact of sea intrusion on fisheries in the study area is the reduction in freshwater fish catch. Due to the unavailability of data, no other relevant parameter could be analyzed at the present time.

5.2.1. Reduction in Freshwater Fish Catch

There are about 127 species of fresh water fish found in the lower Indus Basin including those inhabiting the estuary of the Indus Delta[19]. The pallah (*Tenualosa [Hilsa] ilisha*) is a commercially important migratory fish species that ascends into the River Indus from the sea to breed during April-September. The upstream migration of this fish that tended to travel up to Multan prior to 1930 (before the construction of the Sukkur Barrage) has now been restricted only till Kotri Barrage.

The migration of pallah has been directly related to the inflow of river and the intensity with which it falls into the sea. In 1930, prior to the damming of the river, the landing of this species constituted 70% of fish catch. This had been reduced to 15% in the mid-80s. Its production has further diminished relative to the falling discharge to the Indus downstream of Kotri. The size of individual fish has also been reduced and in extreme

[17] Marine Fisheries Department
[18] Possible Effects of the Indus Water Accord on the Indus Delta Ecosystem, Issue Paper No. 1, April 1991
[19] Mott. Macdonald International, 1992

cases was reported to have declined from 1.3 feet to under 5 inches[20]. Similarly, major Carp species - *Labeo rohita, Labeo calbasu, Catla catla and Cirrhina mrigala* that comprise a commercially important group of Indus River fisheries, have also suffered a decline in production. They are high priced and dominate the catch of the river Indus as well as lakes, dams, reservoir, canals, drains and all other inundation areas connected to the river system. As with the pallah, the production of major carps is also dependent upon the floods in the river and the intensity with which it flows down to the sea. They have also suffered a decline in production and downstream of Kotri and in the Ghorabari area these species have virtually disappeared from catches.

Raw data for the analysis of the parameter *Reduction in Freshwater Fish Catch* was obtained from the Fisheries Department. (Aggregate Tables also attached as Annex 5).

Table 12 - Aggregate Production of Fish in the Study Area (1996/97 - 1999/00)

Name of Fish Specie	1996-97	1997-98	1998-99	1999-00
		Metric Tonnes		
Pallah*	150,000	120,000	70,000	65,000
Major Carps (Dambro, Thaila and Morakha)	21.75	19.6	16.9	16.96
Others	1,295	1,301	1,275	1,250

***** The pallah figures are not in metric tonnes, but are quantified in per fish.

Table 13 provides essential raw data to convert the effects on fish production into economic costs.

Table 13 - Prices for Marketed Fish during 2000/01

Name of Fish Specie	Price (Rs./kg)				
	First Quarter	*Second Quarter*	*Third Quarter*	*Fourth Quarter*	*Average*
Pallah*	-	75.00	87.50	-	81.25
Dambro	70.00	60.00	60.00	75.00	66.25
Thaila	60.00	50.00	50.00	65.00	56.25
Morakha	60.00	55.00	55.00	70.00	60.00
Others	50.00	45.00	45.00	60.00	50.00

* Price for the fish is given per piece

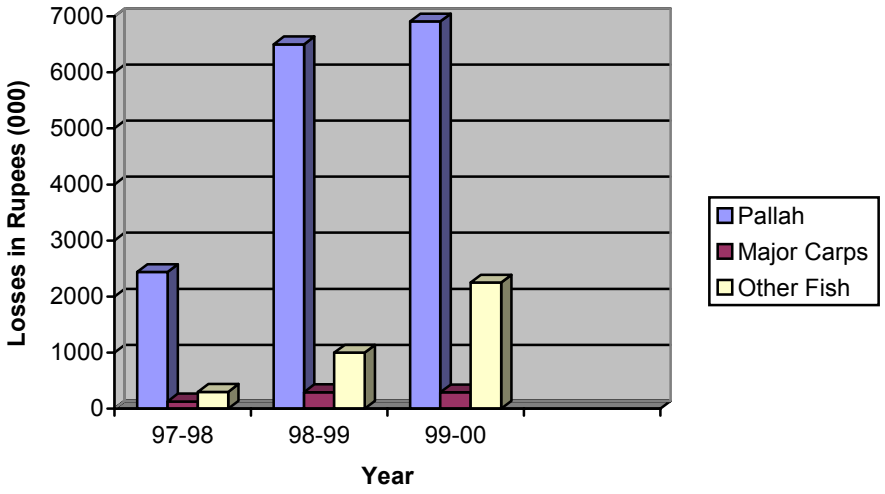
[20] Effect & Economic Losses on Marine Life and Aquaculture due to Shortage of Fresh Water in Downstream Kotri Barrage up to Sea and Encroachment of Sea in Coastal Areas, Fisheries Wing, Agriculture, Livestock and Fisheries Department, Government of Sindh

Table 14 below demonstrates the economic losses in fish production 1996/97-1999/00.

Table 14 - Losses on Fish Produce at 2000/01 prices for the period of 1996/97 - 1999/00

Name of Fish Species	1996-97	1997-98	1998-99	1999-00
Pallah Losses		-2,437,500	-6,500,000	-6,906,250
Major Carps Losses		-130,785	-295,026	-291,376
Other Fish Losses		300,000	-1,000,000	-2,250,000
Absolute Fish Losses		-2,268,285	-7,795,026	-9,447,626
Relative Fish Losses		-2,268,285	-5,526,741	-1,652,600
% Change Annually		*2.90%*	*7.27%*	*2.35%*

Figure 8
Losses on Fish Produce



An analysis of the data highlights the following:

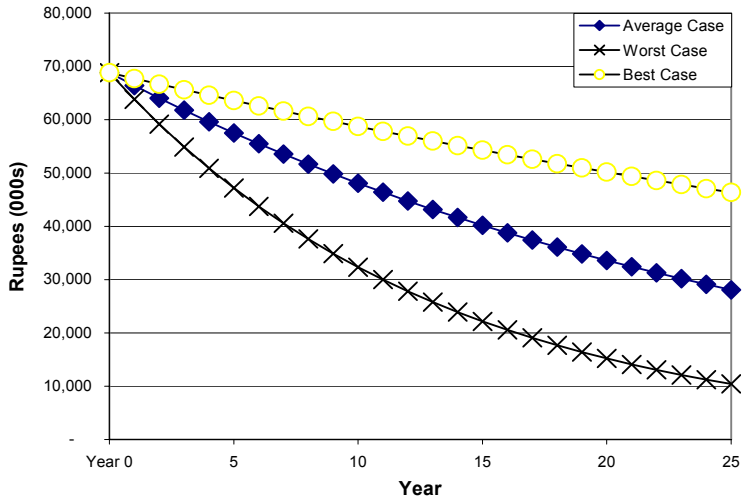
- Fisheries production has declined overall and for individual species over this period, especially pallah, which has declined by more than 50%. The small recovery of other species in 1997/98 is not very significant, as it does not change the trend.
- Average annual loss is estimated at Rs. 3.15 million.
- Annual loss shows a clear pattern. While, over the study period it is an average of 4.2%, however, it has varied considerably between 2.4% and 7.3% (1998/99, obviously a rogue year).
- In absolute terms, losses were over Rs. 9 million in 1999/00, and over the period of 4 years the cumulative losses amounted to over a hefty Rs. 19 million.

Again, these figures indicate substantial losses to the local economy, where fish contributes significantly to the livelihoods, and is a major source of protein, especially for the poor. With these declining trends the number of the poor would be disproportionately affected and increasingly pushed below the poverty line.

Figure 9 has been created below delineating fish produce losses 10 years into the future. Three scenarios have been depicted: average rate of decline (4.2%), worst-case rate of decline (7.3%), and best-case rate of decline (2.4%). The analysis reveals the following:

- The Average Case: total costs over the next 25 years of Rs. 604 million or a net present cost of Rs. 138 million
- ***The Worst Case Scenario***: total costs over the next 25 years of Rs. 976 million, or a net present cost of Rs. 237 million.
- The Best Case: total costs over the next 25 years of Rs. 311 million, or a net present cost of Rs. 69 million.

Figure 9
Future Trends in Fish Losses: Best Case, Average Case and Worse Case Scenarios



Again it is crucial to recognize that at some point in the future, due to persistent degradation, the ecosystem will probably reach a critical point and then collapse, giving no more economic output.

5.3 Forestry

The two major forest types that fall within the study area are:
1. Riverine forests along the banks of the Indus; and
2. Mangrove forests in the Indus Delta.

The riverine area constitutes the land on either side of the river that is liable to flooding should floodwaters over-top the river-bank. Effectively this means the strip of land bordered by the river on one side and by flood bunds or naturally occurring high ground on the other side. These forests are economically very important since they provide the major timber requirements for construction, mining, furniture manufacture as well as fulfilling the fuel and fodder requirements of the local communities. Furthermore, forestry is, in many cases, the only viable option for the development of land adjacent to the river.

The riverine forests downstream of Kotri Barrage cover an area of 43,400 hectares and produced 170, 617m^3 of timber between 1962 and 1992. This area directly supports a population of over 130,000 people predominantly engaged in activities related to the direct or indirect use of the River Indus and a significant population indirectly.

The riverine forests of the study area essentially fall within *Taluka* Ghorabari on the right bank of the Indus. The list of these forests with their area statement is given as Table 15. The major tree species in the riverine forests are *Babul* or *Kikar* (*Acacia nilotica*), *Kandi* (*Prosopis cineraria*), *Bahan* (*Prosopis euphratica*) and *Lai* (*Tamarix spp.*). The most economically important of these species is *Acacia nilotica* that was once reported to have been the most common of the larger riverine tree species.

Table 15 - Area Statement of State Riverine Forests in Study Area

Range	Forest	River Bank	Total Area		% of Total Riverine Forest Area
			Acres	Hectares	(%)
Ghora Bari					
	Kathore	Right	2,378.0	962.5	2.3
	Hayat Gaho	Right	836.6	338.6	0.8
	Gulel	Right	219.7	88.9	0.2
	Marho Kotri	Right	5,442.4	2,202.5	5.3
Total			**8,876.7**	**3,592.5**	

Source: DFO Office, District Thatta

The decline of outbank flows capable of flooding significant areas of forests following the construction of various major storage and water diversion structures on the river is significant. Before the regulation of the river, outbank flow could be expected on average 8 years in 10, whereas now it only occurs on an average of 4 years in 10. The young *Acacia* seedlings are now less able to develop their substantial taproots that enable them to exploit the subsurface moisture and survive the prolonged periods of no inundation (see Box 3).

Acacia nilotica is now being replaced by the deeper-rooted and faster growing *Prosopis spp*. that are better able to exploit the reduced flooding regime. However, these species

do not produce such good quality timber as *A. nilotica* and are mainly exploited as a source of firewood since they coppice well.

Surface water studies have established that substantial out of bank flows in the region of 11,300 to 14,200 m^3/sec are required to flood the majority of the existing riverine forests. Given the water requirements for tree species and permeability of the soils within the riverine areas it has been calculated that in the region of 8-10 MAF of water would need to be discharged in order to achieve this.

The other important forest type in the study area is the mangrove forest spread sporadically along the coastline but mostly concentrated in the Indus Delta, which stretches from Karachi in the north-west to the Rann of Kutch on the Indian border. Due to the regulation of the Indus, principally over the last sixty years, the bulk of this area now lies outside the direct influence of the freshwater releases downstream Kotri Barrage and the active delta has shrunk to a mere 250 km^2 as opposed to 6000 km^2 a century ago. Satellite imagery depicts that mangrove coverage has also decreased from about 263,000 hectares in 1977 to about 160,000 hectares in 1991[21] - a loss of more than 100,000 hectares in less than 20 years.

Box 3

Excerpt – Newspaper "The Dawn", January 10, 2002

THATTA: Sea intrusion destroys forests in Thatta
By Muhammad Iqbal Khwaja

THATTA, Jan 10: The regeneration of Babool, Kandi and Lai trees on more than 4,500 acres in Marho Kotri, Budhani, Ach Marho, Allah Bux and Bahadipur forests has vanished due to sea intrusion on low-lying forest areas in Thatta coastal belt since last couple of years.

District forest officer (afforestation) Riaz Ahmed Wagan told Dawn that due to acute shortage of flood water in riverine tract of this district for last several years, particularly since 1994, the composition of these forests has been changed by replacing the Babool, Kandi and Lai species with salt tolerant and more xerophytic "Mesquite" species.

Besides some 20,000 to 25,000 acres of riverine land previously cultivated on river water in riverine tract of Thatta district has been rendered unproductive due to non-availability of sweet water in the riverbed.

The mangrove forests serve the multiple functions of coastline stabilization, protection of ports against natural disasters, and form an integral component of the economy of coastal communities, providing fuel wood, fodder and various other products. It has been estimated that about 100,000 people in the delta use a total of 18,000T of mangrove firewood each year[22]. The annual value of legally collected firewood is around Rs. 4,900,000 and cut fodder alone is valued at Rs. 2,000,000[23].

In addition to these direct uses, mangroves constitute a significant part of the productivity base of several important fisheries. Pakistan has a large and lucrative prawn fishery, generating annual revenues of around USD 60 million. An estimate cites that 70% of the Pakistan shrimp fishery is dependent on mangroves[24]. The situation is similar with respect to fish. Around 155 species of fish have been recorded from the mangroves of Pakistan, many of them of commercial importance. The export of marine fish, shrimp,

[21] Fisheries Wing, Agriculture, Livestock and Fisheries Department, Government of Sindh
[22] Meynell and Qureshi, 1993
[23] Meynell and Qureshi, 1993; Beg 1991; Qureshi 1991; Sindh Forest Department, 1991
[24] Beg, 1991

lobsters and crabs help the national economy earn Rs. 2.2 billion annually besides providing employment and livelihood to more than 100,000 people associated with the fishing industry. If the mangroves are degraded, much of the 250,000T of fish caught off the Sindh Coast will be at risk[25].

The mangroves have been subject to indiscriminate cutting and lopping. The local population has exploited mangroves for fuel-wood and fodder since decades. In addition, herds of camel visit these islands every year for grazing purposes and create big blank areas.

The parameters being used to assess the economic impact of sea intrusion on forestry in the study area are:

- Loss of forest cover/ productivity
- Loss of forest land

5.3.1. Loss of Forest Cover/ Productivity

The following data pertaining to the study area (*Talukas*, Keti Bunder, Kharo Chan and Ghorabari) has been obtained from the Conservator of Forests, District Thatta. The losses encompass the period from 1995 – 2000. Unfortunately time-series data was not available.

Table 16 - Forest Productivity Losses - 1995/00

S.No.	Particulars	Quantitative Loss (stacks)	Value per stack (Rs.)	Total Loss (mill. Rs.)
1.	Loss of riverine forests (*Acacia. nilotica*, *Prosopis cineraria* and *Tamarix spp*.)	4,000	25,000	100
2.	Loss of mangrove forests (*A. marina*)	45,000	1,000	45
	Total Loss			**145**

Source: Conservator of Forests, Thatta

5.3.2. Loss of Forest Land

The loss of forested land during the study period and the related economic costs have been summarised below.

Table 17 - Forest Land Losses - 1995/00

S.No.	Particulars	Area Loss (ha.)	Value per hectare (Rs.)	Total Loss (mill. Rs.)
1.	Loss of culturable riverine land	1,619.43	49,400	80
2.	Loss of mangrove lands	18,218.62	1,235	22.5
	Total Loss			**102.5**

Source: Conservator of Forests, Thatta

[25] IUCN, 1993

As per analysis, ***the net loss from productivity loss of riverine and mangrove forests and the associated land losses over a period of five years amounts to Rs. 247.5 million. If no measures are taken to improve this condition, the projected losses over the period of the next 25 years would multiply to a staggering Rs. 1.2 billion.***

Though it is acknowledged that the loss of forest cover may be on accounts of indiscriminate cutting and lopping of timber, it is important to note that the release of water from Kotri Barrage during Rabi and Kharif seasons could improve water quality and allow some more land and forests in the riverine and deltaic areas to be irrigated. The fresh water sediments and nutrients brought down by the river are important to prevent further degradation of coastal and riverine ecosystems and would help improve the situation.

6. The Social Dimension

Generally environmental issues affect the poor more since their livelihoods are integrated with nature to a greater extent than the more affluent who may have other resources at their disposal. The phenomenon of sea intrusion in River Indus is no exception to the fact. Geomorphological changes due to the reduction in the flow of fresh water and intrusion of the sea in the riverine and deltaic areas of the River Indus have led not only to economic but also social deprivation of the resident communities.

The population of the study area is by and large rural based with their livelihoods dependent upon agriculture, livestock, fisheries and forests. The availability of freshwater is mandatory to ensure the productivity of all these sectors. Sea intrusion coupled with persistent drought conditions and low rainfall over the last several years has severely diminished this supply, hence causing devastating losses of livelihoods, migration to hinterland and a rise in poverty levels (see Box 4). Some other indicators of the deteriorating socio-economic condition of the locals are unavailability of potable water and increase in the incidence of disease. Economic implications of the delta's deterioration are already making their presence felt in all sectors.

Box 4

http://www.dawn.com/weekly/review/review4.htm

Life without water
By Rasool Bux Shah

Seventy-year-old Muhammad Saleh, a resident of village Keti Bandar - situated at the Sindh coast in district Thatta - was a prosperous agriculturist a decade ago. He used to cultivate 40 acres of his 60-acre agriculture land and reared large herds of animals. But for the past several years, particularly the last five, prosperity has become a dream.

His cultivation drastically dropped to only 10 acres during the last crop. Following the death of a number of animals due to the non-availability of fodder because of the prevailing drought, he sold his remaining cattle including goats, sheep and cows, and his only horse. "My children used to wear new clothes a few years ago but fate has turned its back on us and now they wear old clothes," said Saleh as he pointed at his children's rugged clothes, with tears in his eyes.

Saleh is not the only one facing an acute water shortage in Sindh's coastal belt. Thousands of inhabitants of Keti Bandar, Shah Bandar, Ghorabari, and Kharo Chan Talukas in district Thatta and some parts of district Badin are facing a lot of problems due to the drought. "We don't even have drinking water! It's ridiculous," said Khamiso Baran, of Keti Bandar. "We never thought we'd face such a situation. Not a single drop of water has reached our lands this year. You can see there is desertification everywhere. And the sea is encroaching, coming towards us. I fear one day it will take us," he said.

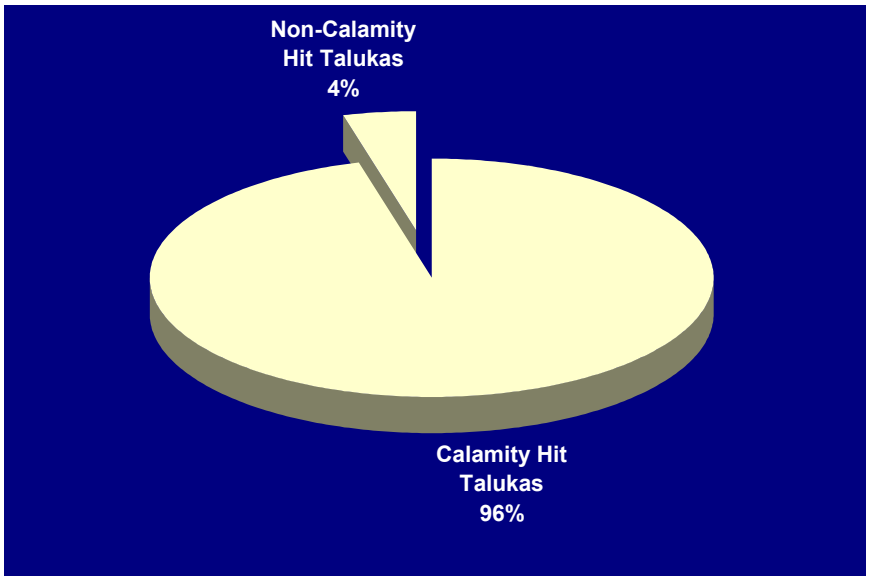
The Indus Delta region was once the hub of economic activities emanating from agriculture, livestock and fisheries. But today the desolation is evident. There are no estimates available mentioning the number of affected villages and displaced population forcibly migrated due to tidal encroachment induced by water shortages in the delta. However, according to the Drought Assessment Report of 2001[26], the drought has decimated livestock and severely affected fruit orchards and rain-fed cereal production.

[26] Drought Assessment Report on Pakistan was produced by FAO and WFP in collaboration with UNDP. In Sindh three districts were covered by the study i.e. Dadu, Thatta and Badin.

The Government of Sindh on June 14, 2002, under the provisions of Sindh Natural Calamities (Prevention & Relief) Act, 1958 has declared eight *talukas* out of nine in District Thatta as "calamity hit areas" (Annex 2). All the six coastal *talukas* including the three covered in this study are also included. This declaration has been made by the Relief Department after undertaking comprehensive assessment of these areas

The *talukas* covered in this study (Keti Bunder, Kharo Chan and Ghorabari) comprise 15.6% of the total calamity hit area. According to the officials of this department water shortage has badly affected the economic activities, particularly agriculture, in the area.

Figure 10
Calamity Hit Area of District Thatta



The parameters identified for this section of the study are:

- Wage loss
- Impact on health

Due to the non availability of statistical data it was not possible to translate the impact of sea intrusion on selected parameters into economic costs, as has been attempted for the sectors of agriculture, forestry and fisheries. However, a descriptive analysis of these impacts has been given. The socio-economic analysis has been based upon the two last Census reports (1981, 1998) and on-site interviews.

6.1 Wage Loss

The three-year drought has intensified dependence on migrant wage labour. However, the increased supply of labour has resulted in a decline in wage rates of 40 to 60 percent.

Although the nominal price of wheat remained stable, decline in wage rates coupled with reduced prices fetched for livestock have seriously eroded the coping capacity of small livestock herders in the areas. There has been a decline in the consumption of important food items like milk, meat and vegetables. This is a major nutrition concern particularly for women and children, who already have high malnutrition and anaemia in the resource poor area. Many households are reported to be surviving only on chillies, onion and bread.

6.2 Availability of Fresh Water and Sanitation

One of the most important impacts of sea intrusion is the contamination of freshwater resources, that has in turn affected all socio-economic and ecological sectors. It has made potable water scarce in the area, giving rise to a number of water-borne and other diseases. This parameter has been analyzed here in greater detail.

Box 5

"When you go back, send us the water," said an eight-year-old boy, staring at a small water cooler in our vehicle. When we gave the cooler to him, the boy quickly took the cooler and ran home nearby along with the cooler and rushed back to get the cooler emptied in his water pots. "Have you mixed the sugar in water," asked the anxious little boy after drinking a few drops from our water. An old man, Khan Mohammad, who was standing there, explained, "people are used to drinking saline water here so whenever they get a chance to drink sweet water, they think it has sugar mixed in. Due to drinking the saline water, almost all the population has become prone to different water borne diseases," he added. "The Indus water was the only source of sweet water as the underground water is saline here."

Life without water
By Rasool Bux Shah

Ground Water

The distribution of population in the study area is unique in the sense that most of the population is concentrated in several smaller settlements instead of a few large villages. These settlements, with populations of under a thousand persons each, are located on the agricultural lands.

The groundwater in the study area is mostly saline (see Box 5). Hence water supply and sanitation assume great importance[27]. Formerly, fresh water for drinking purposes was readily available from the various distributaries of the Indus that traversed the area. But with the progressive intrusion of the sea, these have now become saline. Potable water is now available only from the nearest irrigation sources, which are located at considerable distances from the coastal settlements. Water is transported from these sources by vehicles and boats and is exclusively used for drinking and cooking purposes. At times of water shortage, the perennial Odero Canal, which supplies water to Ghorabari and Keti Bunder *Talukas*, does not contain enough water to flow down to the tail-end branches. As a consequence, water supply ponds of various towns have no water at all and residents face severe problems in obtaining water for daily use.

In areas that do not have saline groundwater, hand pumps constitute another source of freshwater. The Rural Development Department is responsible for the provision of water supply in the settlements that are located in the study area. Table 18 depicts the distribution of hand pumps in the studied *talukas*.

[27] District Development Profile/Plan for District Thatta- June 1999

Table 18 - Water Supply Coverage in Settlements with Population below 1000 through Provision of Hand Pumps till June 1999

S. #	Taluka	No. of settlements (population under 1000)	Total no. of hand pumps installed	No. of settlements with hand pumps	% of settlements with hand pumps
1.	Keti Bunder	127	9	9	7.08
2.	Kharo Chan	63	48	48	76.19
3.	Ghorabari	337	10	7	2.07
	Total	**527**	**67**	**64**	**12.14**

Source: District Development Profile/Plan for District Thatta, June 1999

Of the 527 settlements in the study area, only 12.14% were provided with hand pumps till June 1999. The most severe shortage was observed in Ghorabari, followed by Keti Bunder.

Coverage of piped water supply and drainage

The villages with populations of 1000 and above having brackish groundwater are provided with piped water supply by the Public Health Engineering Department (PHED). The following table shows the water supply coverage by the PHED in the study area.

Table 19 - Water Supply Facilities in Rural Areas of District Thatta

	Year	Keti Bunder	Kharo Chan	Ghorabari	Total
No. of Completed Schemes	Till June '94	0	0	5	5
	1994-95	0	0	0	0
	1995-96	0	0	0	0
	1996-97	0	0	0	0
	1997-98	0	0	0	0
	1998-99	0	1	0	1
Ongoing Schemes		0	0	0	0
Total No. of Schemes		0	1	5	6
No. of Settlements with population 1000+		0	1	10	11
Development Gap		0	0	5	5

Source: District Development Profile/Plan for District Thatta, June 1999

There are 11 villages with a population of above 1,000 persons in the study area. The data shows that from 1994 to 1999 water supply schemes were provided in only 6 villages.

The data reveal that Keti Bunder *Taluka* does not have a single water supply scheme, whereas Kharo Chan *Taluka* had one scheme in 1998-99. Ghorabari *Taluka* had schemes in five settlements out of ten leaving a development gap of five.

Sanitation

In general the study area lacks any system of excreta or wastewater disposal. Residents have constructed makeshift latrines, with mat walls, near the sea. In the settlements where piped water is available, wastewater drains into large stagnant pools.

The following figure shows the details of household latrines provided up to June 1999 in the study area by the Rural Development Department (see Annex – for detailed data).

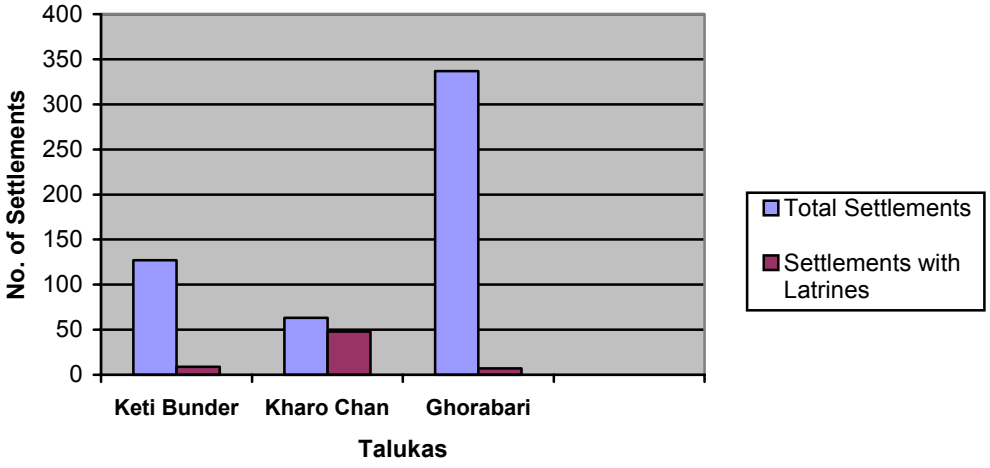
Table 20 - Sanitation in Settlements with Population of below 1000 through Provision of Latrines up to June 1999

Taluka	Settlements with Population under 1000	Settlements with Latrines	Settlements without Latrines	Total No. of Latrines installed	Percentage of Settlements Covered
Keti Bunder	127	9	118	51	7.08
Kharo Chan	63	48	15	139	76.19
Ghorabari	337	7	330	23	2.07
Total	**527**	**64**	**463**	**213**	**-**

Source: District Development Profile/Plan for District Thatta, June 1999

The data provided in the Table 20 has been graphically depicted in the figure below.

Figure 11
Provision of Latrines in Study Area till June 1999



The data indicate that the majority of settlements in the study area lack sanitation facilities. Though, *Taluka* Kharo Chan appears to have the highest coverage of sanitation, the least number of settlements in the study area are located here.

6.3 Impact on Health

Potable water is considered a pre-requisite for the health of people. Lack of clean drinking water, and sanitation in the three *talukas* have contributed to widespread water borne diseases, of which diarrhoea is the most serious. The waterborne diseases are transmitted by poor quality of water and sanitation, which depletes human energy resulting in sickness reducing thereby the productivity of the people.

The Health Management Information System (HMIS) run by Health Department, Government of Sindh is responsible for compiling and maintaining health related data, including occurrence of various diseases. The data of HMIS covering the three *talukas*, shows that there has been substantial increase of various water borne diseases over the period of three years i.e. 1999-2001. This information has been depicted in Figures 12, 13 and 14 (detailed data attached as Annex -).

Table 219 - Prevalence of Waterborne Diseases

Disease	1999	2000	2001	% increase
Taluka Keti Bunder				
Diarrhoea	396	943	1,362	244
Dysentery	274	612	668	144
Suspected Viral Hepatitis	164	282	259	58
Taluka Kharo Chan				
Diarrhoea	145	255	250	72
Dysentery	44	143	87	98
Suspected Viral Hepatitis	3	0	0	-
Taluka Ghorabari				
Diarrhoea	1,328	1952	2,405	81
Dysentery	652	853	1,127	73
Suspected Viral Hepatitis	176	444	503	186

Source: Heath Management Information System (HMIS), Department of Health, Government of Sindh

Figure 12
Prevalence of Waterborne Disease – Taluka Keti Bunder

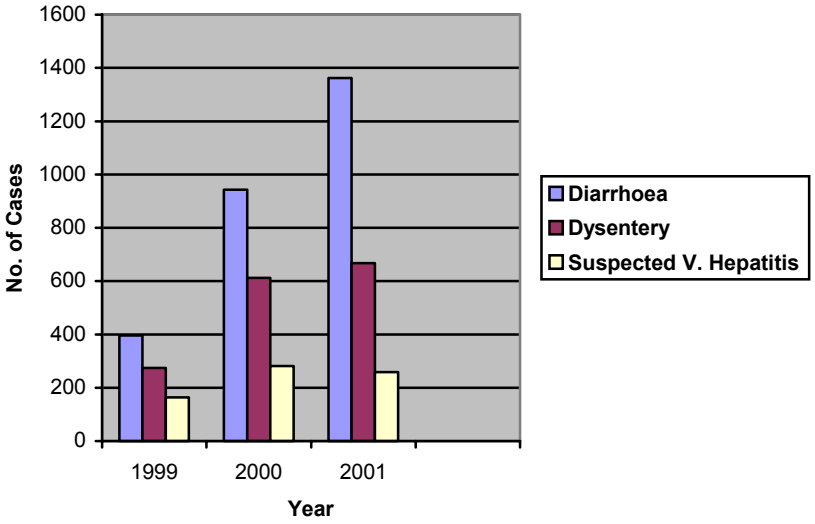


Figure 13
Prevalence of Waterborne Disease – Taluka Kharo Chan

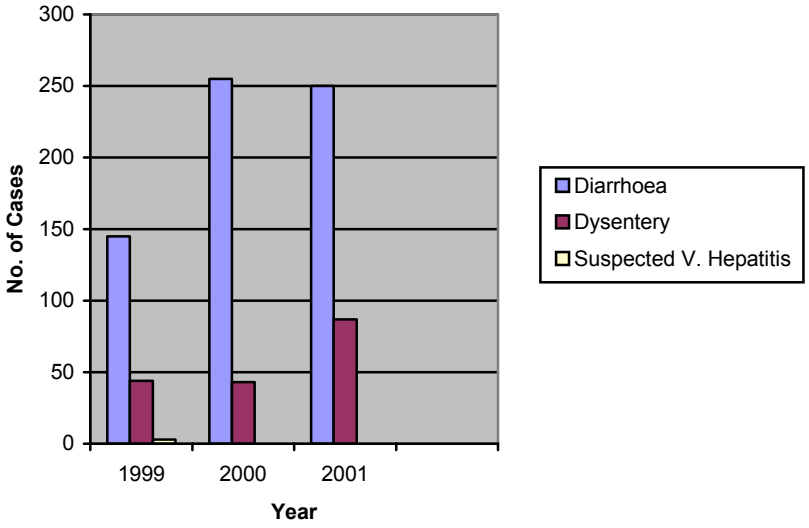
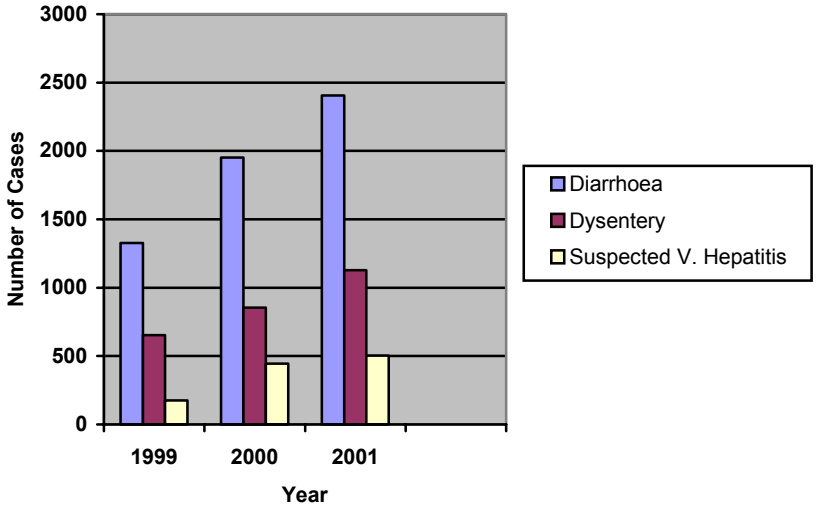


Figure 14
Prevalence of Waterborne Disease – Taluka Ghorabari



The figures reveal that there has been a sharp rise in the incidence of water borne diseases in the study area, the highest occurrence being in *Taluka* Ghorabari. Since this is the most densely populated *taluka* in the study area, the comparative rate of disease incidence is higher. The other two *talukas*, namely Keti Bunder and Kharo Chan, have a much smaller population because they have been severely affected by sea intrusion and many people have migrated to other areas.

The causative factor to which such a rise in water borne diseases can be attributed is the inaccessibility of potable and uncontaminated water. This prevents standards of sanitation and hygiene from being maintained. Secondly, the depletion of fresh water resources caused by sea intrusion have resulted in loss of livelihoods dependent upon agriculture and fresh water fishing, thereby increasing poverty and malnutrition levels and making the people more susceptible to diseases.

Eveready Pictures Pvt. Ltd/IUCN-Pakistan

Women walk for miles in search of drinking water, Ghorabari

Clean drinking water and sanitation are essential for human health. Absence of both is a

major factor contributing to the occurrence of diseases. The frequent occurrence of diseases not only affects the health but also impacts the economy of the people. On one hand, the sick people have to spend considerable amounts on treatment, whereas on the other hand their productive time is also lost. Frequent occurrence of disease has added more miseries to already vulnerable communities of the study area. The following box illustrates another dimension of health problems that may occur due to environmental stress.

Box 6

Ecological Deterioration causing Mental Ailments in Coastal Areas

(The News – Friday, 3.5.2002)

KARACHI: Ever thought of ecological deterioration coupled with natural calamities taking toll on human mental well-being? A landlord psychiatrist fears the same happening within 80 to 90 kilometres from the Indus Delta.

A fact-finding mission led by the concerned psychiatrist from Karachi unanimously termed the symptoms prevalent in Thatta, Hyderabad and Badin Districts as a psychiatric condition called "transient hysteric phobia".

Alerted by some reports in the local press of a strange ailment haunting people in the interior of Sindh, Dr. Karim Khawaja – a consultant psychiatrist having lands in Mir Pur Bathoro of District Thatta – decided to look into the matter on his own.

"Feeling a bond of relativity, I went to the affected families", Dr. Khawaja recalled. "Since a rare combination of symptoms including fits, temporary amnesia, fear and falling unconscious was reported, I decided bringing in a fact-finding mission there", he said.

Prof. Mussarat Hussain from JPMC, Prof. Bekha Ram from LMCH, neurologist Dr. Raza from JPMC, Dr. Razzak, Dr. Amirali Channa, Dr. Nisar, Dr. Murtaza and Dr. Mughal were among the members of the team.

Sindhi newspapers last month had reported about the cases of fits among families residing in certain areas of above-mentioned districts.

The affected people complained of fear, dry mouth, sudden blindness, tearing of clothes, forgetfulness, running and falling unconscious. These symptoms lasted for 7-12 days.

A week ago Dr. Khawaja visited Mirpur Bathoro, where eight members of a single family were hit by the said symptoms.

Having examined the 150 sufferers, the team ruled out the possibility of having the disease within the purview of medicine and neurology.

"We called such a syndrome transient hysteric phobia to be treated with psychotropic drugs", Dr. Khawaja, a 37 year old psychiatrist said. "We have provided drugs to the affected people".

According to the report, a similar set of symptoms was reported in Khario Ghawar, in District Badin, within the radius of 80 – 90 kilometres of the Indus Delta. Incidentally, the area constitutes the drought-hit lower Sindh in proximity of the coastal belt.

Dr. Khawaja said that the socio-economic and overall living conditions of these people have been deteriorating with the cyclone and tremors. "Since there is hardly any rain in these areas, life of tillers is badly affected".

Another doctor, wishing not to be named, maintained that it was the manifestation of a kind of break-up of the social system, otherwise deemed intact in rural areas. "Poverty is rampant and medical facilities are scant. What else is to be expected?" he asked.

A verbal autopsy with regard to the very set of symptoms carried out among patients and their relatives revealed that the victims were fearful as if an earthquake had occurred in the dead of the night.

Not only doctors but environmentalists also believed that the significant reduction in downstream water up to Kotri, sea intrusion in the coastal areas of District Thatta and frequent tremors have been adding to the miseries of the local population.

Acknowledging an outbreak of leishmaniasis in district Badin last February, the team believed that the transient hysteric phobia could be cited as the second most occurring phenomenon.

Expecting an action plan from the provincial health department in this regard, doctors said transient hysteric phobia by virtue of its peculiarity in the region could be considered a new kind of psychiatric illness, vanishing with the passage of time but leaving traumatic stigma on affected families.

7. Environmental Loss

7.1 Ecological Loss

The Indus River is the life-giving artery to a corridor of water-related environments, both natural and man made. Such environments are diverse in nature and may range from the more quantitative, such as freshwater availability for irrigation, to the more qualitative such as coastal physiology and ecology. Any reduction in residual flow has the potential to alter the status quo, which may in turn affect the associated environment and have severe ecological repercussions.

Before the construction of diversions and storage facilities on the river, the Indus discharged an annual volume of 150 MAF of water and a sediment load of 500 million tonnes into the sea[28]. Both have now been reduced to negligible amounts (0.72-2 MAF of discharge downstream of Kotri Barrage was recorded in 2001), causing serious ecological imbalance. In the absence of a retarding force provided by the river flow and its sediment load the sea encroached into the Indus Delta and up the main course of the river.

Whenever the sea replaces an estuary that has functioned for a long span of time, certain physical, chemical, and biological changes in its ecosystem inevitably follow. The outcome is habitat and species loss, degradation of soil and water resources and eventual desertification of areas once irrigated by the river. In this course of action inter-tidal vegetation, such as seaweed, are likely to disappear from the estuary and with progression up the trophic levels of the food web, higher life forms are successively influenced. More salt-tolerant species may also be introduced.

A summary of the ecological changes that took place in the deltaic and riverine regimes with the decline in Indus water discharge is given below.

7.1.1 Land and Soil

Sea intrusion has affected the land resources of the study area in two manners; through the physical inundation of land and through rendering soils saline, water-logged and unfertile. The flora and fauna dependent on the land have been exterminated due to loss of habitat and lack of conducive conditions. The coastline has become more susceptible to erosion heralding further land loss. Seepage of saline water into fertile land has increased the salinity of the soil making it unsuitable for agriculture and forestry. The water salinity measured at Village Darwesh in *Taluka* Ghorabari ranged between 25-35 ppt, which is alarming, since the village is situated some 54km upstream. The decrease in the freshwater discharge of the river and its sediment load has resulted in saltwater intrusion in the lower deltaic plains

To date 1,06,588 hectares of land have been lost to sea intrusion over a period of 40 years. If the same rate of land loss is considered, another 26,647 hectares will be lost in the next ten years.

[28] Milliman et al., 1984

7.1.2 Water Resources

Both underground and surface freshwater resources have been degraded by sea intrusion. Freshwater aquifers have been contaminated through underground seepage of saline water. Moreover, seawater has encroached into the creeks, delta channels and ultimately into the main course of the Indus causing the soil salinity of adjacent lands to exceed culturable limits. Potable water has become scarce and wells that yielded fresh water a few years ago have turned brackish. The natural vegetation is under environmental stress due to hypersalinity and change of habitat. The freshwater and brackish water ecosystems have changed to marine, causing the indigenous flora and fauna to die out and be replaced by marine species.

Forty years ago sweet water was to be found at a depth of 10-28 ft. in the villages of Darwesh and Ghorabari. Today it is found at 70 ft.

7.1.3 Fisheries

The delicate eco-balance of estuarine habitats is essential to the breeding and initial development of a wide range of marine and freshwater fisheries. During the maturation stages of their life cycles these species require low salinity water i.e. 12ppt to 15ppt which is not available in the sea and hence estuaries and deltas serve as breeding grounds. The propagation and recruitment of the seed of important marine and freshwater fish species has always been reciprocal to the timings and intensity of monsoon floods and the continuous flow of water down into the sea.

The discharge of fresh water into the sea plays a significant role in the formation of an extended delta and a fertile estuary for the breeding and growth of juvenile fish and shrimp. With the reduction in Indus outflows the active delta area has shrunk from about 600,000 hectares in the last century to only 25,000 hectares today. One of the major implications of this development is the quantitative loss of breeding ground of numerous species. The qualitative aspect is reflected by the change in the hydrologic regime of the Indus Delta that has led to an irreversible loss of species. Fish that breed in brackish water have been most severely affected. Viewed in the wider context of biological diversity, the impact of transition of habitat and ecosystem will be experienced by organisms at all tiers of the food and energy transfer chain/ cycle of these environments.

To demonstrate the loss of species being perpetrated examples of some significant fisheries are given below.

Pallah Fisheries: (Tenualosa (Hilsa) ilisha)

The marine anadromous fish specie Pallah is considered a delicacy of Sindh and constituted about 70% of fish catches prior to 1930. However, since the construction of barrages on the River Indus that prevents the upstream migration of this fish, the landings of Pallah were reduced to a mere 15% in the mid 80s.

Major Carps

The major Carps, members of a commercially important group of River Indus fish, constitute of four species of family Cyprinidae. Locally they are known as *Rohu* or *Dambro, Dahi, Catla* or *Thaila* and *Morakha*. Late or reduced flood in the monsoon season has been hampering the production of major carps especially downstream Kotri and in Ghorabari area it has virtually disappeared in catches for change of habitat from sweet water to saline. These fish are high priced and the reduction in their landing has

adversely affected the earnings of the local fishermen.

Shrimp Fisheries
Of the marine fisheries the shrimp catch has been most affected. A considerable decline has been noticed in the catches of the Jaira variety of shrimp, which has been the greatest foreign exchange earner in the fisheries sector. Other marine fisheries resources include crustacea (lobsters, crabs), cephalopods (cuttlefish, squid, octopus) and bivalves (oyster, clam and mussel). Though there is ample potential of exploitation of these resources for export they are of relatively little economic importance today. However, they represent a valuable natural resource, which is being depleted even before its potential has been realized. The beds of bivalve shell particularly of oysters have suffered from the ecological transformation of the Indus Delta. Oysters belonging to the genera *Ostrea, Crassostrea* and *Lopha* used to form extensive beds in the creeks of the Indus estuarine area but natural stocks have now been depleted and oyster fisheries have collapsed.

The Pallah catch has declined from 70% of total fish catch in 1930s to 15% in the 1980s. The size of the individual fish has also declined. Over the next ten years this species of fish may by and large migrate from this area.

7.1.4 Riverine Forests
Riverine forests are ecologically classified as Indus inundation seral stage. Large areas of natural and managed riverine forests stretch fairly evenly down the length of the river from just downstream of Kotri Barrage. These forests are the net result of the spate of river Indus on lands and soil over its banks. The spate is a summer phenomenon. It is the result of rise in water level, which is a consequence of flows of larger quantities of waters at that time. The river itself structures both the land configuration and soil quality.

Forestry is, in many cases, the only viable option for the development of land adjacent to the river. Riverine forests form an important land use closely associated with soil resources, water management, wildlife conservation and fisheries development in addition to being an important source of fodder, firewood and other social uses. In addition, the mature forests provide a degree of channel stabilisation prohibiting the movement of the main channel. The maintenance of the forests relies upon regular out of bank flooding in the river to provide the forests' consumptive water requirements.

One of the earliest indications that all was not well with the riverine ecosystem was the reduction in the number of species flourishing here. All timber producing species such as *Acacia nilotica*, *Prosopis euphratica* and *Prosopis cinneraria* have been replaced by *Prosopis juliflora,* which is a hardy and xerophytic species.

The interpretation of the 1989-90 satellite imagery has shown the area covered by forests to be 35,700 hectares or 26% is covered with subgrowth of varying densities that may develop into mature forests if left undisturbed. According to the Management Plan for Riverine Forests of Thatta district prepared by Sindh Forest Department in the year 2000, out of the total area of 41,336 hectares of riverine forests, 22,313 hectares are under vegetative growth.

Prosopis euphratica (bahan) has completely disappeared in the riverine forests down the Kotri Barrage during the past 40 years. The next most important tree species and the mainstay of forestry in Sindh, Acacia nilotica (babul), will also become extinct in the next ten years.

7.1.5 Mangroves

Mangroves are open-ended ecosystems with an overall transport of matter and energy from land to sea. There are several mangrove-related systems of importance that vastly benefit from the intensive energy budget and exports from the mangrove. Biological cycles are completed in a short span of time, the turnover rate is intense, microbial degradation is fast and the tendency to form anoxic sediments and acid sulphate soils is also processed very fast. Litter-fall from the forest is mechanically and bio-chemically broken down by animals such as crabs, that feed on it. This is the first step in nutrient recycling. The whole system functions as an enormous complex where rich nutrients are continuously produced.

Mangrove forests are an essential life-supporting ecosystem providing habitat, shelter and breeding ground for a number of economically important wild fauna and flora. They are also of great significance as a source of nutrients for freshwater and marine fisheries as well as for providing fuel-wood and fodder for the local populations. Further, mangroves act as a barrier for the protection of coastal region/ ports against disastrous natural phenomena such as cyclones, windstorms, flooding, and soil erosion. Due to the nature of their root system, they provide a very effective erosion protection belt. They assist the process of sedimentation by trapping suspended particles and consolidating the soil and thus retard the process of coastal erosion. This may be of particular importance in Pakistan, where the country's second largest port, Port Qasim, is protected from wave action by mangrove-covered mud-banks.

The Indus Delta mangroves are unique in being the most extensive arid zone mangroves in the world[29]. Of the total 600,000 hectares of tidally inundated historic Indus Delta, mangrove forests cover an area of 160,000 hectares from Karachi in the west, to Rann of Kutch in the east. They exhibit one of the most critical and complex coastal systems, which has been severely threatened due to reduction in the discharge of the Indus downstream of the Kotri Barrage. For the mangroves to flourish they require an element of freshwater flushing provided by the physical mechanism of floodwater distribution in the delta. They are almost wholly dependent upon these discharges and a small quantity of fresh water from domestic and industrial effluence of Karachi.

This flushing mechanism also removes from the creeks the pollutants in the industrial effluents being discharged into the creeks and washes them out to the sea. In the absence of freshwater to flush the creeks, the pollutants stagnate here and are extremely toxic to the flora and fauna as well as the land and water resources. Here they also enter the food chain and eventually impact human health.

Based on satellite images, mangrove coverage has decreased from about 263,000 ha. in 1977 to the present 160,000 ha. in 1991. There has been a progressive decline in the

[29] Farah and Meynell, 1992; Harrison et al., 1994

extent of the less salt-tolerant mangrove species, which traditionally grew at the freshwater – saltwater interface in the past as indicated by the pollen analysis of mud samples. Out of the eight species of mangroves reported in the Indus Delta in 1950s only three remain. *Avicennia marina*, the most salt-tolerant species, forms about 98% of the total mangrove crop but even this is unlikely to flourish without a regular input of fresh water. Two other species, *Ceriops tagal* and *Aegiceras corniculatum*, are sporadic and concentrated in localized patches indicating ecological stress. Recently IUCN has introduced a fourth species, *Rhizophora mucronata,* in the Indus Delta.

The mangroves are very important ecosystems both economically and ecologically. Although the mangroves play both protective and productive roles, their protective role is more effective. Some of the functions of mangroves are listed below.

- A pool of biodiversity supporting diverse forms of plant and animal life;
- Provide food, shelter and breeding ground to prawn, shrimp, several fin-fish, crabs and other marine life;
- Reduce wave action and help stabilize coastlines;
- Assimilate sewage water wastes and heavy metals from industrial plants;
- Protect sea ports from siltation;
- Reduce the intensity of cyclones;
- Provide livelihood to a population of more than 100,000 people living along the coast;
- Provide a source of wood for heating and cooking and fodder for livestock; and
- Provide shelter to migratory birds during winter.

Degeneration of vegetation manifests itself in the premature death of trees, stunted growth and lack of regeneration. A reduction in fresh water supply has caused the following negative impacts on the mangrove ecosystem.

- Increase in the salinity of sea-water from 10-15 ppt to 50 ppt, which is detrimental to the growth of most species of mangroves.
- A decline in the flow of alluvium – the fine-grained nutrient rich soil brought by the river during its course through the fertile plains. The end result is a sharp decrease in biodiversity of mangrove ecosystem in terms of number of species, habitats and size of trees
- Further sea intrusion up to 30 kms inland from the original delta according to some reports resulting in mass migration in Thatta and Badin districts in Shah Bunder, Keti Bunder and Kharo Chan *talukas* etc. Simultaneously the agriculture and fisheries of the areas have been badly affected
- Changes in the geomorphology of the delta
- Changes in nutrient balance of the ecosystem

The loss of five mangrove species from the Indus Delta during the last forty years, the stunted growth of mangroves, decline in fish productivity, social impacts and the analysis of plant pathology under these conditions provide sufficient evidence to suggest that reductions in fresh water supplies in future may further reduce species and genetic diversity of the mangrove ecosystem. Fish resources may also be depleted in the process. Other marine wildlife species including mammals, migratory waterfowl using the Indus flyway, reptiles and marine turtles will also suffer. If the mangrove habitat is destroyed the continued existence in the Indus Delta all of these species will be threatened.

Five species of mangroves have been lost from the Indus Delta during the past 70 years. Of the remaining three species, two are also on the verge of extinction.

7.2 Other Losses

The Indus Delta area contains several archeological sites representing the rich cultural heritage of Sindh. These include the Ratoo Kot Fort, ruins on Juna Bunder and the historical site of Bhambhor. A brief description of all these sites has been given below.

Ratoo Kot Fort
The 500 – 600 year old ruins of the Ratoo Kot Fort, including some graves and shrines, are located on Muchaka Island in the Indus Delta. The fort appears to have been a customhouse and also a forward defensive position against marauding pirates and invaders and is of a size sufficient to control the channel access to Bhambore. The super structure is composed entirely of baked bricks. The main walls oriented on the cardinal points form a quadrangle, which measures 88 x 92 meters externally. Each wall is reinforced by bastions that are semi-circular in plan. The tower walls are 2-2.2 meters thick while the curtain walls are 1.8 meters thick. The entrance lies on the south side. Near the south-west corner is a direct access door protected by two flanking bastions. Glass and stone ware give indication of a principal occupation between 8th and 11th centuries continuing up to the 13th century. Ratoo Kot is therefore comparable with Bhambore. Some remains of villages, where brick masonry was employed for construction of buildings, have also been found. These archeological remains are deteriorating rapidly.

Juna Bunder
Juna Bunder is characterized by a recent archaeological discovery comprising of the ruins of a fortified citadel on the right bank of Kuddi Creek and a very small town in the southern part of the island. The town must have been a port of some significance and its situation has led many a scholar and historian to classify it in the same period as Bhambore. An almost complete cross section of mounds has revealed two levels of occupation. The earliest people who lived here were Hindus and Buddhists until the arrival of the Muslims. However, after the 13th century the importance of this settlement diminished, mainly due to the shifting course of the river, and gradually it was abandoned. The fortified citadel once had an imposing wall that was built in the Hindu period. This impressive brick and stone wall around the fort is strengthened with bastions at regular intervals and at the corners. Other significant remains at Juna Bunder include the graveyard and several small houses.

Bhambore
The site of Bhambhor is considered as ancient Debal, the capital city of Raja Dahar's state. The Arab General Mohammad Bin Qasim attacked and conquered it in early 8th century A.D.

Sea intrusion has caused considerable damage to these sites and other buildings located in the study area, specially in the *talukas* of Keti Bunder and Kharo Chan. Water surges during the monsoon period crash directly on to the structures of the Ratoo Kot Fort on Muchaka Island and the remains of the citadel on Juna Bunder. Since no maintenance is

carried out, these structures are undergoing overall degradation. The homes of people that are made of brick masonry are also being demolished and the population is compelled to periodically migrate.

The location of Keti Bunder town has changed thrice during the past 70 years due to the progressive intrusion of the sea.

8. Recommendations

Sea intrusion in the Indus Delta and riverine tract has led to widespread environmental degradation and the loss of livelihoods of the thousands of people living here. The fundamental cause of this disaster is the reduced outflow of fresh river water into the sea and the effects of prolonged drought in the country over the last few years. Despite the Indus Water Accord of 1991, the Indus Delta and riverine tract of Thatta and Badin districts continue to receive less water than allocated under the Accord in order to check sea intrusion. The most necessary element in curbing sea intrusion is therefore the increase in downstream flows to the level defined by the Indus Water Accord. The recommendations that emerge from this study focus on the present scenario when downstream flows from the Kotri Barrage may not be available to the desired level.

Guidelines for Effective Management of Flood Releases

These have been developed for the conservation of downstream ecosystem and livelihood of local population. They have been described below according to various sectors.

Riverine and Mangrove Forests

- The mechanism for inundating the forest area is a more important consideration than actual quantities. Consequently, out of bank conditions have to be maintained and developed which need a discharge of around 400,000-500,000 m^3/sec to inundate half the reserve forest area and other forest areas outside of the forest reserve. Currently four out of bank events occur every ten years. Any further reductions in the number of out of bank events will be serious.

- The fresh water requirement of mangroves is a question of absolute quantities. For mangroves to flourish, soil and associated soil moisture salinities must be within the physiological limits. Flushing of the mangrove areas with less saline water greatly helps maintain the required salinity level.

Fisheries

- The frequency of out of bank flows should not be significantly changed thus continuing to recharge and restock fresh water wetlands.

- Release downstream of Kotri must be managed in such a away that the mangrove stands receive adequate flushing to maintain the fish breeding grounds

- Sufficient flows should be released downstream of Kotri Barrage during the critical breeding period of Pallah to maintain its current population.

Coastal and Deltaic Oceanographic Studies

- Any reduction in the current discharge arrangements, especially relating to higher discharges carrying heavy silt loads, will affect the silt transportation to the delta and marine area, with a resultant effect on the mangroves, fisheries and ecosystems of the delta and coastal areas. Hence detailed monitoring should be carried out to determine the siltation/ erosion process that currently operates in the deltaic system.

- Salinity levels throughout the river and creek system should be monitored and evaluated to establish an optimum mechanism for fresh water distribution.

Environmental Studies

- Monitoring programmes should be developed and implemented to form a strong database in water quantity at critical locations, industrial effluent discharge, dynamics of Pallah fish etc. in the Indus Basin. The database should be used to develop minimum residual flow requirements as necessary.

Surface Water Modeling

- Increased upstream extraction under the Indus Water Accord 1991 will reduce the reliability of low flows. Surface water modeling is essential to maintain at least these minimum flows.

Recommendations for Government and Line Departments

- Tribunals responsible for distribution of water to the provinces should include the subject of seawater intrusion as a factor while allocating the water resources of Pakistan to the various provinces. This will result in reducing the amount of economic loss currently being faced by Sindh, which ultimately effects the country's national accounts. A study may be undertaken that explores the impact on other provinces of increasing the water share of Sindh for release in the Indus Delta.

- The efficiency of the irrigation system needs to be improved on a priority basis by curtailing wastage. Farmers should be provided training and incentives to practice on farm water management so that the available irrigation supplies are optimally utilised.

- Private and public sector institutions involved in extending agricultural credit need to incorporate mechanisms within their credit approval and extension processes to evaluate the risks caused by environmental degradation. This will enable such agencies in reducing overall portfolio risk, thereby reducing default rates and increasing returns to the national exchequer.

- Investment in research and development is essential to develop saline resistant crops on a large scale. Sustained effort in this direction is required urgently and research facilities around the world should be tapped for this purpose.

- Studies should be undertaken to ascertain how other countries facing a similar problem are dealing with this issue, and how their programs can be adapted to suit our local needs.

- To avoid large-scale migration, a structured plan to relocate people from the affected areas should be prepared. This should also include a blueprint for vocational training.

- A maintenance plan should be formulated regarding existing agricultural land in the affected area, together with details of capital required. This plan must be formulated at the Federal Government level and focus on sea intrusion as a national as well as a provincial problem

- International Donor Agencies should be made aware of the damage to people and agricultural resources of reducing water flow in the Indus River when they finance large water management projects. The damaging effects of sea intrusion should be included as costs of the projects being implemented by them. This

would allow for capital for the maintenance of these lands.

- The same should be the case with projects financed by foreign DFIs (Development Finance Institutions) such as the World Bank etc.

Immediate Measures

- The extent of sea intrusion and its physical impacts should be recorded through satellite imagery and remote sensing. There is an urgent requirement of up to date maps of the coastal areas so that any changes may be monitored and recorded.

- Salt tolerant inland species of trees should be promoted in the riverine tract. These include inland trees such as *Cassurina equisitifolia* and *Conocarpus lancefolios* (Ethiopian teak). Both these trees have good quality timber. *Prosopis Juliflora* is already thriving in the area. The wood from this shrub is used for making coal.

- The concerned departments and agencies should provide incentives and training to the communities for the promotion of forestry of salt tolerant species in areas where agriculture is no longer possible. Though a longer-term income yielding exercise than agriculture, forestry will provide fodder for the animals in the interim period and will prevent against further degradation of land. The Forest Department should promote the raising of block plantations of salt-tolerant species such as *Cassurina equisitifolia* and *Cornocarpus lancefolios.*

- Civil society organizations and government agencies should undertake awareness raising of communities on sustainable resource use.

- Capacity of local communities should be built for adopting alternative livelihoods. Concerned departments as well as NGOs working in the area should provide vocational training in sectors that offer such a possibility. For example, fishermen dependent on freshwater fishing should be provided training and micro-credit facilities to change their vocation to marine fishing.

- Micro-credit schemes should be initiated for local communities to facilitate them in adopting alternate livelihoods and developing other sources of income.

- Detailed studies based on primary data should immediately be initiated on all ecological and socio-economic aspects of the deltaic and riverine areas. Deficiency of data was one of the major constraints encountered during the course of this study.

Finally, it may be mentioned that all these recommendations can be implemented through existing government machinery. What is required is acknowledgement of the problem and a commitment to curtail it.

9. Conclusion

Environmental degradation caused by sea intrusion has affected the entire Sindh coastline spread over the two districts of Thatta and Badin. This study attempts to assess the economic and ecological costs incurred by this phenomenon and the impacts on the livelihoods of the local population in three *talukas* of District Thatta i.e. Keti Bunder, Kharo Chan and Ghorabari that form a contiguous belt along the right bank of the River Indus.

The purpose of this document is to present a case study and to provide indicative trends of losses precipitated by sea intrusion and the ensuing environmental degradation. Hence only a few parameters from the sectors of agriculture, forestry and fisheries were selected for calculation of losses. An exhaustive calculation of total losses was not intended.

The study concludes that in the sectors of agriculture, forestry and fisheries the economic losses in the chosen parameters over a period of five years have been ***Rs. 572.9 million***. If these trends continue for the next 25 years, the cumulative losses may amount to the staggering amount of ***Rs. 4.1 billion.*** Though the projections have been calculated for 25 years, the losses will be substantial even in the brief period of only ten years.

It is apparent that the current water situation is not sustainable. Despite the impressive development of a conventional irrigation system in the last two decades, the extreme climatic conditions of the last five years have proven to be unmanageable. Considering the issues and constraints, our water policy should become more imaginative, creative and flexible. The change in approach should target and ensure sustainability.

The alternatives to today's water resources development problems are through efficient water delivery systems for on-farm conservation and usage of ground water. The development of strategies to shift funding and water development planning towards more sustainable projects will provide long lasting social, environmental and economic benefits for progress and prosperity. Sound alternatives need to be evolved to meet initial energy and agricultural needs. We must move towards sustainable and indigenous renewable development and restoration of the rich integrity of the natural resources of Pakistan.

A substantive evaluation of the downstream effect of dams and barrages in Pakistan, both those constructed and proposed, will promote the formulation of a rational water policy in Pakistan. Such an evaluation is also needed to restrain donor agencies from funding water projects in the presence of alternatives that are both financially more cost-effective as well as sustainably less destructive for people and nature.

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- Abdul Waheed, Chief Engineer Al-Asif Sugar Mills, Asifabad Gharro

NGOs

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- Abdul Aziz Memon, Achal Young Welfare Organisation, Keti Bunder
- Sindh Graduates Association, Thatta
- Asif Qureshi, District Coordinator, SINGOF Thatta

Community Members

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- Mir Asfaq Ahmad, Ghorabari
- Mohammad Mubashar, Al Yousuf Farm, Mirpur Sakro
- Mohammed Urs, farmer at village Ibrahim Panhwar, Ghorabari
- Focus group discussions with over 200 community members of Ghorabari; Keti Bunder; Wadera Khuda Baksheesh village, Taluka Keti Bunder; Deh Chach Wali Mohammed, Taluka Kharo Chann; Darwesh Village, Taluka Ghorabari and adjacent villages of Haji Babro; Meero Wadero; Goth Hafiz Hussain; Haji Khushk; Usman Barhan; Abdullah Amro; Allah Bakhsh; Khushk and Malik Allah Dino.

Annexures

Annex 1

World team witnesses destruction of Indus Delta

By Mohammad Iqbal Khwaja
The Dawn

THATTA, Feb 15: The representative of the World Bank, Asian Development Bank, IMF, and some international donor agencies accompanied by two provincial ministers visited areas of Indus Delta in Thatta district on Friday to witness losses rendered by the sea intrusion for the last couple of years.

The team visited the deltaic region in boats through various creeks and witnessed the devastation caused by the halt to the discharge of Indus river water into the sea.

Briefing the international team, Sindh Irrigation Minister Syed Ali Mir Shah and the acting chief engineer of Kotri Barrage, Basheer Ahmed Dahar, disclosed that owing to prevailing situation so far 122,360 acres of agricultural land had been submerged under the sea water in eight talukas of Thatta and Badin districts.

They said that dams and irrigation schemes on the River Indus had reduced the flow of river water from 181 billion to 25 billion cubic meters during floods.

The situation has also caused tremendous losses to the riverine forests of Thatta district spread over 120,142 acres on both sides of the River Indus.

They told the team that about 1,850 million square meters of the deltaic region used to be covered with mangroves but according to a recent satellite survey now the degeneration of mangroves was significant in Keti Bandar and Shah Bandar areas where the mangrove forests had been reduced to 1,000 square meters in slightly over a decade.

Mr Shah said that the River Indus ranked 18th among the world's biggest rivers but it was a pity that its delta was diminishing day by day while the other big rivers were developing a 10 to 4,000 meters delta every year.

Sindh minister for finance Dr Hafeez Shaikh and the country manager of the World Bank, were of the view that the problem of poverty was related to the agricultural production in the country and the people of this area were suffering due to destruction of delta and submerging of the fertile lands besides the recent catastrophic events, including cyclone.

Mohammad Ali Malkani, an ex-MPA PPP who belongs to this coastal belt, told the team that the entire Sindh had been suffering for the last four years due to shortage of irrigation water and non-flow of river water downstream Kotri had brought the deltaic range at the verge of collapse.

He appealed the donor agencies for provision of funds for the erection of embankment as well as streamlining and excavation of riverine network of the Kotri Barrage to streamline the water flow to reach up to its dropping point without wastage of a drop.

He also proposed a coastal highway from Keti Bandar to Ali Bandar via Shah Bandar to open avenues of coastal development, develop jetties and to avert the possible erosion in the area due to sea intrusion.

The delegates also visited the partially submerged ruins of Chatriyan Jo Sheher, a big settlement that was inundated between 1994-95 due to the sea intrusion.

The Country Director, World Bank, John W. Wahl, IMF Country Manager, and other foreign delegates sympathetically heard the woes and miseries of local people. Earlier, they arrived in Dargah Shah Qadri village, Shah Bandar taluka, in three helicopters and prior to landing had an aerial view of the area.

Annex 2

Notification of Calamity Hit Areas in Sindh

GOVERNMENT OF SINDH
RELIEF DEPARTMENT

NOTIFICATION

No.R/F- 342 /2002, WHEREAS, the District Tharparkar, Dadu, Thatta, Mirpurkhas, Badin, Ghotki, Sanghar, Larkana, Jacobabad, Sukkur, Khairpur, Shikarpur and Karachi (defunct District Malir) reported to have been affected by shortage of irrigation water/drought :

AND WHEREAS, in the opinion of the Government of Sindh action is warranted under the provisions of Sindh National Calamities (Prevention and Relief) Act, 1958 :

NOW, THEREFORE, the Government of Sindh in exercise of powers vested under Section 3 of the Act, is pleased to declare the following Districts/ Talukas/Dehs as "Calamity Affected Area".

S.No	District	Area
1.	Tharparkar	Entire District
[illegible]	Dadu	[illegible]
3.	Thatta	Talukas (1) Thatta (2) Shah Bunder (3) Jati (4) Keti Bunder (5) Mirpur Sakro (6) Ghora Bari (7) Kharo Chhan (8) Mirpur Bathoro
4.	Mirpurkhas	Talukas (1) Umerkot (2) Pithoro (3) Kunri (4) Kot Ghulam Muhammad (5) Digri (6) Samaro
5.	Badin	Talukas (1) Badin (2) Tando Bago (3) Shaheed Fazal Rahu (4) Talhar
6.	Ghotki	Talukas (1) Mirpur Mathelo (2) Ghotki (3) Khan Garh
7.	Sanghar	Talukas (1) Khipro (2) Sanghar (3) Sinjhoro (4) Jam Nawaz Ali
8.	Larkana	Talukas (1) Shahdadkot (2) Waryah (3) Qambar Ali Khan
9.	Jacobabad	Talukas (1) Jacobabad (2) Thull (3) Ghari Khairo
10.	Sukkur	Talukas (1) Rohri (2) Saleh Pat (3) Pano Akil
11.	Khairpur	Talukas (1) Nara (2) Faiz Gunj (3) Mir Wah
12.	Shikarpur	Talukas (1) Shikarpur (2) Gahri Yasin
13	Karachi (Defunct District Malir)	Dehs of defunct Taluka Malir (1)Modian (2) Jhangkand (3) Kand (4) Khar (5) Shorkand (6) Wankad (7) Lusar (8) Bhad (9) Terari (10) Soondi (11) Jhunjhar (12) Meharjabal (13) Gadap (14) Huderwah (15) Langheji (16) Karmatiani (17) Shoring (18) Bolhari (19) Shahi Chib (20) Kathore (21) Chuhar (22) Khaeji (23) Abdar (24) Boil (25) Amilano (26) Ghanghar (27) Pipri (28) Dhebeji (29) Koterio (30) Bakran (31) Konkar (32) Kharkharo (33) Tore (34) Thado (35) Khakhar.

RELIEF COMMISSIONER SINDH

NO. R/F- 342 /2002, Hyderabad dated 14th June, 2002

A copy is forwarded for information and necessary action to the :-

Chief Secretary Government of Sindh.
2. Additional Chief Secretary (Dev) P & D Department, Govt: of Sindh.
3. Principal Secretary to Governor Sindh.
4. Director General (ERC), Cabinet Division, Govt: of Pakistan Islamabad.
5. Administrative Secretaries (All)
6. Members, Board of Revenue, Sindh (All)
7. Pakistan Banking Council
8. Chairman A.D.B.P, Islamabad
9. Zila Nazims (All)
10. District Coordination Officers (All)
11. Executive District Officers (Revenue) (All)
12. Secretary (Revenue) / (SLC) Board of Revenue, Sindh
13. Headquarters 18 Division, Hyderabad
14. Registrar, Cooperative Societies, Hyderabad
15. Private Secretary to Ministers (All)

ADDL: RELIEF COMMISSIONER SINDH

A copy is forwarded to the Director Information, Government of Sindh, Hyderabad. He is requested to kindly arrange wide publicity through press and Radio/T.V.

A copy is forwarded to the Controller-Cum-Superintendent Sindh Government Printing Press Karachi for publication of above notification in extra ordinary issue of Gazette. He is requested to supply 25 copies of the Notification to this Department for record.

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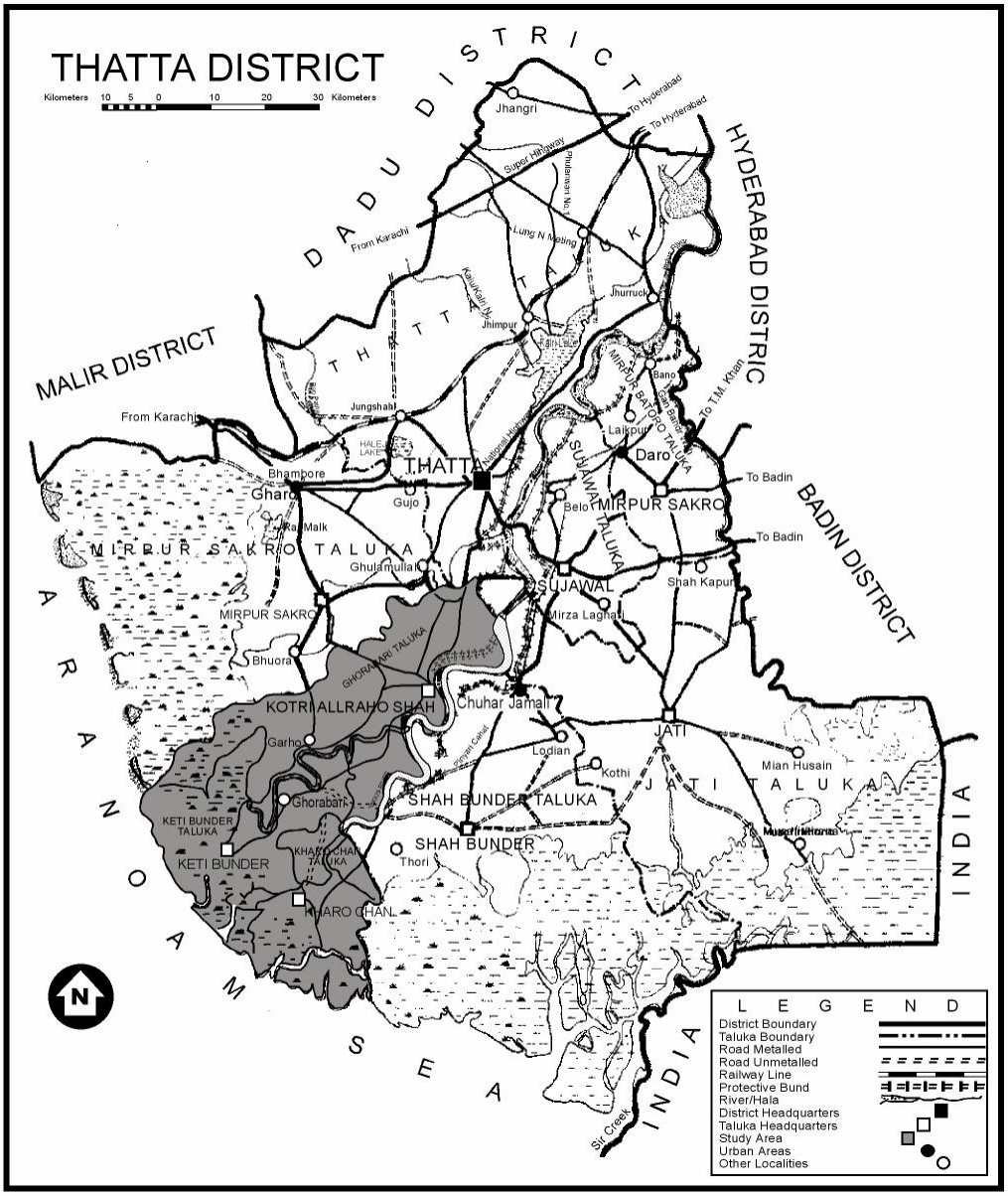
Annex 3

Map of District Thatta showing the Study Area

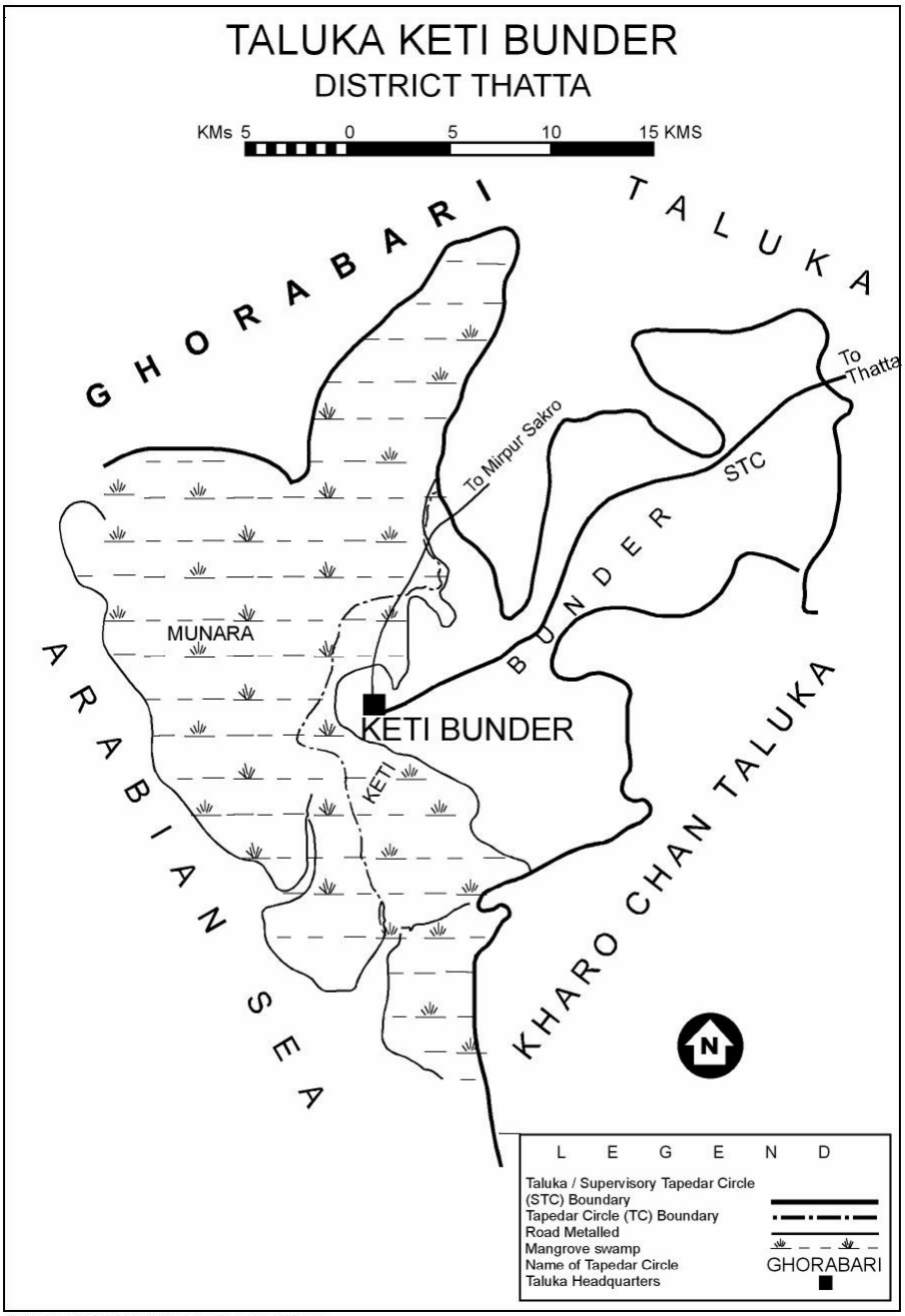


Source: 1998 District Census Report of Thatta.

Design by: Amir Ali Khan (Amafhh Traders)

Annex 4

Map Taluka Keti Bunder

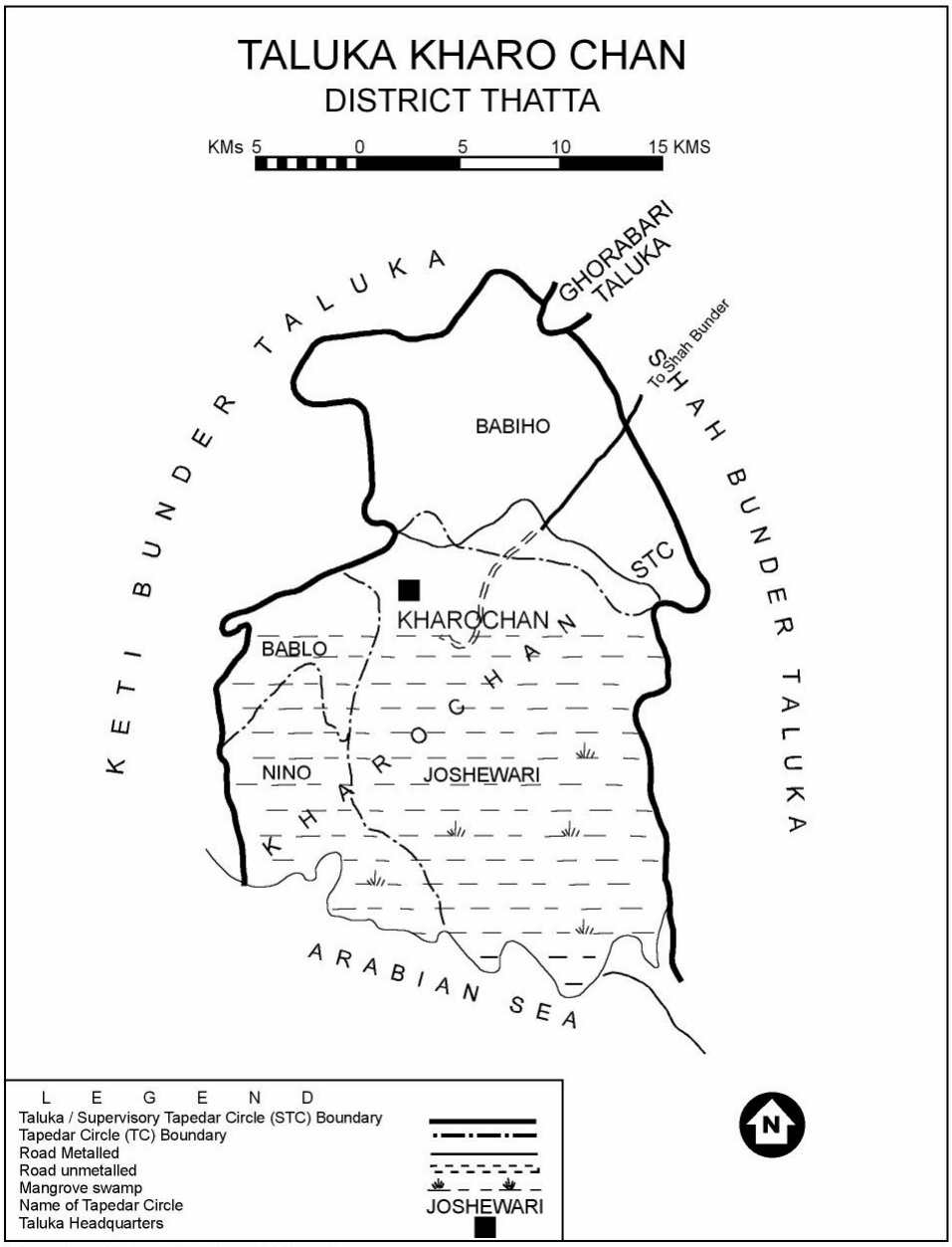


Source: 1998 District Census Report of Thatta.

Design by: Amir Ali Khan (Amafhh Traders)

Annex 5

Map Taluka Kharo Chan

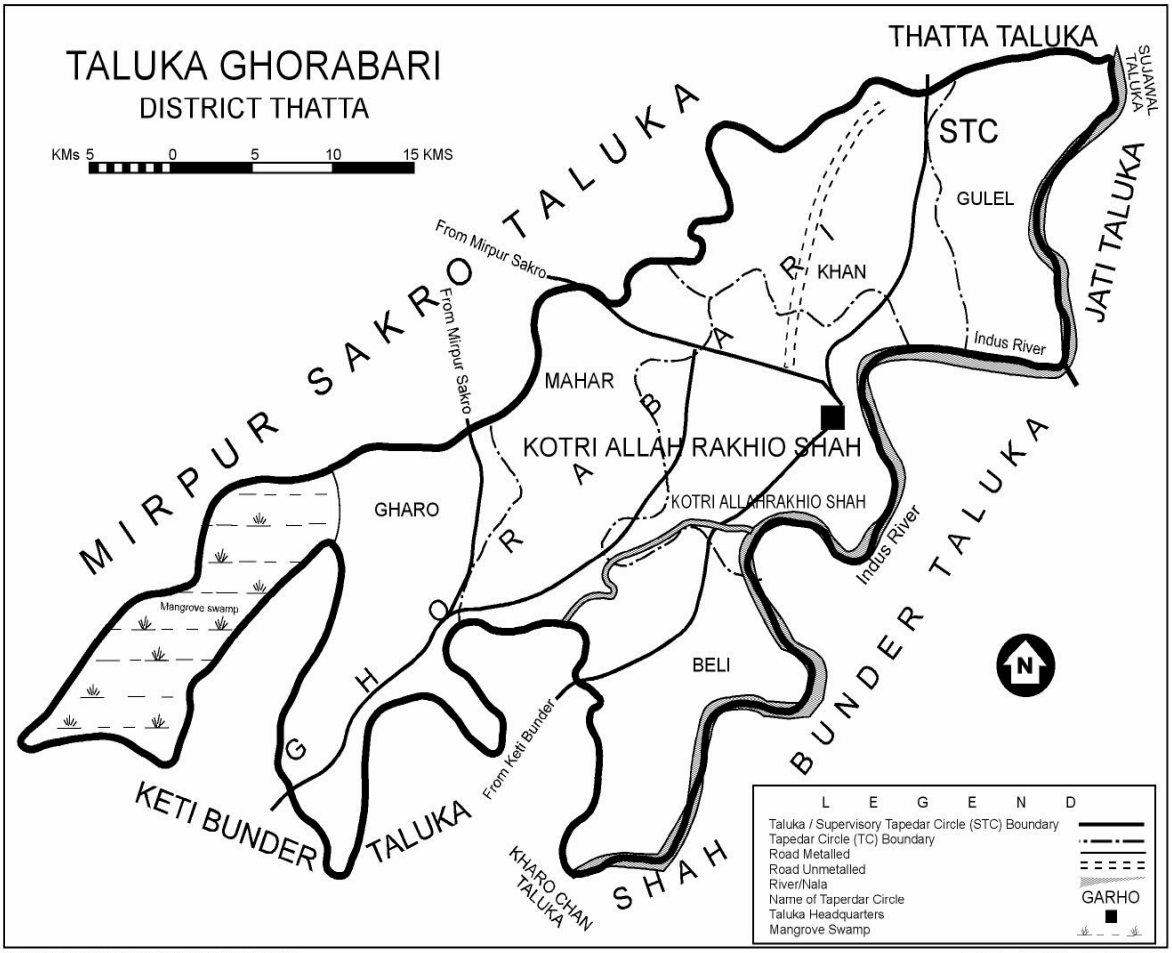


Source: 1998 District Census Report of Thatta.

Design by: Amir Ali Khan (Amafhh Traders)

Annex 6

Map Taluka Ghorabari



Source: 1998 District Census Report of Thatta.

Design by: Amir Ali Khan (Amafhh Traders)

Annex 7

Taluka wise Land Loss

S.No.	Taluka	No. of Dehs	Area of Taluka (ha.)	Area Affected				
				Dehs fully eroded by sea	Area (ha.)	Dehs partially affected	Area (ha.)	Total Area Affected (ha.)
1.	Keti Bunder	42	60969	28	45732	1	405	46137
2.	Kharo Chan	41	102069	21	40044	9	8872	47702
3.	Ghorabari	59	93919	2	2962	8	9787	12749

Source: Board of Revenue, Govt. of Sindh

Annex 8

Aggregate Data of Selected Crops in Study Area

Aggregate Production in Metric Tonnes/Hectares of Selected Crops in Study Area (1995/96-2000/01)						
	1995-96	**1996-97**	**1997-98**	**1998-99**	**1999-00**	
Rice	16,282	15,909	15,563	15,305	14,903	
Wheat	1,737	1,715	1,711	1,668	1,724	
Maize	423	417	388	364	319	
Bananas	6,681	6,419	6,150	5,883	5,472	
Total	**25,122**	**24,461**	**23,812**	**23,221**	**22,418**	
Prices for Selected Crops 2000/01 (per kilogram in Rupees)						
	1st Qtr.	**2nd Qtr.**	**3rd Qtr.**	**4th Qtr.**	**Average**	
Rice	5.00	5.00	5.00	5.00	**5.00**	
Wheat	4.07	4.07	4.07	4.07	**4.07**	
Maize	0.63	0.63	0.88	1.63	**0.94**	
Bananas	6.25	7.50	8.75	10.00	**8.13**	
Value of Production at 2000/01 prices (Rs '000)						
	1995-96	**1996-97**	**1997-98**	**1998-99**	**1999-00**	
Rice	81,409	79,547	77,814	76,527	74,515	
Wheat	7,061	6,973	6,956	6,779	7,007	
Maize	398	393	366	343	301	
Bananas	54,279	52,158	49,967	47,803	44,461	
Total	**143,147.34**	**139,070.87**	**135,103.02**	**131,452.65**	**126,283.85**	
Annual Change in Value of Production (Rs. '000)						
	1995-96	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**Average**
Rice		1,862	1,733	1,287	2,012	1,724
Wheat		87	17	177	228	13
Maize		6	27	23	42	24
Bananas		2,122	2,191	2,163	3,343	2,455
Total		**4,076.46**	**3,967.86**	**3,650.36**	**5,168.81**	**4,216**
% change		*2.848%*	*2.853%*	*2.702%*	*3.932%*	*3.08%*
Absolute Costs of Decline in Value of Production (Rs. '000)						
	1995-96	**1996-97**	**1997-98**	**1998-99**	**1999-00**	
Rice		1,862	3,595	4,882	6,894	
Wheat		87	104	281	53	
Maize		6	33	55	97	
Bananas		2,122	4,313	6,476	9,819	
Total		**4,076.46**	**8,044.32**	**11,694.68**	**16,863.49**	

Annex 9

Aggregate Data of Marketed Fish in Study Area

Aggregate Data of Marketed Fish in Study Area in Metric Tonnes (1996/97 – 1999/00)					
	1996-97	**1997-98**	**1998-99**	**1999-00**	
Pallah	150,000	120,000	70,000	65,000	
Major Carps (Dambro, Thaila, Morakha)	22	20	17	17	
Others	1,295	1,301	1,275	1,250	
Prices for Marketed Fish during 2000/01 (price per kg in Rupees)					
	1st Qtr.	**2nd Qtr.**	**3rd Qtr.**	**4th Qtr.**	**Average**
Pallah	-	75.00	87.50	-	**81.25**
Dambro	70.00	60.00	60.00	75.00	**66.25**
Thaila	60.00	50.00	50.00	65.00	**56.25**
Morakha	60.00	55.00	55.00	70.00	**60.00**
Others	50.00	45.00	45.00	60.00	**50.00**
Value of Production at 2000/01 prices (Rs. '000)					
	1996-97	**1997-98**	**1998-99**	**1999-00**	
Pallah	12,188	9,750	5,688	5,281	
Major Carps (Dambro, Thaila, Morakha)	1,323	1,192	1,028	1,032	
Others	64,750	65,050	63,750	62,500	
Total	**78,261**	**75,992**	**70,466**	**68,813**	
Annual Change in Value of Production (Rs. '000)					
	1996-97	**1997-98**	**1998-99**	**1999-00**	**Average**
Pallah		2,438	4,063	406	1,727
Major Carps (Dambro, Thaila, Morakha)		131	164	4	93
Others		300	1,300	1,250	813
Total		**2,268**	**5,527**	**1,653**	**2,632**
% change		*2.90%*	*7.27%*	*2.35%*	*3.52%*
Absolute Costs of Decline in Value of Production (Rs. '000)					
	1996-97	**1997-98**	**1998-99**	**1999-00**	
Pallah		2,438	6,500	6,906	
Major Carps (Dambro, Thaila, Morakha)		131	295	291	
Others		300	1,000	2,250	
Total		**2,268**	**7,795**	**9,448**	

Annex 10

Community Perceptions on Impacts of Sea Intrusion

The observations of the villagers made during interviews and focus group discussions have been summarised below. These have not been scientifically verified but have been included as an annex to provide the reader some insight in to what is being experienced by the residents of the affected areas.

a) Village Ghorabari, Taluka Ghorabari

The only source of drinking water in the *katcho* area is sub soil water, which has also turned brackish due to sea intrusion, and is causing abdominal diseases and skin disorders. The *Katcho*[30] area has undergone much greater degradation due to sea intrusion, than the *pacca* [31]area. The people here have been forced to migrate to the *pacca* area and their income has been reduced by 50%.

The Malhar and Mir Bahar are the communities most affected by sea intrusion because they rely heavily on fishing for their livelihood. Also they don't have any appropriate skills or equipment for fishing in seawater. It was also mentioned that due to sea intrusion, the agricultural output was reduced by 50% in both *pacca* and *katcho* areas. Almost all the villages in the *katcho* area of Taluka Ghorabari have been totally destroyed.

Most of the Mir Bahar have migrated to Karachi. However, those who earn their livelihoods from agriculture have shifted to *pacca* land, because of which the economic activities of the people here have been affected. The migrant population has made their temporary houses with wood stalks in the *pacca* area. Burglary cases are on the rise due to unemployment of *katcha* area people. The *dehari* rate has also been reduced from Rs. 200 to Rs. 120 due to the availability of surplus labor.

Women used to work in the fields before the intrusion of the sea, but now due to the destruction of their land, the majority does not participate in economic activity and this has affected the income and living standard of families.

b) Village Darwesh, Taluka Ghorabari

Due to sea intrusion and its impact on the availability and nutritional value of fodder and freshwater, the quality of cattle here has declined drastically. The impact is immense on livestock as the majority of goats and sheep suffer from a lung disease called *"Dewi"*, which is fatal. Since there are no vaccination or medical services of a Vet available for the villagers, they have to rely on local remedies, which mostly prove to be ineffective.

Saline water is the cause of many health disorders including diarrhoea, jaundice, abdominal disorders, skin diseases, eye infections etc. Almost ten to fifteen women die every year because of reproductive health complications, as they do not have access to relevant medical facilities near Darwesh.

The migration of four to five thousand families from the *katcha* area of Darwesh to Thatta, Malir and Karachi can be assessed as the most significant impact of sea intrusion. The majority of the migrants were either farmers or the fishing community whose lands (above 250 hectares) had been destroyed by sea intrusion. The cultivation of banana, mangoes, peas, ladyfinger, pulses, tomatoes, maize, pepper and other food crops in the *Katcha* area has been destroyed. The *Pacca* area food crops such as sesame, rice and wheat have also suffered. On the other hand, there have been devastating effects on fish breeding, particularly on *Palla* and shrimp, because of the scarcity of sweet water, and the fact that fishermen do not have appropriate equipment for saline water fishing. Salinity has contaminated the ground water in the *Pacca* lands also and has rendered it unsafe for drinking.

[30] land subject to seasonal flooding
[31] land which is not inundated by river water

c) Village Keti Bunder, Taluka Keti Bunder

Village Keti Bunder shows a downward trend in population growth rate, largely due to the migration of the villagers to Thatta, Ibrahim Hyderi and Hyderabad. Sea intrusion has gradually changed the occupation of the residents from agriculture to fishing. However this profession is dominated by multinationals trawling the waters on a massive scale with which the small fishermen cannot compete. Hence their livelihood is endangered. The area under banana cultivation, an important product of the region, has fallen drastically. Livestock in rural life is considered to be an asset, which can be cashed in on rainy days. But since no land is available for grazing, this asset no longer exists. According to the interviewed group, the sea has affected some 120,000 hectares of land, leaving only about 3000 hectares for agriculture related activities.

Sea intrusion has also brought about a change in the occupation of women. Formerly they had helped men in agriculture but now, even though they help them in the cleaning of fishing nets, the major chunk of their time is spent in obtaining potable water for the family.

d) Wadera Khuda Baksh Village, Taluka Keti Bunder

The village hut where the discussion took place was located on the beach at the brink of seawater indicating the steady encroachment of the sea. It was learned that a large section of the residents had migrated to Karachi, Thatta and Hyderabad due to sea intrusion. The villagers expressed the opinion that sea intrusion would force the rest of the population to also migrate in the near future.

This village has no potable water, electricity nor are there any metalled roads. People use wood for cooking and purchase potable water from Union Council tankers. The houses are all made of reed wood.

The women do not participate in any economic activity. Besides the conventional daily chores, their main occupation is the cleaning and repair of fishing nets.

e) Deh Chach Wali Mohammed, Taluka Kharo Chan

Most of the agricultural land here has been destroyed and the women in the village are occupation less. In the areas less affected by sea intrusion, they are associated with livestock. The acquisition of potable water is a major problem here.

Diseases that have spread due to sea intrusion are asthma, jaundice, urinary infections, eye infections and gastro-enteritis. Unemployment of women is causing tensions in the households.