

ECONOMIC DEPRIVATION OF INDUS RIVER DELTA, SINDH, PAKISTAN: CAUSES AND SUGGESTIONS

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ABSTRACT: Economic losses of the Indus River Delta are constantly increasing since the last two decades. Due to climate change and construction of different projects on River Indus, there has been a decreased flow of fresh water in the river. Mangroves are washed away from the region as 38% area of the delta has been reduced due to shortage of freshwater below the Kotri barrage. Brackish water of the Arabian Sea is increasing due to the intrusion of seawater and the production of fish, crops, fruit, and mangrove forests are decreasing. To study the causes of economic deprivation of the delta, soils and water samples were collected from eight different locations of the delta for pH, EC and TDS analyses. Laboratory analyzed data shows that TDS, ranging from 29000 to 42000 and salinity affects the growth of crop plants. Fish and mangrove forests are also being destroyed due to high salinity and shortage of freshwater. Freshwater in the river may push backward the seawater intrusion and will aid the survival of the mangrove forests and crops. So, the Government should develop fair water policies and laws to discourage construction of any project reducing water flow and enhancing seawater intrusion in the delta.

Key words: Economic, deprivation, Indus River Delta, Sindh, Pakistan, suggestions.

1. INTRODUCTION

A deposition of transported material (gravel, pebbles, sand, and silt) collected at the mouth of a river especially near the standing water bodies (oceans, seas or lakes), where the volume, speed and velocity of the river's water are reduced, is known as Delta. Geographically, River Indus starts from the world's largest Mountain Range, Himalaya, and its sub-range, Tibet plateau, and ends at the Arabian Sea. Total distance between the Tibet plateaus and the Arabian Sea is 2880 km. Actual source of the river is Mansarovar Lake. The river water falls from 5182 m elevation of the Plateaus. Indus Delta is the fifth largest delta of the world. The delta is positioned at latitude 23° 59.34' N, longitude 67°

24.34'E. The delta is situated on the two coastal districts of Sindh province of Pakistan [1].

The growing rate of Indus Delta was between 4 to 30 miles per year, due to the deposition of silt and deposits more than 400 million tons per year. The delta covers an area of about 16,000 square miles (41,440 km²), and is approximately 130 miles across where it meets the sea. It is located at the mouth of the Indus River shaping 563 km of the entire coast of Sindh (Fig.1), with seventeen major creeks and extensive mud flats. The region consists of fertile clay soil [2].



Figure 1: A view of Indus River Delta. Source: [3]

The River Indus travels an extensive Indus plain before reaching the Arabian Sea. The flow in the river is generally low in the period from November to mid April at which point the snowmelt increases the discharges. Highest river discharge occurs in July to August, coincident with the peak of rainy season. The six months, from May through October, account for more than eighty percent of the river discharge. The mean discharge of Indus ranges from 5500 to 7500 m³s⁻¹. Most of the ocean word gauging stations on the Indus, however, show the mean discharge about 1500 m³s⁻¹ with maximum discharge during flood seasons (about 20,000 m³s⁻¹). The Indus Delta mangrove forest covers an area of 650,000 acres; this is the world's fifth largest mangrove forest [1]. The main source of those mangroves forests is fresh water of River Indus. All estuaries of the delta are very dynamic area for thousands of biological, marine, and wildlife species. The mangroves are the major elements of the deltaic flora and fauna, and are an ideal place for the growth of Prawns.

1.1. Economic values of mangrove forests

The mangrove forests have imperative economic value. The mangroves estuaries are four to five times more financial, valuable and productive than humid estuaries. An acre of delta mangroves is three times more economical than an acre of agricultural land. About 20 million populations are settled on the coastal area of Delta. Pakistan's largest city Karachi is situated at the western margin of the deltaic region. The delta provides fodder and grazing for cattle, goats and camels for local inhabitants as well as for demand of the largest city that is, Karachi. Coastal mangroves protect from soil erosion, tropical cyclones, tides, waves and tsunamis. All mentioned disasters originated in the Arabian Sea from time to time.

The mangrove forest is located in Sindh province along the coastal belt of Arabian Sea on the fan shaped delta of Indus River. At a time, this forest was among the world largest mangrove forests but now survival of the forest is complicated. While these types of forest survive on low salinity water availability from its parent river, similarly, mangrove forests of Indus Delta depend upon the fresh water of Indus River. Since last two decades some mega projects (Water reserve dams and link canals) are built on River Indus and a few mega projects are under consideration by Government of Pakistan. Water reserve dams and link canals block the flow of fresh water, so the salinity is continuously rising. On other hand, the saline water of Arabian Sea is also moving toward the delta. Therefore annual production of crops, fruits and wood is decreasing slowly.

Pakistan has 1120 km coastline, continental shelf of 50270 km², and total maritime zone, 30% of total area. In 1958, the first fish harbor was constructed in the Karachi Sindh. In fact the estuaries of the Delta are natural fishing hatchery, and provides favorable geographical environment for fishing growth. Approximately few people are busy in this business.

In 1989, 2.25 billion rupees was earned from the Delta and its estuaries from the fishing sector. The coastal belt of Sindh (from Karachi to Sir Creek) provides almost 67.3610% of total fish caught from Pakistan. Pakistan earned about Rs. 8 billion from fishing industry in 2000. Presently, Pakistan provides fish more than 50 countries [4].

Table 1: Province-wise fish production (000 tons) 1999-2006.

Year	Sindh (Delta belt)	Punjab	Baluchistan	KPK	Pakistan (Total)
1999	464.7	65.7	123.1	1.0	654.5
2000	422.3	61.8	129.7	1.0	614.8
2001	431.2	62.0	135.3	1.1	629.6
2002	435.0	65.0	136.5	1.3	637.8
2003	376.0	61.4	126.8	2.0	566.2
2004	380.0	63.0	128.0	2.5	573.5
2005	362.2	62.7	130.1	2.4	557.4
2006	345.9	61.6	132.4	2.5	542.4
Total	3217.3	503.2	1041.9	13.8	4776.2
Percentage	67.3610	10.535	21.8144	0.2889	100

Source: [5]

In the light of Table 1, Sindh contributes greatly to Pakistan fishing market, Share of Sindh province is 67.3610%, Punjab province 10.5355%, Baluchistan province 21.8144%, and Khyber Pakhtunkhwa province 0.2889%. But on the contrary, annual production of Sindh province is reducing since the last ten years. Table 1 shows the annual production of fishing Pakistan, of which since 1999 production is reducing slowly. In 1999, total fish production of Sindh province was 464.7 (000) tons, but this figure has been reducing year by year. In 2006, total fish production of Sindh province was 345.9, it means 118.9 (000) tons of fish reduced in last eight years. Therefore Pakistan suffers Rs: 22.29 million economical losses in a year only in fish production from the Sindh province due to shortage of fresh water in Indus River.

The belt of Indus River Delta is not favorable only for fish but it is also perfect for fruit and agriculture purpose, Soil of the delta is very attractive for rice, wheat, cotton, sugarcane, Jowar, banana, maize, and onion. From Table 2, the Kotri Barrage to coastal belt, a vast 16 km extensive belt of border districts is continuously under agriculture. But an average annual production of agriculture and fruits are gradually reducing since last ten years, due to shortage of fresh water availability in Indus River [6]. Table 2 shows that Pakistan records Rs: 5656.247=/million losses from the above mentioned commodity cultivated on the fertile soil of Indus

Table 2.Area and production of various crops and fruits in Indus Delta (2008-2010)

Crop	Area (ha)	Production (metric tons 2007)	Production (metric tons 2008)	Production (metric tons 2009)	Total	Reduction in the last 2 years (M.T)	%
Rice	140770	297628	282587	233217	813432	64411	7.91
Wheat	43455	71237	64961	61712	197910	9525	4.81
Cotton	2773	10280	6922	5323	22525	4957	22.72
Sugarcane	85840	5853200	5362900	4573562	15789662	1279638	8.11
Jowar	290	162	156	115	433	47	10.85
Bajra	436	194	184	168	546	26	4.76
Maize	1272	601	557	456	1614	145	8.98
Onion	4419	59733	57987	49389	167109	10344	6.18
Banana	3603	9135	8821	8134	26090	1001	3.83
Mango	1511	11104	10458	92398	113960	1764	1.49

Source: [7]

delta. Unfortunately, Pakistan has been suffering this loss since last ten years, hence the future's uncertainty

1.2. economic deprivation of the Delta

At present, the Delta is in front of a bundle of troubles. A chief cause of economical deprivation of the Delta is decreasing fresh water availability below Kotri downstream. As the delta dries up, the mangrove forests are washed away. At a time, the mangrove forests of the delta were busy on 345,000 ha, but this figure has changed entirely; now, these economical forests cover only 160,000 to 205,000 ha [8].

Twenty years ago, in 1991, a Water Accord was signed between the provinces by the co-operation of Federal Government of Pakistan. In the light of the accord, 10 million acre feet (MAF) water was to be released below the Kotri Bridge downstream. But unfortunately, since 1991, the required water was not released below the Kotri Bridge downstream till 2011, due to the abnormal condition (flood seasons) in the Indus River. According to a survey of the largest local news paper, only 6.8 MAF water reached the bridge during 1999 to 2004. However, in 2002 and 2003, the delta remained dry due to dangerous shortage of fresh water below the Kotri barrage, hence only 2.00 MAF water was released in the above-mentioned years. It was observed that only 1 MAF was recorded in 2001, which was the lowest flow of water ever recorded [9].

1.3. Construction of projects on Indus River and water flow

In the British period, some mega-projects were constructed for the improvement of the irrigation system on River Indus. Since then almost all projects have been completed except a few which were completed after the partition of the sub-continent. Projects such as between Sukkur and Kotri barrage was completed in 1932 (this is the largest barrage of south Asia), then Kotri barrage in 1955, Guddu barrage in 1962. Currently, 12 inter river link canals and 19 barrages carry more than 106 million acre feet above the Kotri barrage. Apart from the above projects, major water reserves dams located on Indus River or its tributaries used to block the water flow. Some other projects are under consideration by the consultation and assistance of Government of Pakistan and WAPDA, that is, Kalabagh Dam and Thall canal. Among four provincial assemblies, three provincial assemblies have passed the bills against controversial projects [10].

In 1967 and 1974, two huge dams, Mangla and Tarbela Dams were constructed on Indus River and its tributaries. The capacity of the Tarbela dam is 13.69 km³ with 143.26 m and 2743.2 m heights. On the contrary, the capacity of Mangla dam is 7250 million m³ with 138 m height from river level and 3140 m length. Both dams are responsible for shortage of water in Indus River. The river discharge in the deltaic region has now reduced to about one-fifth and the river has been confined to a single channel almost down to the coastal area.



Figure 2: Local NGO and political protest against man-made degradation of Indus Delta

In Sindh province, local political parties, NGOs and Organization are protesting against the man-made destruction of Indus Delta (Fig. 2). The protesters are claiming that WAPDA is responsible for destruction of the Delta, because WAPDA is always against the 1991 agreement. At present so many mega project are under construction on Indus River with the permission and co-operation of WAPDA. So the WAPDA is violating constitutional, economical and social rights of local people inhabited on the Delta.

Intrusion of sea water

At a time, the creeks of Indus River delta from Gizri Creek to Sir Creek were filled with fresh water of Indus River. But now the situation has changed entirely; it is observed that all the creeks from Gizri Creek to Sir Creek are filled with the saline water of Arabian Sea. Saline water of Arabian Sea is increasing vastly on surface and sub-surface area of the coastal districts of Sindh and badly affected by salinity of Arabian Sea.

According to a research of Indus Institute for Research and Education, Salinity of Creeks at the coastal belt of Arabian Sea is more than water of Arabian Sea. Salinity at the coastal subdivisions has reached 3.8 to 4.2% and Salinity of Arabian Sea is 3.6%. "According to a survey conducted by Kotri barrage study 11," salinity of water near the coastal area of the Karachi is at 35,500 to 36,900 parts per million (PPM) and has increased to 41,000 to 42,000 PPM in back waters and tidal creeks [11]. A survey conducted by the Board of Revenue that more than the 1,200,000 acres of the delta is now under threat of brackish water intrusion. Eight coastal sub-divisions of the Badin and Thatta districts are almost under threat. Currently about 550,000 acres of fertile land of both coastal districts are under effect of saline water [9].

2. MATERIALS AND METHODS

The Indus Delta is located on latitude $23^{\circ} 59.34' N$ and longitude $67^{\circ} 24.34' E$ and covers the southern part of Sindh province of Pakistan and Northern (coastal) part of the Arabian Sea. Regularly, the Delta is under threat of brackish water of Arabian Sea. It is mostly a muddy area with large quantity of silt, clay, clay-silt which consists of rich organic matter from the surrounding area of River Indus and Himalaya Mountain hit by annual erosion process.

For laboratory analysis and purpose, soils and water samples were collected from the different areas of the delta. Soils

samples were collected from 8 different locations of the study area (soils samples collected from 6, 9 and 12 inches depth and mixed in each other) and packed in plastic bags, then those samples were air dried. Thirty grams of filtered soil mixed in 150 ML of distal water in conical flasks. All samples were kept on the mechanical shaker in conical flasks for 30 min. After the shaking, all the elements may dissolve in water. We use filter paper for pure filtration of soil analysis, and then we checked the pH, EC and TDS of the soil. pH was measured by pH meter (Hanna Instruments HI 8014), electrical conductivity (EC) calculated by EC tester (Hanna Instruments HI 98304) and total dissolved salts (TDS) were calculated by the TDS tester (Hanna Instruments HI 98301) at Soil and Water Testing Laboratories Department of Botany, Shah Abdul Latif University (SALU) Khairpur, Sindh [12].

Similarly, the water samples were collected from the 8 different locations of the region in purified plastic bottles. All water samples were analyzed at above-mentioned laboratory. In the laboratory, three tests were conducted, that is, pH, TDS and EC. pH measurement was conducted by pH meter, TDS test conducted by TDS tester and EC test was conducted by EC tester (Table 3).

3. RESULTS AND DISCUSSION

The reduction of fresh water in River Indus is very harmful for deltaic flora and fauna. Brackish sea water intrusion is increasing day by day. Saline water contents with groundwater are very harmful for agriculture and fruit plants and saline ground water affects overall production. According to a research report produced by University of Sindh, an amount of total dissolved solids (TDS) in Indus River below the Kotri is more than 42,000 PPM. On the contrary, the limit of WHO is 1500 PPM. Therefore, increasing ratio of salinity below the Kotri downstream is harmful for fertile soil [10].

Due to high contamination of Arabian Sea, growth of Mangrove forests is still horrific. A greater area of the delta is covered by the brackish water of Arabian Sea. Favorable environment of fish in the estuaries is scratched so natural fishing hatchery is going out of phase. Delta flora and fauna and migratory birds live with complications or migrating at nearest water bodies' lakes that is, Keenghar Lake, Manchhar Lake, etc.

Table 3:Water composition of the estuaries of Indus River Delta

S/N	Date of collection	Time	pH	EC ds / m	TDS (ppm)
01	24.12.2009	13.40	8.1	1.78	38000
02	24.12.2009	14.45	8.2	1.9	35500
03	24.12.2009	15.20	7.9	2.2	38800
04	24.12.2009	15.40	7.8	2.00	42000
05	25.12.2009	09:00	8.2	2.1	32000
06	25.12.2009	10:30	7.6	1.9	29000
07	25.12.2009	13:30	7.7	1.7	29800
08	26.12.2009	11:00	7.8	1.9	30000

ppm = Parts per million and ds/m= decisiemens Source: [12]

Laboratory analyzed data shows that plant roots could not sink down and did not collect required food, Nitrogen, Phosphorus etc, for growth from the soils of the Delta. Plants and leaves of plants cannot grow properly, so salinity affects on the size/height of plants and leaves (Table 4).

Table 4: Annual losses of different commodities of the Indus Delta

Crop	Per year loss in metric ton*	Price per ton(PKR) **	Annual loss in million (PKR)
Rice	32295.5	35000	1127.2
Wheat	4762.5	25000	1190
Cotton	2478.5	305000	75.5
Sugarcane	639819	4625	2959.1
Jowar	16150	16150	0.037
Bajra	20000	20000	0.26
Maize	21420	21420	1.55
Onion	50000	50000	258.6
Banana	-	-	***
Mango	50000	50000	44.1

* Annual average of 2007, 2008 and 2009. ** Price of 1\$ = 85.5PKR as at 20-02-2011. *** Date not received.

Source: [10].

It is calculated that River water from below Kotri Barrage in Indus Delta was about 150 million acre feet (MAF) in the past. So River Indus had also been carrying some 400 million tons of different type of soils deposited at deltaic region. Due to reduction of fresh water in the last 60 years this ratio of deposited soil is reduced; this is the main cause of devastation of delta.

In the last two decades, four different types of mangroves are completely washed away from the area due to shortage of fresh water. But, *Avicenna marina*, *Ceriopstagal*, *Aegiceras corniculatum* and *Rhizophora mucronata* species are found here. The *A. marina* species is spread on the 85% of the total area of the delta, other two species of mangroves covered on 1 to 2% area that is, *Ceriopstagal* and *Aegiceras corniculatum*. Deficiency of River water below the Kotri barrage affected the species of mangroves and also affects the growth of mangroves forest because mangroves take fresh and plenty of water for their survival [6].

A survey conducted by Space and Upper Atmosphere Research Commission (SUPARCO) through satellite images showed that about 260,000 ha of mangrove forests cover Indus Delta in 1980s. On the contrary, in 1990s data released by same department showed that Indus Delta and its mangrove forests covered 160,000 ha only. It means 38.5% hectares has been reduced in ten years (Table 5).

Table 5. Maximum peak discharges (in cusecs) of River Indus for different years.

S/N	Year	Discharge s(in cusecs)	Reduced flow	Reduced %
1	1994	826369	-	-
2	1995	799447	26922	3.36
3	1996	415000	384447	9.26
4	1997	321180	93820	29.21
5	1998	295322	25858	8.75
Total average reduced % per year				12.64

Source: [5].

4. CONCLUSIONS

Indus Delta is facing a lot of problems; a few remedies are suggested for long survival of Indus River Delta to recover the lost economic structure of the delta. The Indus Delta is mortifying from the last two decades. The resourceful areas of Indus Delta may be useful for betterment of the economic structure of the delta. Government should take actions under the emergency basics. With consultation of all provinces, fair water policies should be developed. A law should be implemented that construction of any project apart from Kotri barrage should be discouraged until the survival needs of the Indus Delta and Mangrove forests are accomplished, because it is a technical, political and very sensitive issue between the provinces. According to the need of the delta, water stream should be released in the light of 1991 accord. Water monitoring system of Indus River should be under independence frame work, from the mouth to tail of the river. According to the need of Indus, Mangrove forests, and its estuaries, fresh water should be released from barrages and dams into the deltaic region on emergency basis. Some missing species of mangrove plants should be replanted. Water creeping under its sub-surface is very harmful to crops, flora and fauna, and local fish breeding. However, flow of fresh water from River Indus is required to return to its original state as saline water of the Arabian Sea.

There is multi-benefits if the fresh water of a river reached the end of the river. To reduce the salinity at coastal belt, mangrove will be able to make protective wall from natural disasters which originate from the Arabian Sea. If the salinity decreased, the area will be fit for cultivation in the future, and the economic condition of the country will be better. Consequently, Delta will offer employment for local inhabitants.

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