An Assessment of Environmental Impact on Agriculture in the Indus Delta Pakistan

Gohar Ali Mahar and Nayyer Alam Zaigham

Abstract

The agriculture sector in Pakistan is still the country backbone. Indus Delta was historically recognized as fertile land but the present study revealed that the severe kind of water-flow and sediment discharge from River Indus to the Deltaic area has changed the situation and deteriorated the greatest part of the agricultural land in the delta. Earlier, during the 1980s, the water flow condition of the Indus River used to be good. The finding related to the land degradation and its impact on the agricultural sector has been compiled and analyzed. (i) The results show that a large area has been submerged by the sea invasion, causing about 26% of the land of six coastal administrative units (Talukas) unusable (ii) The data collected for the period of 1998–99 to 2007–08 show extreme losses in cultivable area and more than 80% of the land was abandoned. (iii) The data collected for the same period related to the yield of rice, sugarcane and sesame also show a declining trend. (iv) Based on a survey conducted in the region, the annual earning of a farmer's family was estimated to be only $ 2 US per day. If enough water were supplied to the delta for agricultural and coastal areas or sea then the situation will be improved.

Keywords

Indus delta • Cultivated land • Indus River • Degradation • Sea intrusion

G. A. Mahar (✉)
Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan
e-mail: goharmahar@gmail.com

N. A. Zaigham
GeoEnvo TechServices (GETS), Karachi, Pakistan

1 Introduction

The Indus delta is located in the south of Pakistan (Fig. 1). The farming system developed in the Indus river delta is centuries old (Mahar 2010). This region was historically recognized as fertile land with a large land area covered by a forest and the people completely reliant on agriculture. Red rice was the special commodity of the delta areas (Brohi 2003). This region was an attractive place for investors due to this fertile land, crop species and other favorable conditions (Ahmed 2004; Memon 2005). In the last four decades, fresh water scarcity and land degradation by seawater intrusion resulted in environmental deterioration and people have started to migrate from this region due to appalling environmental conditions.

Agriculture yields were high before the construction of large reservoirs and water diversions (Khan et al. 2002). Seasonal floods in the deltas provided water resources to introduce a variety of high-value crops; while silt brought down by the river have also provided fertile blankets for cropping (Brohi 2003). The Deltaic land was not only considered as one of the most fertile lands of the plain of the river Indus but also provided a lush green patch with other ecological phenomena in the whole region. Many ecological and environmental changes took place with the reduction of fresh water flow in the delta. Agriculture was one of the major affected fields due to water scarcity (Salik 2016). A maximum flow of fresh water into the sea balances the hydrodynamic level and stops seawater intrusion inland. According to the survey carried out by the irrigation department, and board of revenue, Sindh in 2000, about 326,250 (0.32 million) acre of land in the Thatta coastal district has degraded badly as a result of seawater intrusion. The main objective of this study was to find out the impact on agriculture impact and low water-flow from the upstream area because of the imbalanced hydrodynamic conditions of Indus River and seawater.

H. Chenchouni et al. (eds.), *Exploring the Nexus of Geoecology, Geography, Geoarcheology and Geotourism: Advances and Applications for Sustainable Development in Environmental Sciences and Agroforestry Research*, Advances in Science, Technology & Innovation, https://doi.org/10.1007/978-3-030-01683-8_6

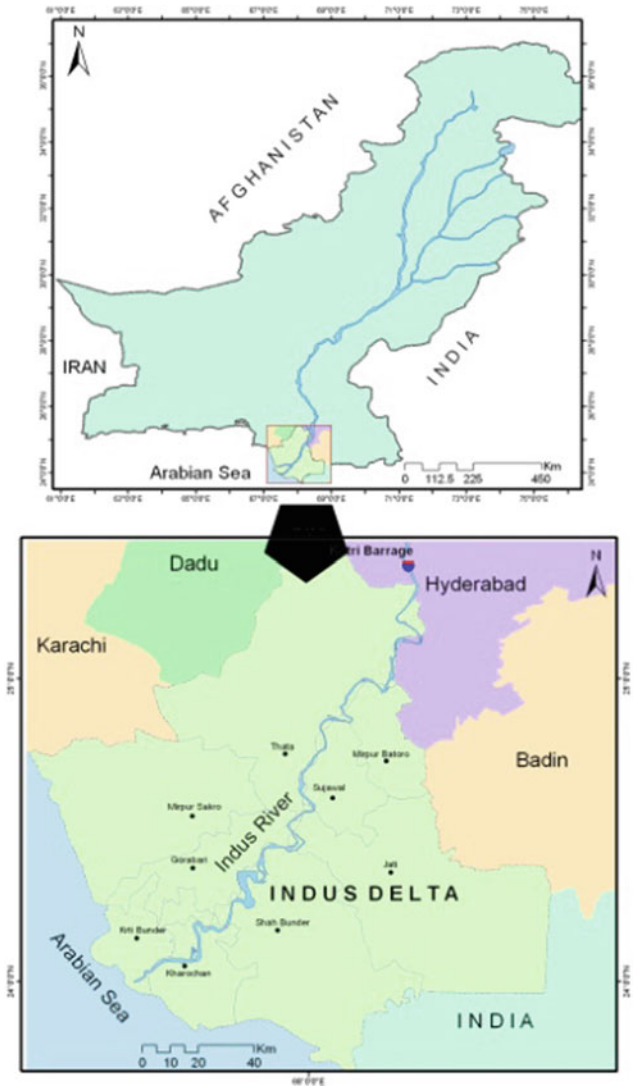

Fig. 1 Location map of the study area (Sindh, Pakistan)

2 Materials and Methods

In this study, the data collected to evaluate the environmental impact on agriculture in the Indus Delta consisted of two types primary data and secondary ones. Primary data have been collected by survey conducted in the study area and field observation. Secondary data have been collected from different sources.

The economic and social conditions of the farmers have been assessed during the field survey. The field survey was conducted in 2005–06. The radom sample selection method was used for the sampling survey and nearly 50 farmers at different locations within the study area have been selected to be interviewed (information).The pre-designed unstructured questionnaires were used to get information. The data of the collected information were compiled to evaluate (i) the cultivated average land owned by a farmer and the farmer's family structure and size and (ii) the budget of total expenditures for land cultivation and output (return) of the wheat and rice for the calculation of the net income per family.

Secondary data have been collected from different sources. Most of the data was related to the area of agricultural land, yield per hectare and production of different crops in a year. The collected data have been compiled and processed to evaluate the objective results. The data have also been plotted to evaluate the time series data and make it presentable. The collected data involved the following:

- Data about 124 Dehs (smallest administrative units), submerged by the sea intrusion.
- The recorded data of agricultural land (cultivable & uncultivable) in the period between 1998–99 and 2007–08 collected from agriculture tax (revenue) collection Department, Government of Sindh.
- Archive data of area, production and average yield of crops between 1997–98 and 2002–03 periods.

3 Environmental Impact on Agriculture

Adverse impacts on the deltaic land started after the construction of the Kotri Barrage in 1954–56, but after 1990s the deterioration rate accelerated and affected most of the cultivable lands. In the decade of 1950, progressive work for the construction of canal commands system (Dam, Barrages, Canals etc.) in the upstream area of the Indus River and was planned to improve agriculture in the country. Since then, parallel, adverse impacts on agriculture in the downstream area have started. Most of the fertile land has been transformed into saline land, due to the scarcity of water in the deltaic area. This situation has not only imbalanced the water quality at the mouth of the delta but inversely, sea intrusion has drastically destroyed most of the area. Therefore, land degradation impact on the agricultural sector has been analyzed from different view points.

3.1 Land Submerged by Sea Invasion

The six Talukas ((Boundary smaller than a district) situated near the coast of the Indus delta are Jati, Mirpur Sakro, Gorabari, Kharochan, Keti Bunder, and Shah Bunder. These Talukas comprise a total of 475 Dehs (Deh is the shortest administrative boundary in Pakistan). In 2000, the Sindh province goverment declared that out of the 475 Dehs, about 124 have been submerged (D.C.O. 2000). These results are a clear warning of the severe intensity of the sea invasion. The submergence rate of the coastal talukas is amazingly high. In

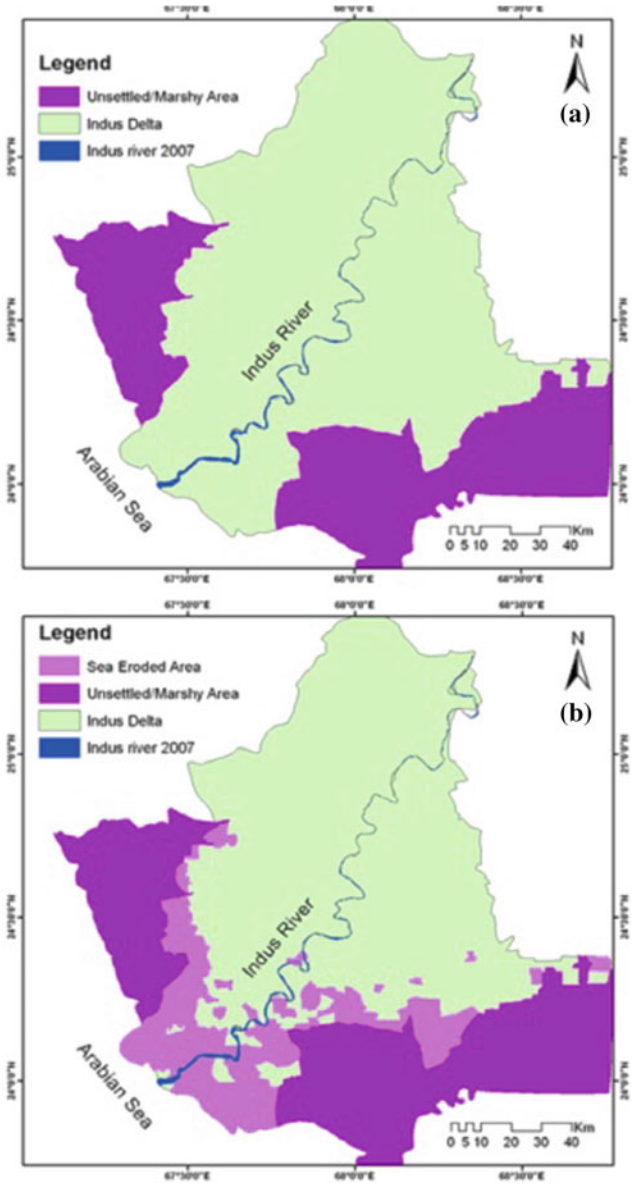

Fig. 2 Maps show administrative boundaries and migration before and after 2000. Map "**a**" represents before year-2000 marshy and the cultivated and populated area. Map "**b**" represents after year-2000, the coastal marshy, sea eroded areas from which people migrated and the cultivated area

Keti bunder about 86% of the land was submerged, 30% in Shah Bunder, 57% in Jati and about 69% in Kharochan (Fig. 2). Mirpur Sakro and Gorabari are inland talukas where the sea water impact was less severe.

3.2 Temporal Loss of Cultivated Area by Sea Intrusion

Taluka wise variations have been evaluated in the cultivated land in Thatta district. The difference of the results between the cultivated areas (during 2007–08) and the cultivable area (in the historic period) shows rigorous degradation of the Talukas, lying near the coast (Fig. 2). About 80% of the area degraded in Mirpur Sakro, 89% in Gorabari, 93% in Keti Bunder, 89% in Shah Bunder, 97% in Kharochan and 90% in Jati. The results of northern talukas of the delta do not show good condition in the cultivable areas. It was found that 60 to 70% degradation of the land has occurred in the Thatta, Mirpur Bathoro and Sajawal talukas.

The yearly loss of cultivated areas in the delta has made a discouraging scenario of the agricultural activities as shown by the graphical picture (Fig. 3). Over the last ten years, from 1998–1999 to 2007–08 our data show that the cultivated area has decreased to 35% but this decreasing trend is not constant. The total cultivable area of the district is 1,876,011 acres. In 1998–99, 25% of the total cultivable area was cultivated while in 2007–08, 16% of the total cultivable area was under cultivation. The fluctuating trend, of the loss of cultivated land of talukas, in the delta is presented in Fig. 3b. Losses are more obvious when focusing on the graphical analysis (Fig. 3c) that proves a huge difference between historically cultivable land and the land cultivated in 1998–99 and 2008.

3.3 Loss of Productivity

The scarcity of fresh water from the upstream and water intrusion from the sea have affected not only the cultivated area but also the production (yield per hectare) of crops in the delta. A decreasing tendency in production of many crops was noticed over the period 1997–98 to 2002–03 (Tables 1 and 2). It was found out from the compiled data that the production of *sugarcane*, *sesame* and *rice* has decreased at the worth seeing rate of 19, 40 and 21% respectively over the last six years. A similar impact on other crops and vegetable was also determined but at smaller rate. The production of millet, maize and cotton seemed to improve at the rate 12, 63, and 33%, respectively, during the study period.

3.4 Micro Economic Loss to Farmers

Based on the collected information, compiled and calculated, the family size of a farmer is eight people and about 3 acres of land is cultivated by the farmer. Thus, the benefits earned as 3 acre of cultivated land per 8 people. The average earnings from production of wheat and rice are 43,500/– per acre land in a year. Thus, $ 725 US (43,500 rupees Approx.) is the earning of a farmer in a year, which is about Rs. 121 or ($2) per day. This amount shows the prevalence of an extreme poverty in the deltaic area.

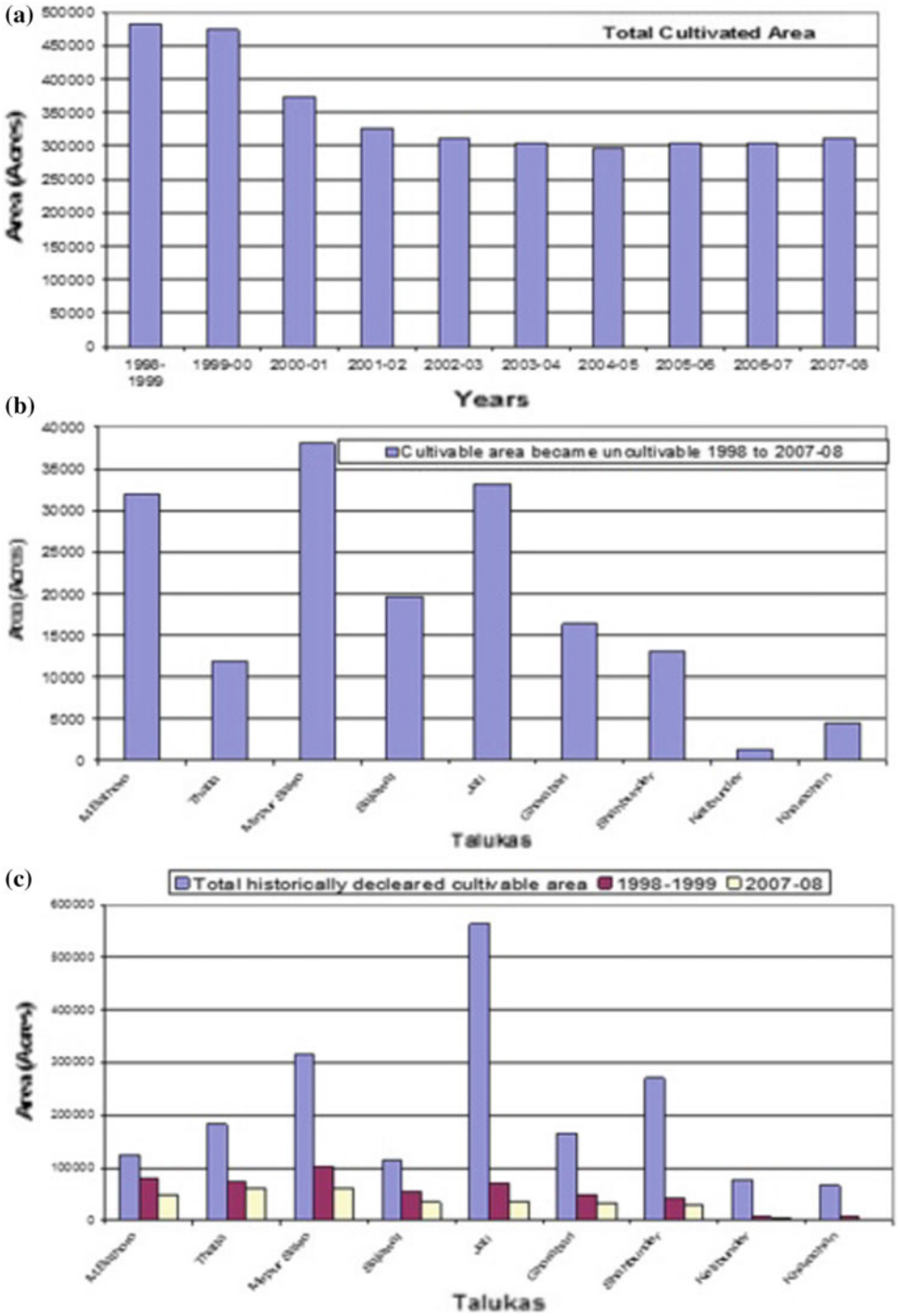

Fig. 3 Graphical representation of the total cultivable land and the cultivated land on time series data from 1998–99 to 2007–08. **a** Shows a declining trend of the cultivated land over time; **b** Shows the cultivated land decrease between 1998–99 and 2007–08 and **c** Shows the total cultivable land and cultivated land in periods of 1998–99 & 2007–08 based on administrative boundaries

Table 1 Data cultivated land (area), production and yield of crops over the periods of 1997–98 and 2002–03

Crops	Year-1997–98			Year-2002–03		
	Area (ha)	Production (mt)	Yield (mt/ha)	Area (ha)	Production (mt)	Yield (mt/ha)
Rice	65,321	130,629	1.99	56,422	89,142	1.57
Wheat	11,024	16,236	1.47	8196	11,828	1.44
Cotton	41	95 bales	2.31 bales/ha	528	1636 bales	3.09 bales/ha
Sugarcane	25,851	1,556,127	60.19	28,226	1,367,086	48.43
Jowar	178	72	0.40	427	169	0.395
Bajra	14	5	0.35	127	50	0.393
Maize	211	75	0.3 e	437	216	0.49
Sesame	43	16	0.37	62	14	0.22
Barley	8795	4540	0.44	5489	2441	0.44
Gram	408	294	0.72	23	13	0.72
Rapeseed & Mustards	1594	757	0.47	463	224	0.48

Source Bureau of Statistics Sindh, Government (1997–98 and 2002–03)

Table 2 comparative data of yield of crops over the period of 1997–98 and 2002–03 (data from Table 1), their yield in mt/ha and percentage

Crops	Yield in 1997–98 (mt/ha)	Yield in 2002–03 (mt/ha)	Difference in yield (mt/ha)	Variation (%)
Rice	1.99	1.57	−0.42	−21
Wheat	1.47	1.44	−0.03	−2
Cotton	2.31 bales/ha	3.09 bales/ha	0.78 bales/ha	33
Sugarcane	60.19	48.43	−11.76	−19
Jowar	0.40	0.395	−0.005	−1
Bajra	0.35	0.393	0.043	12
Maize	0.3	0.49	0.19	63
Sesame	0.37	0.22	−0.15	−40
Barley	0.44	0.44	0	0
Gram	0.72	0.72	0	0
Rapeseed and Mustards	0.47	0.48	0.01	2

4 Discussion

In last four decades, consequent degradation of human activities on the delta and a decline of the socioeconomic conditions of deltaic people have been the subject of discussion and research activities. Now, it is found from the recorded data that a substantial amount of water storage/divergence from the Indus River have depleted the amounts of the river water and the sediment quantity to the downstream areas. This phenomenon resulted in an environmental damage throughout the whole deltaic region. It also caused the socio-economic crises of the local community (Well and Coleman 1984; Qureshee 1999; Kahlown and majeed 2002; Kravtsova et al. 2009).

The sprawl of salinity due to the sea intrusion has severely degraded the groundwater and the land. The lack of fresh river water is the due to the huge water consumption in the Indus River upstream have reduced the cultivated land and affected the production of crops on large scale in the deltaic area. The overall environment shows continuous declining trends in the production of many crops but an improvement of production trends has also been recorded in areas associated with deltas and practically depended on the rain that fed the agricultural practices. The big loss of agricultural land with the decreasing crops production due to the fresh water scarcity of and consequently, sea intrusions have deteriorated the environmental, economic and social conditions of the farmers in the delta region. These facts were found out in field surveys. It was also found that the social values of the deltaic community are rapidly affected in response to the upstream anthropogenic activities. The huge losses of cultivated land and the productivity declining rate under the present environmental flow conditions have economically damaged the farming community of the delta region

5 Conclusion

The depletion of fresh water and sediment from upstream to the Indus delta in response to the construction of large water storage, canals network, barrages, created an environmental disparity between the fluvial and marine hydrodynamic conditions along the coastal belt, which has onset the aggressive sea wave and tidal conditions, generating devastating degradations of the land of the Indus delta. This

situation has consequently affected all land use practices including cultivated land, crops production, and rangelands that have developed adverse impacts on the socioeconomic conditions of the delta people.

The cultivable land decreased and the yield and cropping trends of the cultivated crops also dropped. The farmers' income earned from an average cultivated land was found to be very low. It is concluded that the big loss of the agricultural land, the decline in the production of cash crops and staple food crops (like rice, sugarcane and wheat) had a reverse impact on the socioeconomic circumstances of the farming community of the Indus delta. Poverty has prevailed in the delta and farmers are facing extreme deprivation of basic resources for their survival and thus ensuring their existence under the minimal sustainable conditions.

References

Ahmed, F.: Freshwater resources of Indus Delta eco-region: forever Indus. In: Proceedings of the Consultative Workshop on Indus Delta 260 Eco-region (IDER), WWF Pakistan, pp. 17–36 (2004)

Brohi, S.: Livelihood resources downstream Kotri barrage and their degradation: Indus flow downstream Kotri Barrage Need orWastage, pp. 1–16. SZABIST Center for information & research, Karachi, Pakistan (2003)

D.C.O.: Land eroded by sea in the coastal Talukas of district Thatta, unpublished record of survey in 2000, 5p, District coordination office, District Thatta, Government of Sindh, Pakistan (2000)

Kahlown, M.A., Majeed, A.: Water resources situation in Pakistan. Challenges Future Strat.: COMSATS Sci. Vis. Q. **7**(3) & (4), 46–49 (2002)

Khan, T.M.A., Razzak, D.A., Qamar-uz-zaman, CH., Abdul Quadir, D. Anwarul-kabir, Sarker, M.A.,. Sea level variations and geomorpho-logical changes in the coastal belt of Pakistan. Marine Geodesy **25**,159–174 (2002)

Kravtsova, V.I., Mikhailov, V.N., Efremova, N.A.: Variations of the hydrological regime, morphological structure, and landscapes of the Indus river delta (Pakistan) under the effect of large scale water management measures. Water Resour. **36**(4), 365–379 (2009)

Mahar, G.A., Geomorphic Degradation of Indus Delta and Its Geomorphic Impact, Ph.D. Thesis, Department of Geography, University of Karachi, Karachi (2010)

Memon, A.A.: Devastation of Indus river delta. In: Proceedings of the World Water & Environmental Resources Congress, American Society of Civil Engineers, Environmental and Water Resource Institute, Anchorage, Alaska (2005)

Qureshee, M.T: Neglected coastal ecosystem of Indus delta. In: Proceedings of the National Seminar on the Mangrove Ecosystem Dynamics of the Indus Delta, collaborated by Sindh Forest and Wildlife department and World Bank, pp. 9–18 (1999)

Salik, K.M: Hashmi, M.Z.R, Waheed-ul-Zafar: Environmental flow requirements and impacts of climate change-induced river flow changes on ecology of the Indus Delta, Pakistan. Reg. Study Mar. Sci. **71**, 185–195 (2016)

Well, J.T., Coleman, J.M: Deltaic morphology and sedimentology, with special reference to the Indus river delta. In: Marine geology and oceanography of Arabian Sea and coastal Pakistan, pp. 85–100. Van Nostrand Company Scientific and Academic Editions (1984)