

Economic Effects of Seawater Intrusion on Life of Coastal Communities in Sindh Region of Pakistan

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Abstract *Recently rising sea levels and a decrease of Indus water into the delta have resulted in high seawater intrusion at the coastal shores of Sindh. Seawater intrusion has severely affected the livelihood sources of local people. Therefore, this study is conducted with an aim to measure the economic effects of seawater intrusion on the lives of the local population in the deltaic coasts of the Sindh region in Pakistan. This is a quantitative study conducted through a survey questionnaire in the coastal belt of Badin and Thatta districts of Sindh province, Pakistan. A total of 200 participants were recruited in the study through multistage sampling. Results show a significant impact of seawater intrusion on the economic conditions of coastal communities in the province of Sindh, Pakistan. Adverse effects of seawater intrusion can be seen in the shape of a decrease in cultivated land, low agricultural production, decreasing livestock production and fishing quantity.*

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Introduction

The coastal communities face Seawater intrusion as a permanent issue in their areas. This intrusion of seawater has the strength of degrading natural resources. Consequently, this disturbance of seawater intrusion affects the lifestyles and the livelihood of the communities living in the coastal regions (Magsi & Sheikh, 2017). Pakistan's coastline area is spread on 1050 km and further divided between the provinces of Sindh and Baluchistan along the Arabian Sea. Including Indus Delta, the coastline area of the province of Sindh is stretched on 350 km along with districts of Thatta, Sujawal and Badin (Majeed et al., 2010). There are several countries in the world that are under the threat of devastating effects of climate change, including Pakistan (Pachauri et al., 2014). Global weather is highly affected by climate change and resulting in extreme floods, droughts, and seawater intrusion in coastal areas (Pasquier et al., 2020). Coastal communities of Sindh have been influenced by broadened rising sea levels bringing about loss of land and

business. Environment-related catastrophes have brought about broad pressure and many socioeconomic losses with impacts on lifestyle, livelihood, agriculture, education and health of the local coastal communities in Sindh province in Pakistan. Indus River, which was the lifesaver of agriculture and fisheries in the Delta area, currently contributes some portion of the verifiable and fresh sediment waters in the Arabian Sea. Water extraction at the source through a progression of dams and channels remarkably lower downed water flow from the Kotri downstream. The absence of freshwater has significantly affected the Deltas ecosystem and sources of livelihood. It has been estimated that about 1.2 million hectares of fertile land have become either eroded or uncultivable due to the rising of seawater (Khan et al., 2002). According to Chandio et al. (2011), as per the survey by the Board of Revenue, more than 1,200 000 land in acres of the Indus delta is under danger of water intrusion. The districts of Sindh Badin and Thatta

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are major victims of this effect. Their eight subdivisions along the coastline belt are almost in complete danger. In the current situation, the fertile land of these both districts have been affected due to the seawater erosion is about 550,000.

The areas at the coastline are considered significant economic zones, and socioeconomic activities along these are concentrated in high proportions. The seawater intrusion has strongly influenced the communities living in the belt of the coastline. Over the last fifty years, due to climate change, cyclones have been frequently occurred with greater intensity and caused enough economic consequences over the coastal belt of Sindh, including Karachi, Badin and Thatta districts. Climate change in this perspective has cost about \$14bn per year, and the same loss is equal to the 5% GDP of Pakistan. So, these never-ending losses owing to the seawater rise will impact further the weak coastal economy (Memon, 2016). About 10% population of Pakistan is living in the neighborhood coastal zone. While in terms of development, over 20% of this population is relatively developed, and about 40% of the industry is also found near or on the coast of Pakistan. Suppose a sudden climate change will occur. This will become difficult to save this important population (Rabbani et al., 2008).

Objectives

The study aims to know:

- The economic effects of seawater intrusion on the lives of the local population in the deltaic coasts of the Sindh region in Pakistan.
- The impacts of seawater intrusion on the livestock, agriculture and fishing activities of the coastal communities of the Sindh region in Pakistan.

Literature Review

Previous studies conducted in different countries have highlighted various problems faced by coastal communities due to rising sea levels and seawater intrusion. One study conducted in Vietnam reported land loss, flooding in the coastal area and high intensity of coastal erosion due to the rising sea levels in the country (Nguyen, 2021). Another study conducted in Bangladesh noted severe impacts of seawater

intrusion like increasing salinity in soils and decreasing livelihood sources of the coastal community (Wagas et al., 2021).

In this context, seawater intrusion is a serious problem worldwide, which has been linked with the climate change phenomenon in the world. The agriculture and fishing sectors are highly affected due to seawater intrusion, variability in downstream river flows, shortened rainfalls and other environmental factors (Mansur et al., 2005). Socioeconomic improvement is fundamental for development, but unfortunately, this area has been neglected by the governments, especially in the climate hit areas (Hasan, 2009). Socioeconomic indicators of health, education and other public facilities are highly affected due to climate change (Bradley & Corwyn, 2002). Coastal communities or either connected with agriculture or fishing are highly vulnerable to climate change threats, including sea rise levels and seawater intrusion in the region (Salik et al., 2015). It seems very clear that any profound change in the climate across the world will impact local agriculture, and eventually, the supply of food will be affected. The issue of predicting the future course of agriculture in a changing world is the hot topic of debate among scholars, which may affect the food demand and supply in the world (Abildtrup et al., 2006). Change of climate is a major danger to farm produce in the climate-vulnerable states of the world. One study has anticipated the effects of change climate on the produce of eight noteworthy harvests in Africa and South Asia through precise assessment and meta-investigation of information in 52 unique productions. The results of this study revealed that the anticipated mean alteration in the harvest of all products would decrease by the mid of 21st century. Verification of item yield influence in South Asia is a lot more grounded for sorghum, maize, wheat, and millet (Knox et al., 2012). Due to the rise of the sea level, the salinity has been increased, and mangrove forests have been declined, which has resulted in low activity for fishing in the affected areas (Mendenhall et al., 2020).

Perception, examinations and also the reproduction models show that environmental change would bring about changes in fundamental effectiveness, moves in transport and changes in the possible amount of excessively fished marine species, achieving

consequences for the economic terms of fisheries all throughout the world. Despite the gaps in understanding environmental change ramifications for fisheries, there is satisfactory logical information that includes the need to execute climate change control and essential adaption to restrict the effects on fisheries ([Sumaila et al., 2011](#)). There are solid interrelations between fishing and climate change since fishing diminishes the age, measure, and geographic variety of humans, including the biodiversity of marine biological systems, making both progressively delicate to extra pressure as climate change. Inland fisheries are furthermore compromised by changes in rainfall and water availability. The recurrence and force of outrageous climate events are probably going to have a major effect on the production of fisheries in future in both the inland and marine fishing systems. Decreasing fishing death in the dominant part of fisheries, the same is right now completely misused or overexploited, are the main practical methods for lessening the effects of climate change overfishing ([Brander, 2007](#)). Although the exact effects and bearing of climate-driven change for specific fisheries and fish stocks are questionable, there is visible economic stress or poor opportunities for development in countries that rely on fisheries ([Allison et al., 2009](#)). Fisheries will likewise be presented to a differing scope of immediate climate effects, comprising removal and movement of human populations and settlements; effects on coastal communities because of sea-level increase; and changes in the recurrence, circulation, or force of storms ([Daw et al., 2009](#)).

Another source of livelihood in the coastal region is livestock business. The interrelation of environmental change and animals is relatively an ignored area of research. Very small is available regarding the interrelation of climate change and increase variants in a climate with different drivers of development in livestock systems. In enormous areas in the subtropics and tropics, the rural livestock rearing systems are in rapid variation, the spatial heterogeneity of family unit reaction to change might be huge. Whereas, options may occur for a few family units to take benefit from increasingly favorable rangeland and farming conditions. Now it has been observed that climate change has a significant impact on livestock production and livestock

systems in the emerging world ([Thornton et al., 2009](#)).

Uncertainties in climate also have endangered the agriculture production in the coastal areas of Pakistan as one of the studies noted adverse effects of climate change on cereal crops such as Maize ([Mahmuduzzaman et al., 2014](#)). Data from one study in this regard show more facts about the socioeconomic status of the people in the Indus delta region due to seawater intrusion. It was observed that 52% of the members of the coastal communities in the two districts of Thatta and Badin have lost. Hajamro Creek near Keti Bandar has erupted because of the absence of freshwater availability in the Indus River area under the risk of erosion. Keti Bandar generally used to be a port, yet because man-made activities are limited to be just fishing. If the immediate steps are not taken, time is not far away that locals of the Hajamro Creek must migrate to some other location ([Memon, 2005](#)). In the current scenario, countries like Pakistan are more subject to the impacts of the change of climate. The agriculture sector contributes 45% of the total employment in Pakistan, and climate change effects are very much visible in this sector. These are the major sources of livelihood in rural coastal communities, which might be at larger risk due to the change of climate, as observed in one of the studies conducted in the Indus Basin of southern Punjab ([Qazibash et al., 2021](#)). Despite these few studies conducted in Pakistan, there is rare information available on the effects of seawater intrusion on the life of people in the Indus delta region at the Arabian sea. The results of this study will help in understanding the current situation of the problem and the socioeconomic status of the coastal communities in the region.

Material and Methods

This is a socio-economic study conducted on the participants living in the coastal belt of the Badin and Thatta districts of Sindh province. Multistage sampling was used in the study to select the study participants. In the initial stage randomly 20 villages were selected of 8 dehs in one each Union Council of district Badin and Thatta. Later 200 participants were recruited in the study for data collection. The survey questionnaire was used, and questions were asked from the heads

of the families to find out the economic effect of climate change and assert the impact of seawater

intrusion on the life of people of coastal communities of Sindh, Pakistan.

Table 1. List of Selected Villages

Union Council Bhugra Memon of District Badin		Union Council Keti Bunder of District Thatta	
S. No.		S, No.	
1	Veedho Mandhro	1	Abdullah Sholani
2	Allah Dino Mandhro	2	Ali Muhammad Mallah
3	Golo Mandhro	3	Allah Dino Patel
4	Haji Ali Muhammad	4	Buhan wari
5	Haji Hajjaam	5	Haji Hameer Memon
6	Ibrahim Shah	6	Haji Siddique Shah
7	Lakha Dino Rajo	7	Haji Umar Otho
8	Manthar Mandhro	8	Haji Urs Sholani
9	Shaikh Kiryo	9	Wathyo Sholani.
10	Tayyab Mallah	10	Ladho Sholani

Results and Discussion

Data for this study have been analyzed using software SPSS (Statistical Tools for Social Sciences) version 22. Firstly, the data have been analyzed descriptively with an objective of knowing the frequency and the percentage of the responses as obtained from the participants.

Thereafter, the Multiple Regression Model was applied to know the economic effects of Seawater intrusion on life of Coastal Communities in the Sindh region of Pakistan in terms of income, decrease in sources of livelihood, decrease in cultivated land, livestock and fishing quantity.

Descriptive Analysis

Table 2. Seawater intrusion and Demographic Characteristics of the Participants (n=200)

Variables of Analysis	Frequency	Percentage
Seawater intrusion Observed		
Yes	179	89.5
No	21	10.5
How often is Seawater intrusion Observed?		
Frequent	166	83.0
Rare	13	6.5
Not Observed	21	10.5
Age of the Study Participants		
18-25	26	13.0
26-40	51	25.5
41-60	69	34.5
> 61	54	27.0
Source of Income		
Agriculture	103	51.5
Livestock	8	4.0
Fishing	69	34.5
Wage labor	6	3.0
Services	14	7.0
Decrease in Sources of Income		
Strongly Agree	46	23.0
Agree	128	64.0
Neutral	14	7.0
Disagree	7	3.5
Strongly Disagree	5	2.5

The results in the above-mentioned table show that generally (179) 89.5 % of respondents shared that they have observed the seawater intrusion during the last 5 years. While (21) 10.5% shared that they have not observed the seawater intrusion. Whereas, in answer to the question 'How often Seawater Intrusion Observed', (166) 83.0% participants were of the view that they did not observe the seawater intrusion frequently. Secondly, (13) 10.5% of respondents recorded their response as they rarely observed the coastal erosion. However, (21) 10.5% of participants did not observe the seawater erosion at all.

The majority of the participants of this study fall in the range of age group 41-60 years as their number is (69) and constituting 34.5% of the total participants. Therefore, findings show that most of the data of this study were collected from people above 41 years of age. As far as the

source of income of the participants of this study is concerned, the majority of the participants are earning their livelihood through agriculture as data reveals that (103) 51.5% of respondents are meeting with their earnings through agriculture. While (69) 34.5% of participants rely on fishing as their source of income. We have observed a decrease in the sources of income mainly due to seawater intrusion. This is being exposed by the data that (128) 64.0% participants of this study agree and (46) 23.0% strongly agrees to this point of view that rising sea level and decreasing freshwater from the Indus River is likely to be linked with seawater intrusion.

Following table no. 03 descriptively tells us about the impact of the seawater intrusion on agriculture.

Table 3. Impact of Seawater intrusion on Agriculture (n=200)

Variables of Analysis	Frequency	Percentage
Acres of Farmland Lost		
< 5 Acres	29	14.5
> 5 Acres < 10 Acres	47	23.5
> 11 Acres < 25 acres	65	32.5
> 26 < 50 Acres	48	24.0
> 51 < 100 Acres	8	4.0
> 101 Acres	3	1.5
Land Area under Cultivation Compared to Last Season		
Same	19	9.5
Less	181	90.5
Decline in Farm Produce		
Yes	190	95.0
No	10	5.0
Decrease in Number of Livestock		
Strongly Agree	30	15.0
Agree	93	46.5
Neutral	38	19.0
Disagree	20	10.0
Strongly Disagree	19	9.5

We observed that there is a great impact of seawater intrusion on agriculture. Our data revealed that > 11 acres < 25 acres of farmland has been lost due to this climate change effect. In this context (65), 32.5% of participants are agreed with this fact. The percentage of the participants about the land area under cultivation compared to last season is (181) 90.5%. Therefore, this indicator shows that more land in the coastal area of Sindh, Pakistan is under the

cultivation process, but still, it is under the impact of the change of climate.

It has been observed in this study that seawater intrusion in the coastal areas of Sindh has largely affected livestock production and business. Due to salty water, the number of livestock has been decreased, and people sold it in a way to meet their daily life needs. As (93) 46.5% of total participants were agreed on this point. Secondly, (30) 15.0% of participants

strongly agreed that a decrease in the number of livestock has occurred due to climate change patterns and seawater intrusion in the area. Due to this change, the grassland and vegetation have been decreasing in the region, which is an essential requirement for livestock rearing.

Whereas, following table no. 04 tells us in the Descriptive manners the impact of the climate change in the coastal areas of Sindh, Pakistan on the fishing activities of the people of the same area.

Table 4. Impact of Climate Change on Fishing (n=200)

Variables of Analysis	Frequency	Percentage
Decrease in Fish Catching Quantity		
Strongly Agree	135	67.5
Agree	30	15.0
Neutral	15	7.5
Disagree	14	7.0
Strongly Disagree	6	3.0
Fish Catchments Compared to Last Year		
Lower	130	65.0
Normal	70	35.0
Fish species Quantity		
Increased	18	9.0
Decreased	182	91.0

The study has exposed a decrease in fishing catching quantity in the coastal areas of Sindh due to climate change. In this context, (135) 67.5% and (30) 15.0% participants respectively strongly agree and agree that climate change and seawater intrusion have resulted in the decrease of the fishing quantity of the coastal areas of Sindh. We compared the fish catchments to last year and observed that they had been lowered.

As (130) 65% of participants mentioned that it has lowered. While (70) 35.0% are of the view that it is under normal conditions. One of the alarming results of this study is a decrease in the fish species quantity. Out of a total of 200 participants (182), 91.0% participant's state that fish species quantity is decreased due the climate change and seawater intrusion.

Multiple Regression Model

Table 5. Analysis of Multiple Regression Model (n=200)

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	27055.7783	6571.031		-4.139	0.000
Annual Sales	45573.540	9666.058	0.213	4.766	0.000
Seawater intrusion	1.711	0.418	0.179	4.112	0.000
Decline in farm produce	0.411	0.013	0.565	16.334	0.000
Decrease in livestock Numbers	0.4550	0.036	0.488	16.005	0.000
Decrease in fish catching quantity	0.449	0.068	0.216	7.730	0.000

$R^2 = 0.756$, $F \text{ Value} = 226.042$

Table-5 reveals multiple linear regression analysis results. The model was designed to analyze the economic status of the participants in relation to different independent variables. The analysis confirms that there is a significant relationship between seawater intrusion and other variables with the economic status of the

people living in coastal areas of Sindh province. The results revealed that the economic status (Annual net income) of households is significantly related to total annual sales seawater intrusion, the decline in farm produce, livestock and fishing quantity (P-value: <0.000).

Conclusion and Recommendations

This study has observed the significant relationship between seawater intrusion and adverse economic conditions for coastal communities in Sindh, Pakistan. It has been noted that the main livelihood sources of people like agriculture, livestock and fishing are affected. The majority of the respondents have lost their agricultural land due to seawater intrusion. People have reported a decrease in the number of livestock and low fishing in the study area. This was a socioeconomic study, so we had

limitations in measuring environmental changes in the area. In this context, this study recommends more environmental studies to assess the depth of the problem in the Indus delta area and know the actual intensity of climate-related changes. Furthermore, it suggests government authorities and other stakeholders take essential measures for the socio-economic development of the coastal communities, including development projects, employment opportunities and adoptive strategies to cope up with the current situation.

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