Assessment of Climate Change Impact on Indus Ecoregion Fisheries

Disaster Risk Reduction Measures for Aquaculture

IRANIAN FISHERIES RESEARCH ORGANIZATION (IFRO)

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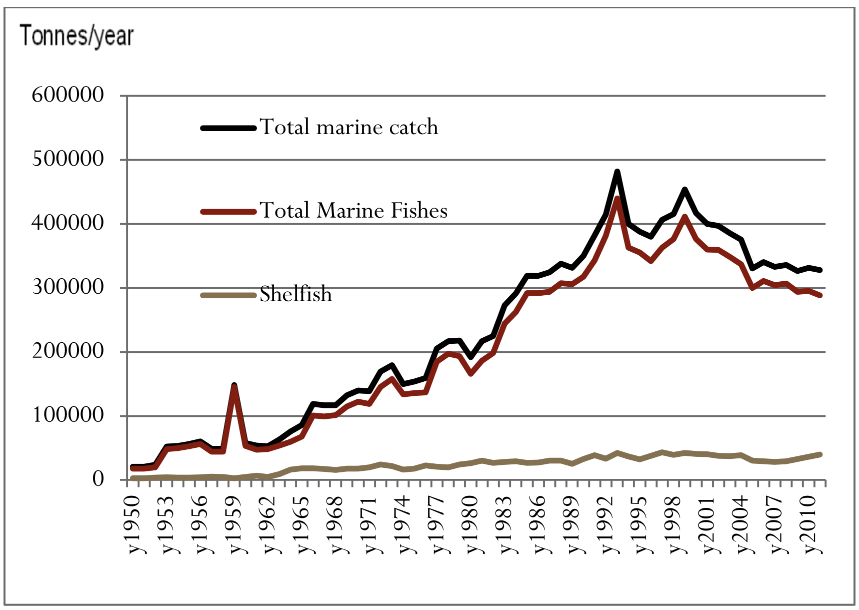
1. Introduction

Indus River originating from Tibetan Plateau flows through Pakistan from north to south. It is main source of agricultural irrigation, drinking water of urban and rural areas, industrial use and aquaculture. There is great potential for increase in aquaculture of Pakistan. It can help in food production in poorest parts of the country. It can also generate working opportunities in the region. The Indus River ends in Arabian Sea with a vast delta that provides well suited ground for agriculture, fishing and aquaculture.

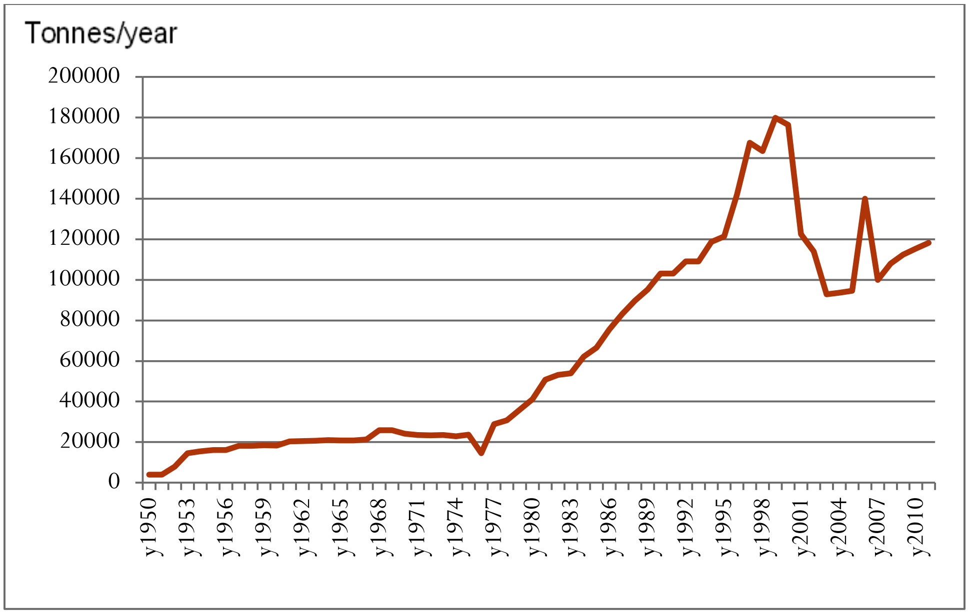
Pakistan fisheries were mostly concentrated in fishing in the sea and Indus River. Both of these resources where exhausted in late 1990s and early 2000s. Marine fisheries catch of Pakistan increased in a slow pace from 1950 until it reached a 482 thousand metric tons peak in1993. Then there has been a decrease in marine fisheries production of Pakistan. Although this decline was somewhat compensated by a smaller peak of marine production of 454 thousand tons in 1998, but since then there were a steady decrease in catch at a rate of around 2.5 percent (Figure 1).

Figure 1. Total fishing from marine environments of Pakistan (Source FAO, 2014).



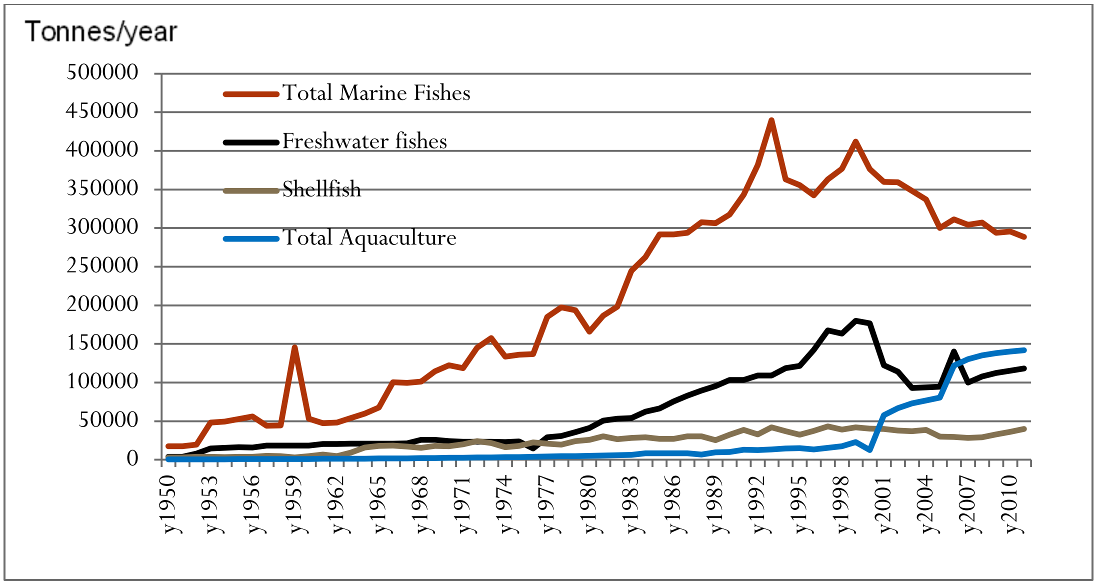
Freshwater fish catch also showed similar trend with a peak catch of 176 thousand tons at the year 2000, then a sharp decline in catch and a secondary comeback up to 140 thousand tons in 2006 followed by more catch decreases happened (Figure 2).

Figure 2. Total fishing from freshwater environments of Pakistan (Source FAO, 2014).



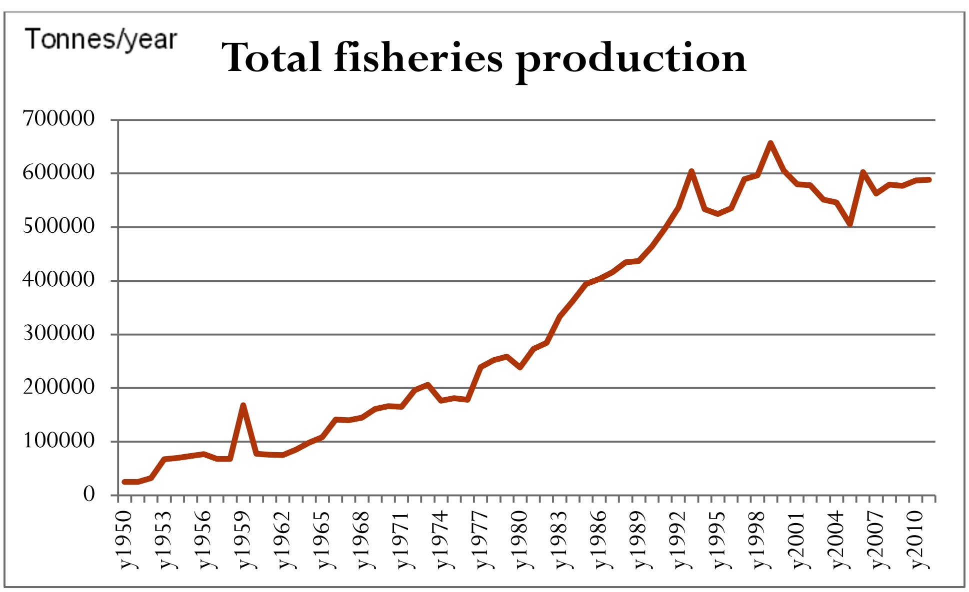
The Federal Government of Pakistan has been successful in developing a progressive aquaculture plan that increased production in considerable scale; however it could not compensate the reductions in marine and freshwater catch caused by climate change. Figure 6 compares production of fish from marine and freshwater wild sources, shellfish from marine sources and total aquaculture of Pakistan. As it is evident from figure 3, aquaculture is getting an important role in fisheries and in the future, it has already passed shellfish and freshwater fish catch statistics and if the pace of its increase is kept intact, it would be able to overpass fish production from marine environment as well.

Figure 3. A comparison of marine, freshwater catch and aquaculture products of Pakistan (Source FAO, 2014).



At this stage overall production trend of fish and shellfish from all sources and aquaculture in Pakistan is becoming steady at around 600 thousand tons, as opposed to the fluctuating period of 1990s (Figure 4).

Figure 4. Total fishing and aquaculture production of Pakistan (Source FAO, 2014).

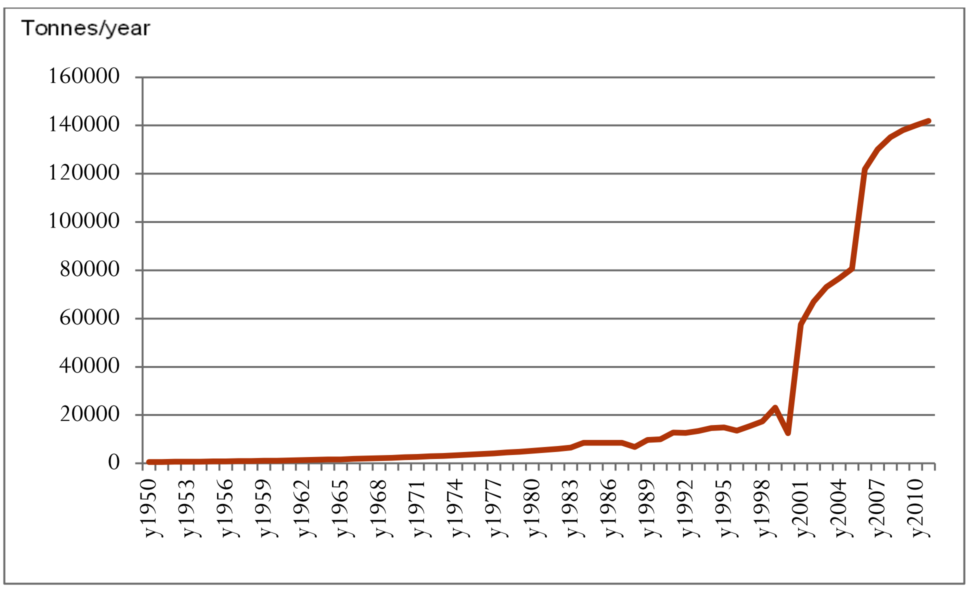


2. Aquaculture sector profile

2.1 Services or Service Flows from Aquaculture in the Indus Ecoregion.

Although fisheries and aquaculture account for only one percent of GDP of Pakistan, but since the Federal Government of Pakistan rightfully emphasized on the importance of fisheries and aquaculture in economic growth, poverty alleviation, food security and environmental conservation, special attention has been given to the sector. In order to enhance fisheries and aquaculture the Federal Government approached FAO to assist in putting together a policy and a strategy with the help of a FAO sponsored TCP to enhance fisheries and aquaculture. It was well noted that there is little room for marine or freshwater fish improvement, so efforts were focused on aquaculture development. As a result of that, sharp increase in aquaculture started from late 1990s and continued up from a small amount of less than 20 thousand tons up to 142 thousand tons in a course of 10 years until 2011 (Figure 5).

Figure 5. Total aquaculture production of Pakistan (Source FAO, 2014)



The Indus ecoregion is in 18 districts in Sindh Province. The ecoregion has a variety of habitats including Delta of the river, the water body of Indus River, vegetation along the river, lake ecosystems along the river, rangelands and deserts, and rangelands. There are more than 20 million people living in the ecoregion. Their occupation is mainly farming, fishing, logging, timber collection, and livestock rearing by grazing in rangelands. To maintain the sustainability of the Indus Ecoregion and decrease poverty in the region, there is a need to reduce human utilization of natural resources of Indus Ecoregion. The main derivers of first phase of the 50-year Indus Ecoregion Programme are environment, water deficiency, and poverty. The threats that can be related to unsustainable use of fish resources of the river, lakes and delta area of the ecoregion include, aquatic species extinction, overfishing and unsustainable fishing practices. In order to attain variability of resource use in the Indus ecoregion development of aquaculture of fish and shrimp is considered by stakeholders and Pakistan Government.

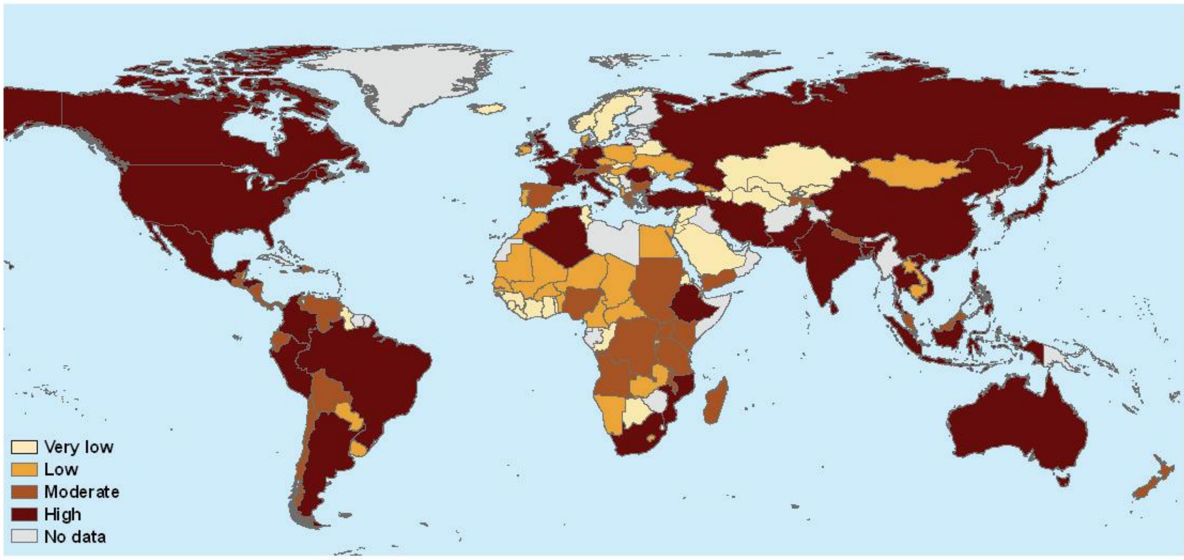
For example creating pen culture of fish in the Nabi Bux Pallari Village of Keenjhar Lake resulted in rearing market size Tilapia, Snakehead, Silver (Grass) Carp, and Sole. The 600 kg fish harvest of 1-2 kg fish was raised in an experimental 50 m2 pen with the help of WWF- Pakistan. Although this looks small, but it should be noted that it is produced in a small pen and it can replace small wild fish (Figure 6) with reasonably sized fish with good market value.

Figure 6. A sample of wild fish catch from Keenjhar Lake, mostly are small- low value fish

2.2. Vulnerability of the Sector to Climate Change Hazards.

There has been an undoubted increase in frequency and severity of disasters (floods, earthquakes, tropical cyclones, droughts etc) in recent decade. Climate variability also increased in recent years. Results of several studies suggest that disaster increase in quantity and effectiveness can be caused by climate change (at least partially). Pakistan is a country very much affected by climate change, Badjeck et al. (2013) in a FAO Report on "the vulnerability of fishing-dependent economies to disasters" groups Pakistan among the high frequency natural disaster countries of the world (Figure 7).

Figure 7.Frequency of natural disasters of the world (Source Badjeck et al., 2013).



3. Identification of Risks, Hazards and Disasters

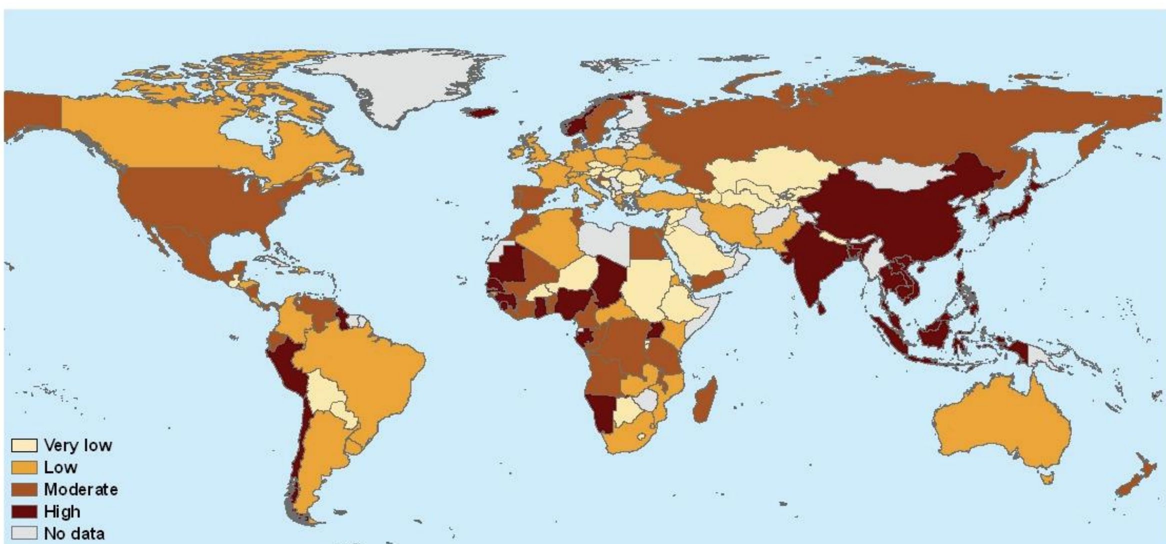
The major disasters that struck the region such as floods in 2010, 2011, 2012 and 2013 showed how catastrophes can potentially impact fisheries and aquaculture enterprises. Floods, earthquakes, cyclones, tsunamis, and sea level rise can damage fish and shrimp farms and devastate fishing boats. Regardless of the nature of disaster, each disasters not only can potentially destroy fish and shrimp ponds, fish cages and fishing vessels, but also damage infrastructures and fishing facilities and ports.

Earthquakes of 2005 and 2013 were two main examples of disasters in Pakistan that could not be easily linked to climate change. But flooding of Indus River, Indian Ocean cyclones, irregularities in monsoon, tsunami and sea level rise can be readily related to climate change. Indus River starts flowing from mountainous region of Tibet and goes all the way down to the Arabian Sea in Karachi. It provides irrigation water for agriculture and is a main source of water for inland aquaculture. Also there is a large fishing industry in this river that catch freshwater fish. The glaciers of Himalaya can melt as a result of climate change and global warming causing increased flow of Indus River which can be flooding for a long time. This phenomenon is not started yet, but there is no guarantee in its prevention in the future. Also irregularities in rainfall and monsoon caused flooding in recent years of the river. These can become more out of control causing even bigger floods.

Marine fishing which is still the largest fish and shellfish production source of Pakistan has already decreased. This can be attributed to direct or indirect climate change effects on the Arabian Sea. Tropical cyclones such are one important disaster at sea coasts. For example cyclone TC02A in 1999 caused around 6 million USD damages affecting Thatta District of Indus River, also cyclone TC YEMYIN in 2007 caused around 560 million USD damages in India, Pakistan and Afghanistan (Sarafraz, 2009). Tsunami is another potential disaster for coastal areas such as Indus delta. Luckily Pakistan has not been hit by tsunami, especially that of 2004 in Indian Ocean, but still there is no reason that in the future tsunami would not affect Pakistan coasts. Draught is less probable in Indus River region, but in other areas of Pakistan it is already affecting local communities.

Badjeck et al. (2013) put Pakistan's fisheries at low sensitivity to climate change disasters on the grounds of low dependency of the economy to fisheries at low sensitivity (Figure 8). It should be noted that fisheries contribution to economy is around one percent of the GDP and it employs as little as 471 thousand fishermen (Ministry of Food, Agriculture and Livestock Government of Pakistan, 2007). If a normal Pakistani household has 5 children on average, adding together each family of 7 persons, it would end up covering living costs of some 3311 thousand people which is less than 0.02 percent of 183 million population of the country. But it should be noted that aquaculture industry is developing and when well developed this equation would be changed. Numbers of freshwater fishermen of Pakistan are about 184 thousand persons, some 1.5 times of the Pakistani fishermen of the sea; showing that there is room for employment change from wild fish catch to aquaculture. This can help in conservation of fish stocks of Indus River as well as poverty eradication.

Figure 8.Sensitivity of fisheries to natural disasters of the world (Source Badjeck et al., 2013).



Marine and freshwater fish are susceptible to climate change due to changes that can occur in physical properties of their environment and damages to spawning sites that can result in reduced reproduction or emigration to new environments. Aquaculture with infrastructures such as ponds, cages etc. is vulnerable to disasters causing fish mass mortality or mass escape into river or the sea, however this has not been reported before. But in 2010 when Cyclone Phet hit the coast of Sindh, aquaculture ponds of Tippun Village at Keti Bunder was left alone due to the called evacuation by Pakistan Navy, causing opportunistic harvest by looters. But the pond structure was left unharmed, leaving the opportunity of starting again (Fatah, 2010). More frequent flooding of Indus River and cyclones from the Arabian Sea are considered to be the main risks for aquaculture. The area of the Indus River Ecoregion is close to sea level. Areas like Keti Bunder are basically at sea level, while Badin with 10 m and up north at Dadu one can find 24 m above sea level; however this cannot provide any shelter against floods or cyclone. But coastal areas are more susceptible to climate change risks.

3.1. Description of Methodology and Proposed Methodological Approach.

3.1.1. Available Primary and Secondary Data

In order to conduct this study primary climate data and fish fingerling production data were made kindly available by WWF-Pakistan. In this study extreme number of years, duration of foods/cyclones and its effects on aquaculture ponds and facilities were evaluated.

3.1.2. Event Analysis Techniques Used Relying on the Available Data

The raw data were showing rainfall in latitude and longitude. The data were first translated to the areas were fish aquaculture sites are present. Then it was looked at carefully and description method was used to evaluate the severity and duration of the events. Finally impact of the disasters on aquaculture farms was evaluated using the aquaculture information which was kindly made available by WWF-Pakistan.

3.1.3. Frequency Distribution Analysis Technique

The raw data of rainfall with information from internet sources were used for frequency distribution analysis. The data were first observed carefully to find any discrepancy or possible errors. Then description method was used to evaluate the frequency of extreme events. This was used to make predictions for the risk reduction measure proposal for future disasters; however it is well pointed out by Awan (2004) that in most cases flood rainfall is not originated from the area of flood, it may well be from another country's rainfall.

4. Results

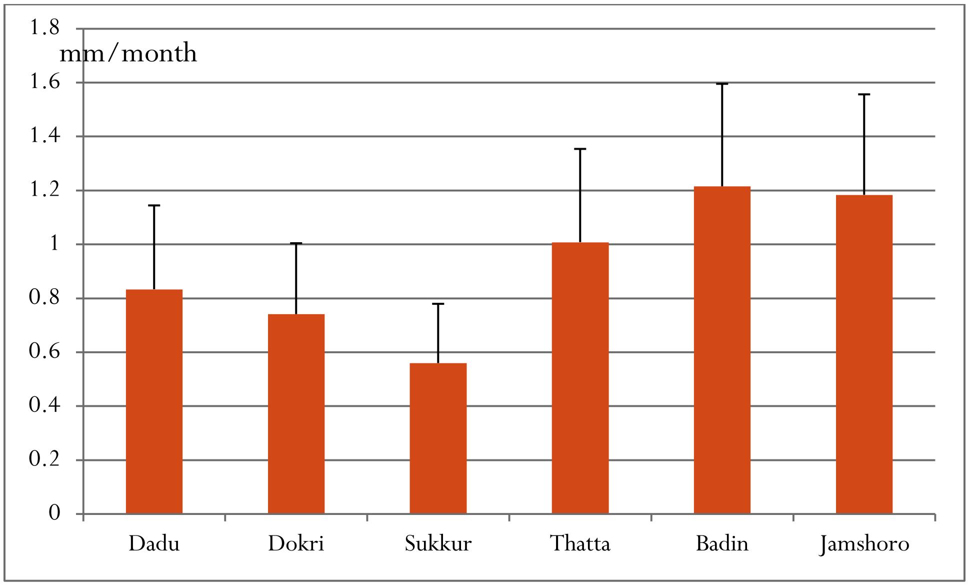
4.1. Results of Analysis of Climate Risks with Emphasis to Floods.

The present report has divided the Indus ecoregion into two areas with high and medium risks. Also predictions were made in two scenarios of low, medium and high level climate change impacts.

The data evaluation of precipitation of the past 22 years showed clearly that the areas closer to shore line of the Arabian Sea are more susceptible to floods compared to landward areas.

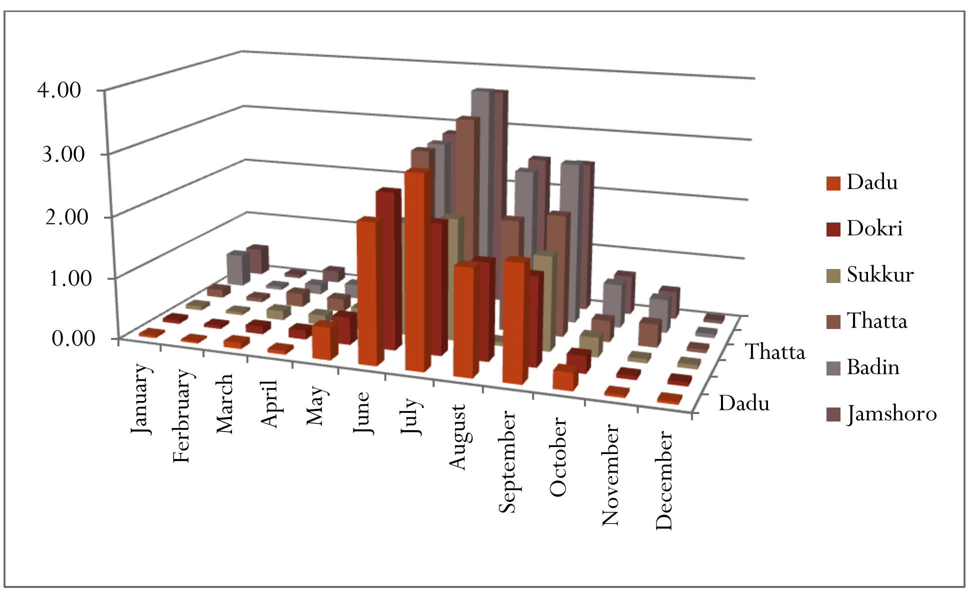
Careful evaluation of data showed that districts like Thatta, Dadu and Jamshoro receive more rain compared to Sukkur and Dokri Districts. Also the 2010, 2011 floods more affected the southern and coastal areas as opposed to inland districts possibly for low altitude of these districts; so Thatta, Badin and Jamshoro are classified as high risk, and Sukkur, Dadu and Dokri are considered to be at medium risk of flood, monsoon, cyclones and tsunami (Figure 9).

Figure 9. Average Monthly rainfall in 6 aquaculture sites at Indus Ecoregion (Error bars show standard error).



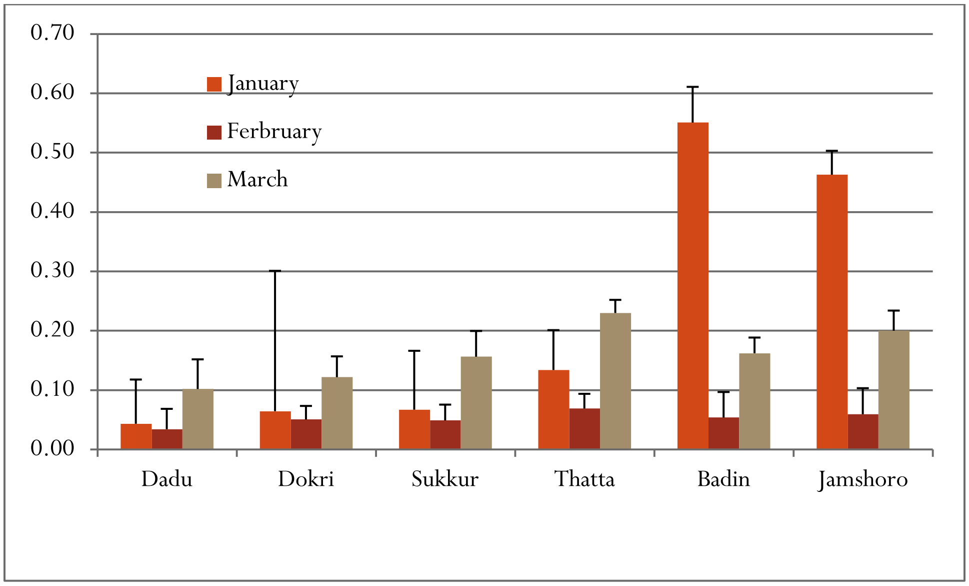
In addition to mean differences of rainfall in districts, one can see There are differences in each month in the region (Figure 10). From this figure it is clear that there is a tendency of change in climate from a more routine precipitation to a changeable one; for example a yearly distributed rainfall can be seen in Badin and Jamshoro, while other sites receive main part of their rain in June and July.

Figure 10. Monthly rainfall in 6 aquaculture sites at Indus Ecoregion.



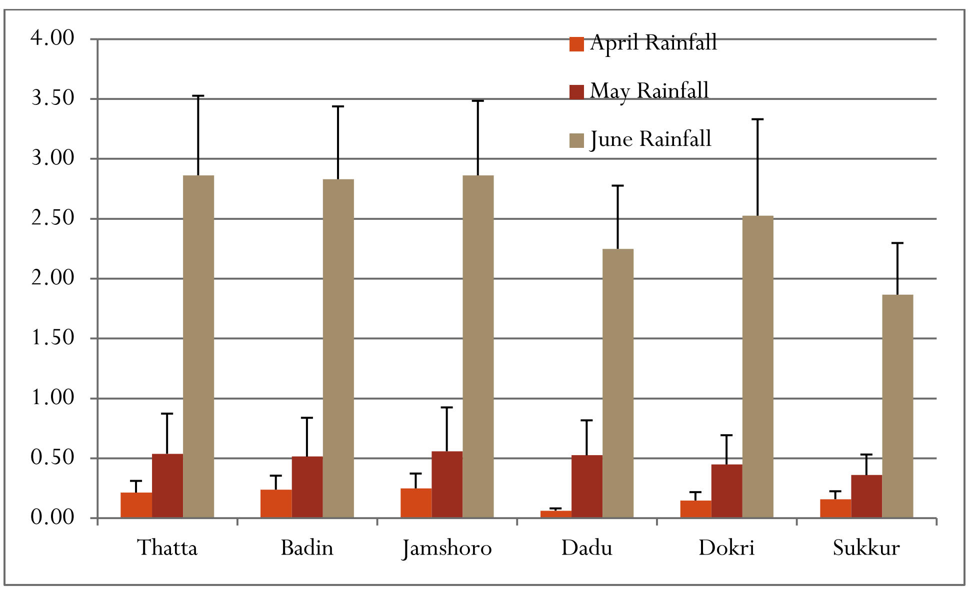
In order to e the fluctuations of the precipitation in the 6 sites, we looked at the data in 3 months period. In the first 3 months of the year (January, February and March) the rainfall was small, however more rain was received in January in Badin and Jamshoro (Figure 11).

Figure 11. First three months rainfall in 6 aquaculture sites at Indus Ecoregion (error bars are standard error).



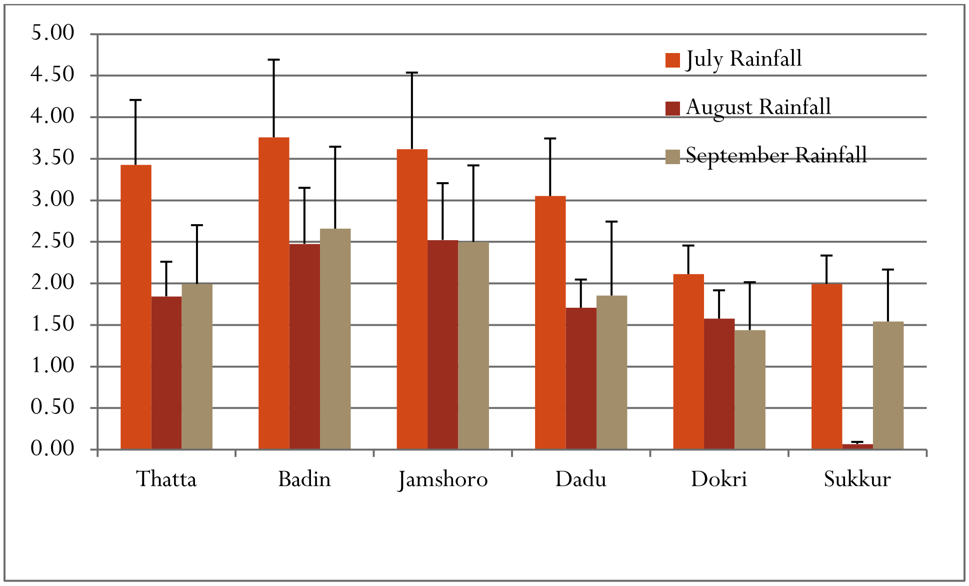
In the second 3 months of the year (April, May and June) the rainfall was greater maximizing in June; a difference between the two areas of high risk and medium risk is evident (Figure 12).

Figure 12. Second three months rainfall in 6 aquaculture sites at Indus Ecoregion (error bars are standard error).



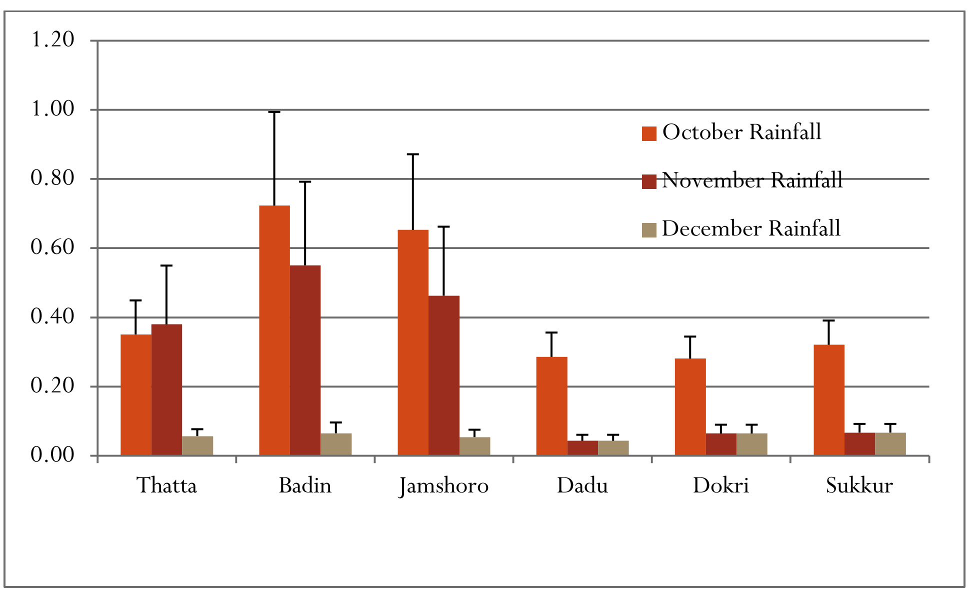
In the third 3 months of the year (October, November and December) the rainfall was small with a maximum in October; a difference between the two areas of high risk and medium risk is evident (Figure 13).

Figure 13. Third three months rainfall in 6 aquaculture sites at Indus Ecoregion (error bars are standard error).



In the last 3 months of the year (October, November and December) the rainfall was small with a maximum in October; a difference between the two areas of high risk and medium risk is evident (Figure 14).

Figure 14. Last three months rainfall in 6 aquaculture sites at Indus Ecoregion (error bars are standard error).



4.2. Results of Analysis of Frequency of Extreme Events with Emphasis on Floods.

The data of precipitation of the last 22 years showed clearly that extreme events are more frequent in recent years compared to past data (Figure 15).

Figure 15. Average rainfall in the last 22 years showing more recent extremes.

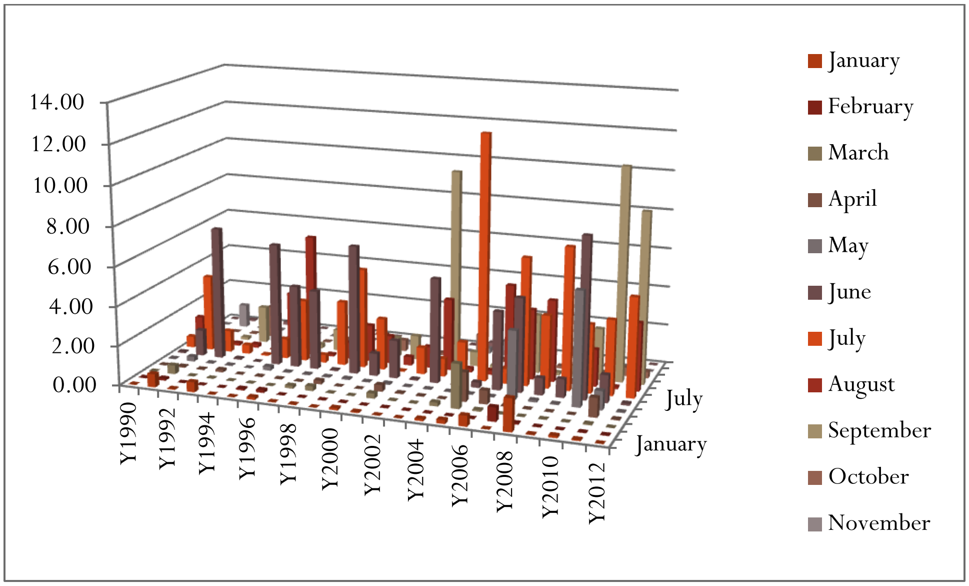
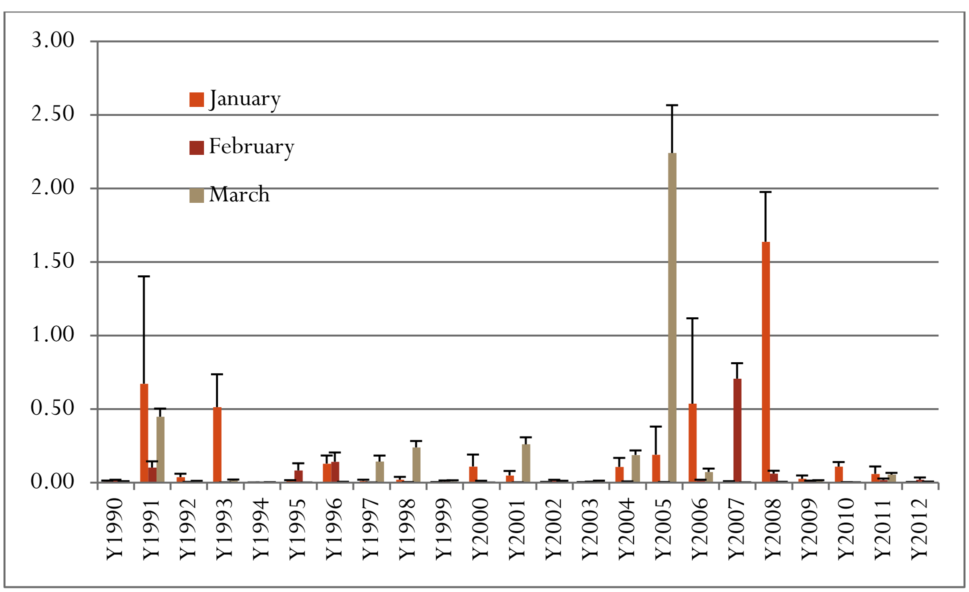


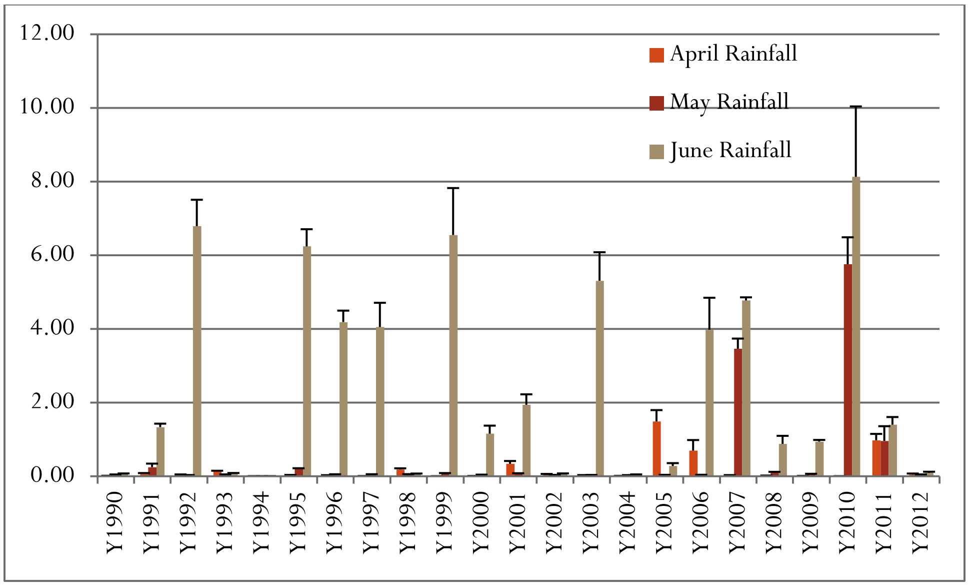
Figure 15 shows that from 2003 on numbers of heavy rains are increased. In order to investigate the extent of climate change in rainfalls from 1990 till 2012 on monthly basis, seasonal figures are presented here. In the first season of the year there is low precipitation, one can see a huge rainfall in March in 2005 (Figure 16).

Figure 16. Average monthly rainfalls of Indus Ecoregion in winter in the last 22 years showing more recent extremes (error bars are standard error).



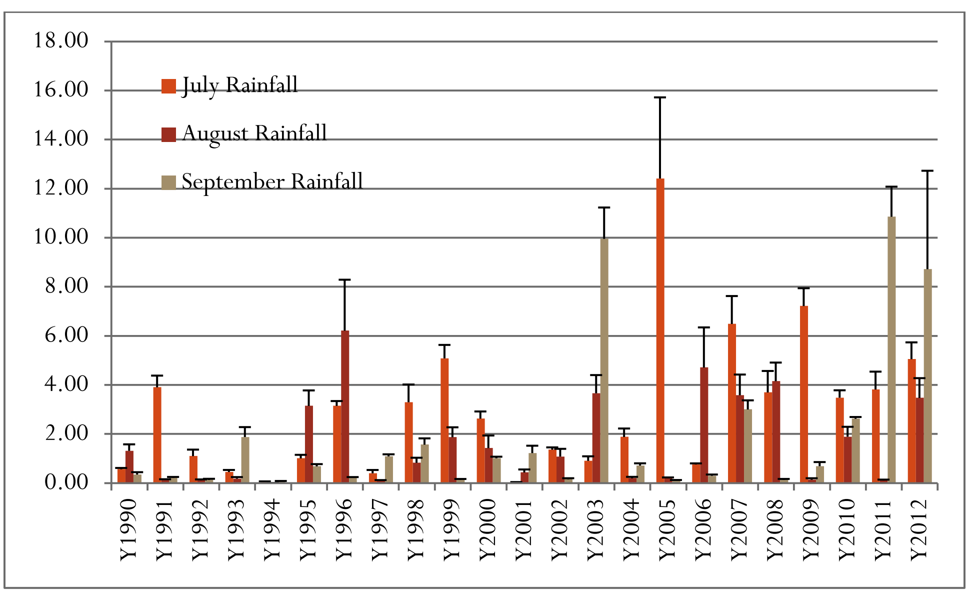
In the second season of the year precipitation fluctuation increased in recent years, also there is an increasing trend in June; one can notice an increase in rainfalls in May (Figure 17).

Figure 17. Average monthly rainfalls of Indus Ecoregion in spring in the last 22 years showing more recent extremes (error bars are standard error).



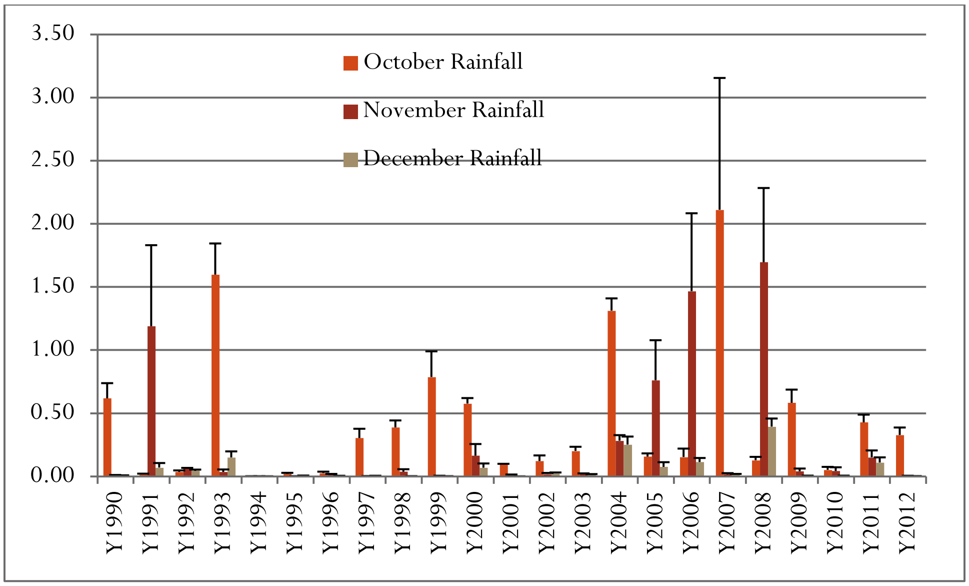
In the third season of the year precipitation fluctuated with recent years' overall increase in July, one can notice an increase in rainfalls of September (Figure 18).

Figure 18. Average monthly rainfalls of Indus Ecoregion in summer in the last 22 years showing more recent extremes (error bars are standard error).



In the last season of the year with precipitation fluctuates in years but there is an overall increase in October rains, one can also notice increase in November rainfall incidents (Figure 19).

Figure 19. Average monthly rainfalls of Indus Ecoregion in autumn in the last 22 years showing more recent extremes (error bars are standard error).



5. Impacts

It is clear that floods are more frequent and a main cause of concern. Floods can initially increase turbidity of water and if it is long lasting, it can cause mortality of some of fish species. Turbidity alters oxygen uptake of fish from water by making a layer of clay covering the gills distancing them from water. Recent flooding rains with peaks at 2010 and 2011 caused damages to fish ponds and caused no of reduced seed production in many fish hatcheries. For example fish fingerling and fry production of Bubak fish was reduced in 2005, 2010 and further reduced in 2011 within its small numbers of hath production, however, it has managed to increase its level of production in 2013. The Dokri fish hatchery had similar trend except that reductions in fish hatchling production were occurred in 2007 and 2011, and there were no increase then on. In Thatta, the Chilya fish hatchery production was not much affected by floods, but due to floods there were a small production reductions and some difficulty in production sales, especially in 2011. In Sukkur there was almost no noticeable impact of floods in fish hatchery productions. Badin hatchery was affected by floods and its production was reduced in 2007 and 2011.

Short periods of flooding for some wild fish species can be useful in having access to more food sources and spawning grounds. Flooding waters can carry pollution and run offs into the lower parts of the river and the estuarine areas, especially delta and finally the sea. Flooding can increase sedimentation rate and may cause some loss of lakes to marsh and reduce the volume of dams and lakes. Figure 20 shows a part of Keenjhar Lake where due to increased sedimentation is more like a shallow marsh rather than a manmade lake established to provide drinking water of Karachi and to produce fish (figure on the front page). This can reduce the life time of dams and damage irrigation systems.

Figure 20. Entry part of Keenjhar Lake was affected by heavy sedimentation (Photo: Author)

Flooding can move fish down the river and to the sea where they could be fed by predators. Strong flood currents can damage fish farms, causing fish mass mortality or causing all of escape of them to Indus River. Escaping genetically engineered fish can be a hazard to natural fish of the river as they can outcompete the naturals in feeding and growth, but may not last after extinction of their native competitors. Floods can destroy fishing nets, damage fishing ports and facilities used in fishing and aquaculture. As a whole flooding can harm aquaculture more than fish capture.

Cyclones, monsoon and tsunami potentially damage fishing vessels, ports and coastal aquaculture farms such as shrimp ponds. They also can cause damages in spawning grounds and shelter habitats of the coastal areas. For example a cyclone can destroy coral reefs on its way towards to shore, or it can out root mangrove trees. It should be noted that cyclones and tsunami eventually makes a stop in fishing activity resulting in lower catch in short run, but can help save fish from overfishing as well. A study in India showed that a cyclone can cause 14 days closing of gill netting. It also indicated that mild storms can cause increase in fishing yield within 14 days (Pati, 1982).

6. Risk Reduction Techniques

Flooding is the first and foremost disaster that is frequent and needs attention. Floods of 2011 were Pakistan's most destructive disaster ever. It caused 2 billion USD of agricultural losses. Fisheries and aquaculture enterprises like other economic and agricultural activities need early warning systems to know in advance and take necessary measures to avoid and minimize damages before it is too late. UNESCO and Japan's International Cooperation Agency are helping Federal Government of Pakistan to set up such early warning systems for flooding of Indus River.

Additionally emergency plans can help in avoiding damages in fish farms and fishing ports. Building canals, dams etc can decrease the access of flood currents to the fishing or aquaculture facilities. Also strengthened structures in the site can reduce damages. One important aspect is choice of place for establishing a fish farm; this should be placed in a location with less likeliness of flood damage. For example choosing form a low-lying and upper land, one should choose the second one that would be less affected when flooded. Or between a place next to the river or a distance away from the river, the second is safer.

Cyclones, tsunami and monsoon also need early warning system that can be equipped with satellite facilities to cover offshore and warn well before these disaster causes reach the coastline. These systems can also predict the path of the cyclone with its speed and possible surge. All these can be used in order to plan for the fisheries and aquaculture facilities safety.

Sea level rise is a phenomenon that can potentially harm all low lying lands of Indus river delta. It is predicted that in the next 50 years sea level in Karachi area would be 5 cm (Quraishee, 1988).

7. Conclusion

In addition to early warning, appropriate planning, best practice in fisheries and aquaculture, preparedness, one needs to have well educated staff in its assistance in the time of disaster happenings. Capacity building is necessary for training the well needed staff. It is very important to be organized for the time of emergency. This should be planned in advance and procedures be worked out and practiced with responsible people.

In Indus Ecoregion there is a high risk area at low lying lands, it is recommended that aquaculture development in this area be done with effective protection facilities such as sea wall. Also low cost structures can help in rebuilding then it a flood occurs. An early warning can help in saving lives and probably harvesting (if harvestable and there is available time), however facilities cannot be protected. Aquaculture facilities can also be made of more resistible materials, such as cement. An emergency plan for such farms can help in minimizing damages.

In high and elevated lands, there is medium risk and more expensive and sophisticated farms should be built there, to avoid severe financial loss due to storms and floods. Supporting drainage channels can help in saving facilities from expected floods.

References

Awan S. A., 2004. Pakistan Report, on Disaster Risk Reduction, Flood Forecasting Division, Pakistan Meteorology, Lahore, Pakistan.

Badjec M. C., Perry A., Renn S., Brown D., and Poulain F., 2013. The Vulerability of Fishing Dependent Economies to Disasters. FAO Fisheries and Aquaculture Circulars. No. 1081, Rome, Italy.

Fatah S., 2010. Indus for All Programme Progress Report, July 2009-June 2010, Communities Speak. Indus for All Programme, WWF-Pakistan.

Food and Agriculture Organization of the United Nations (FAO), 2014. FAO Fisheries Statistics and Information, Fisheries and Aquaculture Department. www.fao.org., Rome, Italy.

Ministry of Food, Agriculture and Livestock, Government of Pakistan Islamabad, 2007. National Policy and Strategy for Fisheries and Aquaculture Development in Pakistan, Part 1. Federal Government of Pakistan, Islamabad, Pakistan.

Pati S., 1982. Journal du Conseil, 1982, 40 (1), 62-66; doi: 10.1093/icesims/40.1.62.

Quraishee G. S., 1988. Global Warming and Rise in Sea Level in the South Asian Seas Region, in the Implication of Climate Changes and the Impact of Rise in Sea Level in the South Asian Seas Region, pp: 1-22.

Sarafraz S., 2009. Tropical Cyclone Development and their Impacts. A paper presented at "ISESCO and PNCU Regional Training Course on Sustainable Fisheries and Protection of Marine Environment, Karachi, Pakistan, 21-24 December, 2009.