SEA LEVEL RISE: A PRELIMINARY EVALUATION OF SINDH COAST

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Abstract

Coastal areas are zones of economic significance, where socio-economic activities are highly concentrated. Sea level rise is a statistical distribution of ocean level variation across the globe. A significant sea level rise of 1 mm along coastal Sindh observed over hundreds of years has resulted in sea water intrusion inland. Intruding sea water has a strong impact on the coastal communities. Recurrence of Cyclones both in increased frequency and intensity in the Arabian Sea over the past 50 years due to climate change has economic repercussions in urban communities like Karachi, Badin and Thatta. Economic importance of Sindh coastal region is evident and the cost of negligence with respect to this phenomenon will be huge. Results of climate changes are already costing around $14bn/year which is 5% of Pakistan's GDP. Continued losses due to sea level rise will have a further negative impact on the fragile coastal economy. Karachi and the Indus Deltaic coastal areas are vulnerable to the threat of sea level rise. Thus, this paper aims to evaluate the trade-off between business as usual scenario, mitigation and adaptation options. Once damage to coastal recourses and structure has been done, then this will lead to capital loss.

Keywords: *Sea level rise; Climate change; Economic; Mitigation options*

Introduction

Pakistan is vulnerable to impacts of climate changes both environmentally and economically. The coastal areas have seen the problem of sea level rise whereas rural area has witnessed deforestation, biodiversity, crop failure, land degradation, and desertification (Khan, 2001). This imposes direct threat to our food security as our agricultural sector is vulnerable to changes in weather conditions, this also directly impact the economy of country. Pakistan

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is basically an agriculture based economy which contributes around 21.4 % to GDP (Pakistan Economic Survey, 2013) and weather conditions are directly linked to the crops quality. Another threat is our water security, with glacial retreat in Himalayan and Karakorum and rain variability, the fresh water availability in Indus river basin is greatly affected. Pakistan is a developing country and its Green House Gas (GHG) emissions are bound to increase with the growth and developmental needs. Despite being the low GHG emitter at the moment, with total emission of around 0.8% (Pakistan Economic survey, 2010), there are several hazardous situations (refer: table 1) that have occurred in the recent past which show the criticality of scenarios.

Pakistan is facing six major risks related to climate change including rise in sea level, glacial retreats, irregular rainfall, floods, higher average temperature and higher frequency of droughts (Carius, Maas & Fritzsche, 2009). During the last century average rise in Pakistan temperature was by 0.6 °C and it is expected to rise by 3.9°C to 4.4°C by 2080, (IPCC, 2007a)(IPCC, 2007b)which will contribute to more variability of monsoon rain and extreme events like floods and droughts. All these natural calamities are interlinked with each other and will have subsequent effect of Pakistan coastal zone. This paper aims to evaluate the risk associated with sea level rise to Sindh coast and its possible implication if no strategic measures taken.

Table 1: Brief Summary of Recent Events as a Result of Climate Change in Last Five Decade in Pakistan.

S. No	Year	Nature of disaster	Location	Impact
1	1950	Floods	Sindh/Punjab	2900 died and 900000 Displaced
2	1964	Cyclone	Indus Valley	450 died & 400000 affected
3	1965	Cyclone	Coastal Area	10000 people died
4	1974	Earthquake	Swat District	5300 people died & 97000 affected
5	1976	Floods	Sindh/ Punjab	5,566,000 affected
6	1977	Floods	Sindh/ Punjab	1000 people died & 1,022,000 affected
7	1978	Floods	Sindh/ Punjab	2,246,000 affected
8	1988	Floods	Sindh/ Punjab	1,000,000 affected
9	1991	Extreme Temperature	Nation wide	961 people died
10	1992	Flood	Sindh/Punjab	1000 people died & 13000 displaced
11	1993	Cyclone	Sindh Coast	609 people died & 200000 displaced
12	1995-1996	Flood	Sindh/ Punjab	Affected 1255000 people
13	1998-2002	Drought	Nation wide	
14	1998	Cyclone	Karachi Coast	12 people died
15	1999	Cyclone 2A	Coastal Area	6400 people died
16	2005	Earthquake	Muzaffarabad	78000 people died & affected 2.5 million
17	2007	Cyclone Yemyin	Coastal Area	703 people died & affected 2 million
18	2009	Flood/Cyclone Phyan	Karachi	Disruption of civic life in the city
19	2010	Flood/Cyclone Phet	Nation Wide	2000 people died & 20 million
20	2013	Flood	Sindh / Punjab	83 people died & 95 injured

Source: EM-DAT: The OFD/CRED International disaster database

Pakistan Coastal Region and Sea Level Rise

Pakistan is strategically located in South Asia. Pakistan coastline extend upto990 km, Sindh coast is a passive margin (Choudary, Mehmood, Rasul & Afzaal, 2009) and it is around 25% of total coastline, it receives the tail end of southwest monsoon and has a shallower profile with combination of sandy beaches, mangrove forest, rocky cliffs and mud flats, and whereas remaining 75% of coastline is in Baluchistan (i.e. the Makran Coast of about 742 km.) (Choudary et al, 2009).The coastline of Pakistan is highly productive from biological, social and economical aspects.

Pakistan coastline is of significant importance both in terms of biodiversity and economic development. And due to seasonal streams and active deltas it is a highly productive fishing area. Also the mangrove forests around the coastline provide breeding ground for variety of fish, shrimps and other invertebrates. Pakistan coastline is also at a risk of tsunamis. The major threat to Pakistan coastline due to climate change is Sea level rise (Sivakumar& Stefanski, n.d.). The increasing global temperature have resulted the progressive melting of glaciers across the globe which results in global increase in sea level.

In the coastal area of Asia, the sea level rise is accounted for between1 and 3 mm/year which is marginally more than the worldwide range. The rate of sea level rise of 3.1 mm/year has been seen over the previous decade contrasted with 1.7–2.4 mm/year (Baur, Kuhu and Featherstone, 2013) over the twentieth century which proposes that the rate of ocean level ascent has quickened in respect to the average.

For tropical cyclones, there is an anticipated increment of 10–20% in the power of storms with an increase in ocean surface temperature of 2–4°C in respect to the flow temperatures in Asia (Sivakumar and Stefanski, n.d.). An increment in statures of storm-surges could come because of the event of stronger winds, increments in ocean surface temperatures and with tropical cyclones bringing about an upgraded danger of seaside catastrophes along the coastal districts of the

countries of Asia (Dasgupta, Laplante, Murray & Wheeler, 2009). According to GISS (Goddard Institute of Space Studies) the rise in global average surface temperature from 1906 to 2005 is 0.6 to 0.9 °C, the in last fifty years rate seems to be doubled then before Karachi, one of the most populous cities of Pakistan located on the coast; impacts of sea level rise might trigger a calamity of gigantic extent. The city planners have ignored the knowledge of evading passing violent wind and sea water intrusion in low lying coastal areas in recent past. Other thickly populated seaside areas and towns, like Jiwani (Baluchistan), Gawader (Baluchistan), Pasni (Baluchistan), Omara (Baluchistan), Sonmiani (Baluchistan), Badin (Sindh) and Thatta (Sindh) are in the same position of ignorance if any calamity strikes the coast.

A) Factors Driving Sea Level Rise:

There are number of causes that influence the sea level rise that can have an impact on coastal resources; these include:

***1) Thermal Expansion*:**

Thermal expansion phenomena occur as sea water become warmer, the top layers of ocean are in contact with atmosphere thus release some of its heat to the atmosphere but the layers below retain this heat with them for larger time and in larger quantity thus leads to the temperature rise in sea water on longer run (Brown, Nicholls, Vafeidis, Hinkel & Watkiss, 2011). According to IPCC the contribution to sea level rise due to thermal expansion is around 1.6mm/yr since 1993 to 2003.

2) Fresh Water Inputs:

Due to the increase in global warming a significant retreat has been seen in glacier layer, ice sheets and sea ice, this increase the fresh water input in sea, second factor that increase the fresh water input is the result of hydrogen cycle due to rising temperature of oceans and surface. According to IPCC the contribution to sea level rise due to

glacier retreat is around 1.19mm/yr since 1993 to 2003 and if the present rate of glacier retreat continues then by 2035 most of the glacier will disappear.

3) Physical Forces:

The tectonic activities like extraction for oil, gas and water create the scenario of subsidence and lifting which in actual do not change the volume of ocean but effect the sea level (Church & White, 2009).

4) Monsoon Variability:

Climate change has a direct link with Monsoon rainfall variability; Pakistan has witnessed frequently excessive monsoon rainfall and flooding. The change in precipitation pattern has increased the intensity of rainfall thus this increase the water flow in lakes, rivers and oceans (Loo, 2014).

5) Ocean Current Variation:

The regional ocean current which moves the large amount of water from one location to another location do not change the volume but definitely affect the sea level at different location(Brown et al., 2011).Like in normal conditions the trade wind drives the warm surface sea water towards the west moving all the way across the Pacific Ocean.

Economic Importance of Pakistan Coastline:

Karachi is considered as the budgetary capital of Pakistan; it represents the greater part of Pakistan's income era. It creates 53.38% of the aggregate accumulations of the Federal Board of Revenue, out of which 53.33% are custom duties and taxes on imports. Karachi creates around 30 percent of worth and 20% of the GDP of Pakistan (Majeed, Zaman, Ali & Ahmed, 2010). In February 2007, the World Bank distinguished Karachi as the most business-accommodating city in Pakistan but rapid urbanization and feeble planning of land use and

inadequate infrastructure has also increased the risk (Dasgupta et al., 2009).

Thatta and Badin coastal area is affected by sea water intrusion, 1.3 million acres of land in two regions has intruded on an average 80 acres of land a day (Rao & Maqbool, 2014). Six sub divisions of Thatta; Ghora Baari, Kharo Chaan, Keti Bunder, Shah Bunder and Jati are the most noticeably affected in Sindh. These regions were verifiably prosperous because of far reaching agribusiness and trade, now these territories are considered as one of the poorest parts of the country. Over 2 million individuals of the two districts have been paying the cost of ineffective decision making process by the policy makers (Rao & Maqbool, 2014).Some main economic activities along the coastline are discussed.

A) Industries:

Karachi is the industrial hub of Pakistan around 70% of industries is located in Karachi. Total number of small and big industries is around 6000 units (Pakistan Economic Survey, 2013). No industrial activity of this massive numbers occurs anywhere else along the coast other than in Karachi. The main industrial manufacturing hubs are SITE, PQA, KITE and HUB. Another industrial activity that operates on the Gadani coast of Lasbella is the Gadani ship breaking industry which provides employment to thousands of people directly and indirectly.

B) Shipping and Trade:

Karachi Port Trust (KPT) and Port Muhammad Bin Qasim (PQA) are the principle sea ports of Pakistan and serves as the major channel for countries imports and exports (Majeed et al., 2010). These two ports handle almost 95% of international trade of Pakistan. Another port is located at Gwader Baluchistan. Plans have been made to turn Gawader deep sea port into a global hub and to provide the outlet for countries like Afghanistan and CIS Countries (Commonwealth of independent states) which do not have any sea port available.

According to Pakistan Economic Survey during the fiscal year of 2012-2013 the cargo handled by Karachi Port and Port Bin Qasim was 38.8 and 24.8 million tones respectively. Pakistan National Shipping Corporation (PNSC) gross profit for fiscal year July-March 2012-13 is accumulated to be around Rs.2558.2million (Pakistan Economic Survey, 2013), this itself implies the significance and importance of this industry in economic terms. Any substantial increase in sea level will impact the port infrastructure and hinder the economic activities.

C) Fisheries

Pakistan coastal fisheries contribute 0.8% to country GDP and 3.7% of coastal agriculture (Khalil, 1999). According to statistics provided by Pakistan Economic Survey during the period 2013-2014 (July to March) Pakistan earned US$ 253.1 million by exporting 103,833 metric tones of fish (Pakistan Economic Survey, 2013).Fisheries provide direct employment to 300,000people approximately and indirect employment to 400,000 individuals in fish related industries (Pakistan Economic Survey, 2013). Badin is also very important when it comes to fisheries, around 10% of all fish exports are instigated by Badin. The fish harbors in Gawader and Pasni are also the main contributor to fish industry; in fact Gawader harbor is the source of almost 70% of employment in the district (Mangroves for future, 2010).There is a possibility to significantly change fish nurture environments and fish nourishment supply and subsequently the richness of fish populaces in Pakistan Coast because of the reaction to future environmental change to the accompanying variables: sea momentums; ocean level; ocean water temperature; salinity and surface winds and intensity, upwelling; mixing of water and dissolved oxygen level (Sivakumar & Stefanski, n.d.).

D) Mangroves:

Dense mangroves plantation are available in Korangi, Phitti, Wadi, Khudi, Khai, Patiani, Dabho and the 17 major creeks of the Indus delta(Amjad & Moinuddin, 2011). The biological community gives a

rich territory to natural life of physical and marine source. About 200 types of fish and crustacean etc have been accounted from the Deltaic region. Mangroves protect against the environmental change. Till late seventies the mangroves spread was approximately 260000hectares, which decrease to 160000 hectares in the nineties and after that the figures has dwindle down to around 80000 hectares in 2001(Majeed et al., 2010).

E) Sociological Impact:

Sea level rise won't just lose valuable agriculture land but will additionally displace local inhabitant living there. And the expense connected with resettlement could be significant. Karachi alone is a densely populated city with twenty million habitants. According to 1998 census population of Thatta and Badin district has around 1.113 million and 1.136 million respectively (Majeed et al., 2010).

Another domestic economic issue will be flooding; if Karachi seizes its economic activities for one day, it will cost 6 billion rupees per day to our GDP. Higher seawater levels would likewise build the danger of flooding because of rainstorms and by diminishing coastal drainage. An ascent in ocean level would raise the water level and coastal drainage (Majeed et al., 2010). All these accumulated impacts could have conceivably damaging, especially for infrastructure in low lying deltaic regions.

Way Forward

Increasing ocean level is no more fiction but a challenging reality for policy makers. Pakistan financing requirements for mitigation and adaptation are evaluated to be between US$14-31 billion (Brown et al., 2011). The worldwide group has so far consented to assemble the US$10 billion every year for three years 2010-12 for brisk begin financing, yet the countries like Pakistan needs to mitigate the effect of environmental change then they need to depend on local resources to respectable degree.

There can be possible ways of dealing the phenomena of sea level rise, which mainly are either, leave the business as usual or take some mitigating steps of wrong doings of past or adaptation for future benefits:

A) Do Nothing Scenario:

As discussed earlier if scenario is considered that Pakistan continues its business as usual and do nothing in reference of sea level rise or climate change then in that case the cost of doing nothing should not be ignored that will further degrade the Pakistan's situation. It is estimated that the Pakistan has to bear as a result of climate change an additional economic cost on an yearly average bases, which is estimated to increase to an average of US$ 2750 million in 2030 as compared to US$500 million in 2010.Additional human lives affected will be 1250 in 2030 as compare to 100 in 2010 and the lost land will be 250 km^3 in 2030 then 100km^3 in 2010 (DARA, 2012).

Karachi being the mega city near coast, the coastal area is close to astronomical high tide mark (i.e. 4meters above Mean Sea Level), as per predictions if we do not take any measures we will bring major sea water intrusion on our coast resulting from the sea level rise. Also massive displacement of people will be witnessed by 2050 due to the combine effect of flat topography of Sindh coast and rise of sea level. According to Pakistan weather portal there have been 50 cyclones in Arabian Sea since 1885 till 2010 and the storm surge from a cyclone 50 kilometers away from the coast could create an abnormal behavior in the sea level. So if Pakistan will not focus on improving the coastal situation, the socio economic conditions may get worse. If pattern of occurrence of cyclone is analyzed on Pakistan coastline, it can be predicted that the occurrence of cyclone will be doubled by 2040 (refer: table 2). Sea water salinity of Karachi coast has already reached 35 PSU, which can further increase (Majeed et al., 2010).

Table 2: List of Cyclone on Pakistan Coastline

S. No	Period (years)	Cyclone occurred/ predicted
1.	1950-1980	2
2.	1981-2010	6
3.	2011-2040	12

Source: Pakistan Weather Portal

Furthermore, if Pakistan follows the "do nothing" scenario than the current situation of sea water intrusion and mangroves will further deteriorate. (Refer: Table 3)

Table 3: Mangrove and Sea Water Intrusion Prediction

Parameter	2001	2050 years
Sea Water intrusion	1300000 Acres	2760000 Acres
Mangroves	8000 Hectares	Nil

B) Mitigation:

Sea level rise on Pakistan shore may cause catastrophic disasters that have not been experienced before. Changes in the coastal communities' lifestyle, environment, social structure and infrastructure may change. Furthermore the economic cost increases over time because the cost of restoration and standard of living would escalate. Sea level rise does not perceive national and international boundaries. Coastal zones provide tangible and intangible benefits and services such as fish, desalinated water, coastal biodiversity, sediments, fish and shrimp nursery and breeding ground etc (Malik Et al., 2012). Therefore all coastal stakeholders should join and collaborate to address their issues resulting from sea level rise. Pakistan already has recognized the issues of mitigation. The National Disaster Management Authority (NDMA) has formulated plans in to natural calamities like tsunami, drought, sediment disaster, avalanches, cyclone with storm surge, etc. (Mangroves for future,

2010)

Furthermore as it is already practiced by Bangladesh and Vietnam the land that has been intruded by seawater can be used and transformed into fish and shrimps farming to support aquaculture production the same practice can be done in Pakistan so that the economic loss incurred due to water intrusion can be compensated(Government of Pakistan, 2011).At community level salinity tolerant rice can be cultivated in the areas were sea water intrusion has been observed along the Sindh coast (Iqbal & Sultana, 2009). Fish and shrimps cultivations can be used in order to make some profit.

It will take many years even if mitigation measures to control greenhouse gasses by cut of 50 % emissions are strictly followed by developed countries. Pakistan must be prepared to follow an adaptative strategy.

C) Adaptation:

Long term adjustments are major structural progressions to overcome difficulty, for example, changes in area utilization near coastal area that is; by setting a setback limit of 200m away from water high tide mark in the land ward direction so that we have a buffer land available due to seawater erosion and intrusion. Develop new varieties of food crop that can with stand extreme climate events such as droughts, increased temperatures, and precipitation and crop diseases.

Mangroves are known not only to protect the coast line from erosion by stabilizing the sediments through its prop root system but also dissipate the storms energy thus reduce vulnerability to floods (Government of Pakistan, 2011). Mangroves have an important role as a carbon sink.

The coastal Infrastructure is vulnerable particularly to cyclones and flooding and other calamities. There is currently a developing appreciation in Pakistan that maintainable coastal administration must be acknowledged through the selection of an 'Integrated Coastal

Management (ICM)' process (Government of Pakistan, 2011). Many attempts has been made to develop sustainable policy to reduce the risk related to climate change but it has been observed that as soon as the external assistance is withdrawn all efforts goes back to the starting line. Best way to is to increase coordination and capacity building among local agencies who are currently working in this area.

Planning commission of Pakistan has set up the Task force on climate change (TFCC) in 2008 to cope with the issues rising in the result of climate change (Government of Pakistan, 2010). Lesson gained from past catastrophes can significantly contribute to countermeasure against future cataclysms. Coastal communities are always on the verge of natural calamities, therefore early warning system should be developed and integrated, this practice is successfully implemented in Bangladesh were around 50,000 volunteer are playing a crucial role of disseminating the information regarding predicted hazards and helping people to move towards safe shelters.

Conclusion

Pakistan's coastal areas are vulnerable to climate change and sea level rise. Coastal areas are perceived as zones of high productivity, where socio economic conditions are highly concentrated. For most nations, the significant atmosphere expenses are those of effect. These expenses emerge from activity of inaction for both mitigation and adaptation. Same is the situation form Pakistan.

The high level of unpredictability in the coastal zone has prompted an attention to setup an Integrated Coastal Management (ICM) as for taking into account the different components of the socio economic sectors of development. Pakistan has several ministries and bodies that are involved in coastal zone management. It is suggested that all public and private organizations dealing with climate change and sea level calamities come under a unified umbrella and the budget allocations if combined along with coastal communities' involvement

the result can be much more and long lasting.

Pakistan at this moment needs an Integrated Coastal Management System with holistic approach with experts and local coastal communities to address all the areas from government policies, awareness and participation in implementation. Creating the buffer zone or no build zone will help to reduce the coastal communities' vulnerability. Plantation of Coastal forest and mangroves will restore the environment of coast and improve the situation in terms of erosion and sediments. If steps in this direction will not be taken now the consequences will be sever and economically damaging, be it in the form of encroachment of sea water in coastal area causing damage to coastal eco system, ports , power plants, residential and commercial property etc. or the increase in tectonic uplift rate.

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