THE IMPACT OF SEA LEVEL RISE ON PAKISTAN'S COASTAL ZONES– IN A CLIMATE CHANGE SCENARIO

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THE IMPACT OF SEA LEVEL RISE ON PAKISTAN'S COASTAL ZONES– IN A CLIMATE CHANGE SCENARIO

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ABSTRACT

Pakistan has over 10% of its population living in the vicinity of the coastal zone, over 20 % of coastal area of Pakistan is relatively developed, 40% of industry is situated on or near the coast. Protecting these human assets will be costly, particularly if the effects of climate change are sudden rather than gradual. A rise sea level of a few mm per year, although not threatening but direct and indirect impact of this rise would have a profound impact on the coastal resources for sustainable coastal zone management. Direct land loss of low-lying areas can rapidly damage or destroy coastal ecosystems. In addition to sea level change a rise in global warming will also increase the frequency of tropical cyclones and will further add to the miseries of the coastal states. Pakistan's coastline with the Arabian Sea stretches to over 990 km. It comprises two distinct units in physiographic outline and geological characteristics. The coastal and offshore geology of Pakistan tectonically exhibits both active and passive margin features. The impacts of the hazards resulting from progressive climate change are apparent all along the coast. The adverse effect of sea level rise on the Pakistan coast is expected to be pronounced in the Indus Delta. Topographically it is a tidal flat zone. A sea level rise of about 2 metres is expected to submerge or sea encroach an area of about 7,500 sq km in the Indus Delta. The low-lying areas along the Baluchistan coast may also exert a significant effect. The mean sea level (MSL) along the coast at Pasni is about 1.4 m from the chart datum. The MSL is slowly but gradually rising at a rate of about 1.1 mm/year. Although a small sea level rise may be compensated by tectonic uplift rate of the Makran coastline estimated at 1-2 mm/year at Ormara.

INTRODUCTION

Global warming resulting from rising atmospheric CO_2 has been cited to retain heat through the earth's atmospheric, oceanic, and terrestrial systems. As a result ocean water would expand and many glaciers on mountains would melt. This process would lead to higher sea levels. Sea level rise (SLR) threatens important environmental and economic assets in the coastal zone. Rising seas will increase the salinity of estuaries, coastal wetlands and aquifers, disrupting marine life and possibly threatening surface/sub-surface drinking water supplies. Sea level rise also threaten to inundate low-lying land and would intensifies coastal erosion process. Globally, a rise in sea level of up to one meter over the next hundred years could severely damage human settlements, agriculture, freshwater supply, fisheries, health and coastal ecosystems. Some of the least developed nations bordering the Indian Ocean are threatened by sea level rise due to a possible impact of climate change.

It is clear that developing countries with large populations in or near deltas and other low-lying areas are especially vulnerable to future sea level rise. One billion people and a third of the world's crop growing areas, will be affected that will endanger the food supply of 200 million people and it could create 50 million environmental refugees. UNEP (United Nations Environmental Programme) through its OCA/PAC regional seas programme (1989) has grouped Pakistan in the countries, which are most vulnerable to the impacts of a rising sea level. Pakistan has over 10% of its population living in the vicinity of the coastal zone, over 20 % of coastal area of Pakistan is relatively developed, 40% of industry is situated on or near the coast. Protecting these human assets will be costly, particularly if the effects of climate change are sudden rather than gradual. A rise sea level of a few mm per year, although not threatening but direct and indirect impact of this rise would have a profound impact on the coastal resources for sustainable coastal zone management. Direct land loss of low-lying areas can rapidly damage or destroy coastal ecosystems. In addition to sea level change a rise in global warming will also increase the frequency of tropical cyclones and will further add to the miseries of the coastal states.

The predictions of the International Panel of Climate Change (IPCC, 1995) predictions suggest that global temperature may increase from 1°C to 3.5°C by 2100. Global average sea level rose at an average rate of 1.8 [1.3 to 2.3]mm per year over 1961 to 2003 and at an average rate of about 3.1 [2.4 to 3.8]mm per year from 1993 to 2003. Whether this faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer term trend is unclear. Since 1993 thermal expansion of the oceans has contributed about 57% of the sum of the estimated individual contributions to the sea level rise, with decreases in glaciers and ice caps contributing about 28% and losses from the polar ice sheets contributing the remainder. From 1993 to 2003 the sum of these climate contributions is consistent within uncertainties with the total sea level rise that is directly observed. According to the IPCC this is likely to be a reflection of the rise in global temperature that has taken place over the same time period. Sea level will rise as melt water from land ice runs into the ocean and as the ocean waters expand. Even if climate change could be halted, the surface warming already incurred will progressively penetrate deeper into the ocean, causing sea level to rise still further. Climatic modeling studies worldwide show that sea level will continue to rise after the 2080s, even if further climate change is halted.

Global sea level is already rising. Over the last 100 years it has risen by 10 cm and 25 cm. Even if greenhouse gas emissions are stabilized immediately this rise will continue because there is a lag time between emissions of greenhouse gases into the atmosphere and a response from the oceans. Models project an increase in sea level between 13cm and 95cm between 1995 and 2100. However, regionally and locally, sea level changes may differ from this global average owing to landmass movements and differing oceanic conditions.

The episodic events of natural calamities associated with climate change are flooding, prolong droughts, cyclones and associated storm surges are on the increase. Since most of the climatic anomalies are inter-linked, it is believed that the coastal and marine regions will be affected by worldwide phenomena. Fortunately, the most adverse effects can be avoided if timely actions are taken in anticipation of sea level rise. Although action may be taken to limit the eventual global warming from rising atmospheric CO_2, the warming expected this century and the resulting rise in sea level are not likely to be prevented. Most CO_2 emission are released by burning fossil fuels. Emission of other trace gases (such as CFC's and methane) could add significantly to the projected global warming. Even if emission are curtailed today, global temperature and sea level will continue to rise for a few decades till the World's oceans and ice cover come into equilibrium.

SEA LEVEL RISE ON THE COAST OF PAKISTAN

The existing information and data on SLR in the archives of the National Institute of Oceanography, Karachi, concurs with the world average rate of increase in sea level. The rate of sea level rise in Pakistan coastal region has been tabulated to approximate 1.1 mm per year. The effects of changes in regional climate have been seriously felt since the past two decades.

Currently scientific sea level information and data in Pakistan is insufficient to reconstruct any quantitative change. It would be pertinent to use eustatic sea level increase of 2 mm/year and 6 mm/year in order to predict possible scenarios for the Pakistan coast for the next 50 and 100 years. These are used as best estimates for sea level rise assuming "business as usual" worldwide emissions. The available Sea level data recorded in Karachi for the past 100 years has been tabulated. The correspondence in their increasing trends, may appear trivial but it clearly suggest, that global warming has had a significant effects on the sea level rise since the 1900. At Karachi the rate of 1.1 mm/year in sea level rise has been observed (Figure 1). Three scenarios- including the existing rate of 1.1 mm/year are shown in table 1. More important than the actual rise in sea level is the possible increase in the frequency and severity of storm surges, which combined with sea level rise, could result in devastating floods in the region. This sea level increase will cause stronger wave action, higher tidal amplitude and greater possibility of surge occurrence that will have significant socio-economic effects on the coastal regions. The combined consequential effects of these coastal processes have been observed in many parts of the Balochistan and Sindh coast. The coastal lowlands around the coastal areas are particularly vulnerable to further change in sea level rise and related coastal processes.

Table.1 SEA LEVEL SCENARIOS

Rate of rise	After 50 years	After 100 years
1.1 mm/year	5.5 cm	11 cm
2.0 mm/year	10 cm	20 cm
6.0 mm/year	30 cm	60 cm

Prior to assessing the impacts of projected rise in sea level and the associated climate change, it is essential to understand the general characteristics of Pakistan's marine and coastal areas and the active dynamical physical processes.

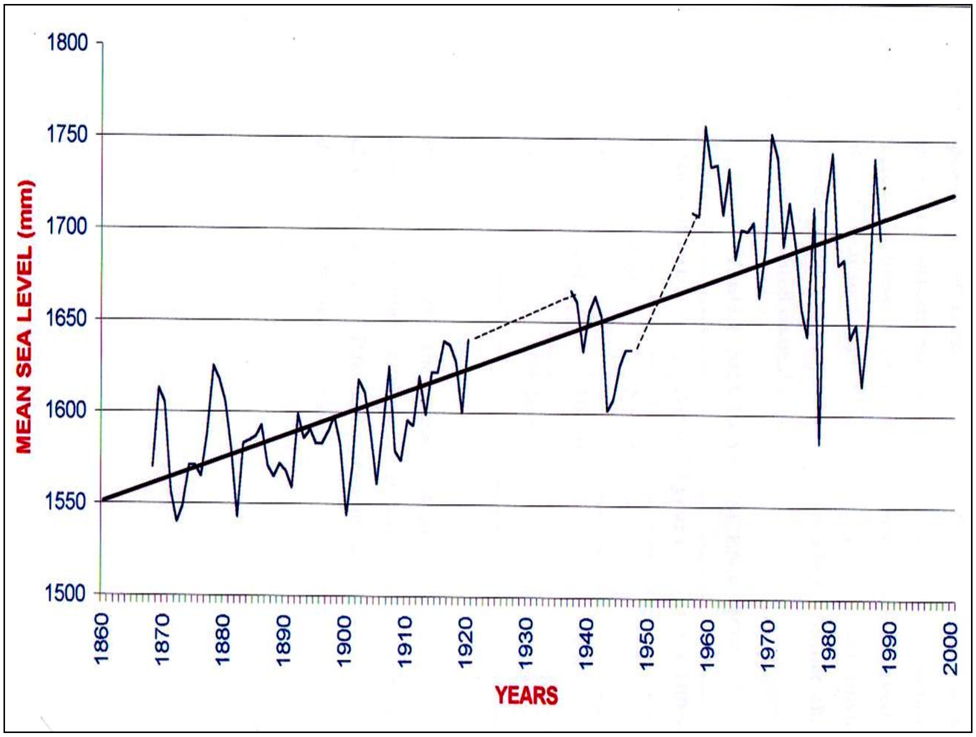

Figure 1: Trend of the Sea level Rise at Karachi. The present 1.1mm/year rate could increase quite rapidly due to land subsidence in the deltaic area as well as due to the predicted trend as given in Table 1.

Pakistan's coastline with the Arabian Sea stretches to over 990 km. It comprises two distinct units in physiographic outline and geological characteristics. The coastal and offshore geology of Pakistan tectonically exhibits both active and passive margin features. The Balochistan coast is active whereas the Sindh coast and Indus deltaic area and offshore Indus basin is geologically passive. The Sindh and Balochistan coasts have differing climatic conditions, geographical location and socio- economic factors.

SINDH COAST

The Sindh coastal region is located between the Indian border along Sir Creek on the east to Hub River on the west (320 km). The Indus River drains into the entire lower plain of Sindh. The Indus delta is the most prominent feature of the Sindh coast. The sediments are subjected to coastal dynamic processes, such as tides, winds, waves and currents, leading to accretion and erosion of the Indus deltaic coast. The coastal morphology is characterized by a network of tidal creeks and a number of small islands with sparse mangrove vegetation, mud banks, swamps and lagoons formed as a result of changes in river courses. The present delta covers an area of about 60,000 hectares and is characterized by 16 major creeks and innumerable minor creeks, mud flats and fringing mangroves. The delta supports wetlands rich in nature and culture, and also nurtures the largest area of arid climate mangroves. This area is very arid; receiving an average annual rainfall about 200 mm. 27% of this land is under water in the form of creeks and water courses. These water courses intervene the island, these are calm and protected water, and are flushed daily by tides ranging upto 3 m.

Karachi Coast

The coast of Karachi is situated between the Cape Monze, a high cliff projecting into the Arabian Sea and the Korangi creek. The coastline of Karachi metropolitan is about 70 km long. It is generally oriented NW-SE. On the western side it is bounded by the Hub river and on the east by the mangrove swamps and creeks of the Port Qasim area. The Layari and Malir river are the seasonal streams which flows during SW monsoon. The rain water from Karachi and its adjoining area drains in the Arabian Sea. The prominent feature of Karachi coast is shallow lagoons, raised beaches, marine terraces and dune fields. Four major inlets, Manora Channel (Karachi harbour), Korangi creek, Phitti creek, and Khuddi creek inveginate the coastline. A small crescent shaped sand bar exists at the mouth of the Korangi creek. The shore terraces and sea cliffs are due west of Hawks bay area. The Cape Monze beach is an example of raised beaches along the coast of Karachi. The eastern coast has tidal creeks with mangrove and mud flats. In the region the seabed is generally smooth.

The Indus Deltaic Coast

The present Indus delta is located at the head of the Arabian Sea, between Korangi Creek and the Runn of Kutch. The Indus drains into the northeastern Arabian Sea forming a large delta. The river discharges nutrient rich sediment load that has a great influence on the marine life of the Indus Delta and the near shore areas. The Indus delta has been found changing its fluvial characteristics due to damming upstream, which has reduced river borne sediments. This has resulted in drying up of the creeks and has induced sea encroachment further inland.

BALOCHISTAN COAST

The Balochistan coast extends from the mouth of the Hub River in the east to the middle of Gwatar Bay in the west and stretches over a distance of about 670 km. The Baluchistan coast has almost entirely desert like condition. The entire coastal area is arid with only 150-mm/year of rainfall. The coast is drained by the small rivers Hingol, Basol, Shadi Khor and Dasht. Despite having large catchment areas, these rivers flow only the during rainy season. Flash floods are frequent and even during scanty rains, there is erosion of top soil from the uncovered hillsides and muddy banks. The eroded material is deposited along the coast at the mouth of the rivers. The Baluchistan coastal region has cliffs, occasionally with rocky headlands**,** and a number of sandy beaches with shifting sand dunes. The region of creeks and coastal lagoon is marshy with scanty mangroves patches.

CYCLONE, STORM SURGES/TIDAL WAVES

In the Arabian Sea the occurrence of cyclones are about equally distributed between pre and post-monsoon as compared to the Bay of Bengal where during post monsoon months the frequency of cyclone is higher than the pre monsoon months. The percentage of storms intensifying into severe storms, is much more over Arabian Sea ~61% than that over the Bay of Bengal ~37%. The tropical cyclones develop preferentially over the southern quadrant of the Arabian Sea and move to the west and to the northwest direction towards Arabia. About one storm in three passes over the western part of the Arabian Sea and strikes the coast of the Arabian peninsula. During the last 110 years 51 Severe Cyclonic Storms have been reported from the Arabian Sea. Favourable periods for the formation of cyclonic storms in the Arabian Sea are May - June and September - December with highest frequency in October which is about 27% of the annual. Usually there are no storms during the winter months of February and March. The average annual number of Cyclonic Storms is about 0.5% which is about 22.1% of the annual number of cyclonic disturbances. The cyclones produce large amounts of rainfall, whereas the rainfall does not have a direct influence on the surge magnitude. Its influence on the Indus river discharge and the coincidence of high water together with sea surge can create critical conditions. The Sindh coast is relatively flat having a low slope it is considered to be a dangerous zone. In this belt, the frequency of storm striking the coast is however low (over a 75 - year period, only four storm have struck the coast between 18^o and 18^o N and only three storms have landed on the coast between 19^o and 20^o N. In the area between Dewarka (India) to Karachi, there is an extensive marshy area which is sparsely populated. The frequency of storm in the region is low and the tracks are not usually favorable for major surge development. However, on rare occasion when they do occur, storm surges of several meters in amplitude could result in the destruction of lifetime achievements of local inhabitants in a matter of hours.

Historical Storms events which affected the coast of Pakistan

The tropical cyclones formed over the Arabian Sea and making landfall at the coastal areas of Pakistan and its vicinity are tabulated during the last 100 years in table- 2.

Table-2: Major cyclonic storms observed in the North Arabian Sea off the coast of Pakistan.

Date/year	Location of Cyclonic Storm
June 14 - 18, 1895	Cyclone made landfall along Balochistan coast between Pasni and Gwadar after weakening into depression.
April 26 – 3 May, 1901	Severe cyclone weakened into a depression before making a landfall near Jiwani.
May 7 - 13, 1902	Severe cyclonic storm weakened into a cyclonic storm and made landfall along Sind coast near Keti Bunder.
June 11 - 16, 1902	Severe cyclonic storm crossed the coast near Karachi.
June 4 - 6, 1907	Severe cyclonic storm crossed the Sindh coast near Karachi.
June 18 - 20 1907	Severe cyclonic storm made landfall south of Karachi.
June 16 - 20, 1926	Cyclone struck Gujrat, recurved again into sea intensified further and hit Sindh southeast of Karachi.
June 5 - 9, 1948	Severe cyclonic storm weakened into a cyclonic storm before crossing the Makran coast near Jiwani.
June 9 - 13, 1964	Cyclonic storm which actually entered the Indian coast did cause an appreciable loss of life and property in Hydrabad and Therparkar districts as it moved north-east wards into southeastern areas of Sindh.
May 1985,	Cyclonic storm which moved towards Karachi, actually weakened over sea while still a few hundred kilometers south of the city. It did however cause concern and panic for Karachites.
November 12 - 15, 1993	Severe cyclonic storm which formed over the Arabian sea started weakening while moving towards

	southeast coast of Sindh and made a landfall on November 15.
June 6 - 9, 1998	Cyclone which formed over the Arabian sea first moved in North westerly direction, intensified into severe cyclonic storm and started moving in Northernly direction recurved and hit the Indian coast of Gujrat near Porbandar and caused widespread damage in India. However some border area of south Sindh received heavy rain and storm wind.
May 17 - 22, 1999	A tropical cyclone (2A) emerged in the Arabian sea some 1300 km away from coastal areas of Pakistan. Initially it was moving towards North westerly and intensified into severe cyclonic storm in the coarse and moved to northerly and recurved to northeasterly and hit the coastal areas of Southeast Sindh on 20th . By the evening of 21st , cyclone lost its intensity and entered the Indian Rajistan area.

Storm Surges/Tidal Wave

Storm surges are oscillation of the water level in a coastal or inland water body in the period of a few hours to a few days resulting from the atmospheric forcing and weather systems. The factors generating storms are the variations in the atmospheric pressure and the winds accompanying the meteorological disturbances which produce normal and tangential stresses along the sea surface and induce the movement of sea water as well as an inclination of the sea surface. The peculiar topography (i.e. triangular or V - shaped basin), of Pakistan coastline and the shallowness of the water body together with a large tidal range, make storm surges more dangerous. While penetrating into rivers, estuaries and deltas, storm surges can interact with river flood and thus cause extra high water levels in the lower river reaches. Storm surges are generated in the areas where low pressure is formed in the atmosphere, which, in first instance, lift the water level locally and are also the source for the formation of strong winds, depending on the air pressure gradients. By transferring the wind energy into the water, the surges are amplified, an effect of which is more pronounced in shallow coastal waters. In the process of movement of storm the surge level is predicted by the wave conditions developed due to the effects of cyclonic forces.

The presence of storm surges can be inferred from the tidal record of the area. The tidal data recorded at Karachi Port was obtained and analysed for the separation of surges from the recorded data. It was observed that maximum surge was never more than 0.79 m. Quraishee (1984) had also analysed 14 years tidal data for Karachi and extracted the surges values given in the table 3.

Table-3: Tidal surge values for Karachi (Source: Quraishee, 1974)

Month	**Height of Tide (Meter)**	**Height of Surge (Meter)**
June 58	2.9	0.4
Jul. 58	2.5	0.4
Oct. 58	2.91	0.42
Nov. 58	2.47	0.24
May 59	3.02	0.55
Jun. 59	2.1	0.49
Jun. 64	2.8	0.46
Jun. 67	2.62	0.52
Jun. 70	2.56	0.61

Quraishee (1984) also reported the highest surge of 0.79 m that has so far been recorded at Karachi due to a storm that crossed the coast 80 km east of Karachi on May 1902. Most of the storms raised the sea level, although the surge heights are not very high but the coastal topography being gentle and flat, even a surge of 0.61 m during spring tide can create flooding.

IMPACTS EVALUATION OF SEA LEVEL RISE ALONG THE COAST OF PAKISTAN

The impacts of the hazards resulting from progressive climate change are apparent all along the coast. The adverse effect of sea level rise on the Pakistan coast is expected to be pronounced in the Indus Delta. Topographically it is a tidal flat zone. A sea level rise of about 2 metres is expected to submerge or sea encroach an area of about 7,500 sq km in the Indus Delta. The low-lying areas along the Baluchistan coast may also exert a significant effect. The mean sea level (MSL) along the coast at Pasni is about 1.4 m from the chart datum. The MSL is slowly but gradually rising at a rate of about 1.1 mm/year. Although a small sea level rise may be compensated by tectonic uplift rate of the Makran coastline estimated at 1-2 mm/year at Ormara.

The possible impact of sea level rise would be on the coastal industry such as power plants, ports & harbours, real estate & housing, tourism, coastal fishing/agriculture etc. Even a modest rise in the sea level will threaten storm barriers and salinate fresh water reservoirs along the coastal belt. The erosional processes (wind and wave) are severe along the Makran coast particularly on coastal cliffs composed of soft rocks. At places the erosion is as fast as 90cm/ year and the shoreline between the promontories of hard rocks may recede at a very high rate. These changes clearly give an idea of the vulnerability of our coast line to the future sea level rise and climate change. The primary and secondary impacts and prediction impacts envisaged for the future as a result of sea level rise are discussed in details.

Coastal Erosion

The coastal erosion over the centuries is a result of natural processes and sea level change. In recent years the rate of erosion appears to have increased at some points along the coast. The islands at the approaches of the creeks have been severely eroded. The creeks which are near the present outfall of the Indus River, at the concave bulge of the delta are facing erosion due to natural hydraulic forces, such as reduction in the supply of sediments by the river, wave reworking in the comparatively recent formed delta together with the arid condition of the delta itself. The high energy wave actions are strong during SW monsoon period. The soil cover in the deltaic area is drift type, made up of material transported by rivers, mostly mudflats and marshy areas and can easily be encroached upon by sea.

Studies undertaken by NIO suggest that intensive wave activities and tidal inundation is the major coastal erosional agent. High tidal levels of over 4.0m occur in the deltaic region which inundate the creek banks and erode the coastal areas. Such high tides were experienced in 1986, 1990, 1993 and 1999 when heavy damages to coastal area were recorded in the Badin area. SW monsoon winds that are in excess of 30 knots add about 0.3m of surge to the tides that further intensifies the erosional processes. Creek region shows recession towards inland. Recession of the HW line have increased the tidal volume of the deltaic creeks that consequently increases the cross-sectional area of the seaward entrance of creeks.

INUNDATION OF COASTAL AREAS

The sea level rise will cause significant flooding impacts in the coastal zone, particularly in the low lying Deltaic regions. Low lying coastal areas would become more vulnerable to flooding for four reasons: (1) A higher sea level provides a higher base for storm surges to build upon, (2) Beach erosion would leave coastal properties highly vulnerable to storm waves (3) Higher water levels would increase flooding due to rainstorms by reducing coastal drainage. A rise in sea level would raise the water table. In the coastal belt of Sindh flooding is an issue of today. Floods along the Sindh coast continue to be a regular event although damage has always been variable. In 1999 a devastating cyclone hit the east coast, inundating coastal lowlands which resulted in over 200 deaths, the evacuation of over twenty thousand people and widespread damage to fishing villages, coastal wetland, coastal agriculture, farmland, live stocks and dairy, tidal link structure (LBOD), protective bunds, utilities, people and their livelihood came under severe stress. This involves relocation of people and having to restart all over again. Frequent flash flooding as a result of torrential rains in Balochistan, particularly Makran division during the Southwest monsoon period causes heavy losses to both human and their property. Hundreds of persons including women and children in villages were swept away and thousands were rendered homeless by flash flood in recent years.

A large part of lower Indus deltaic area would be at risk from frequent flooding by the end of the next century according to these scenarios, even if storms did not become more intense or frequent. Storms would flood much of deltaic region frequently. Although the marshy area Rann of Kutch can adapt to moderate rates of sea level rise, but these areas may be unable to keep up with the accelerated sea rise rates. If the number of coastal storms increased, the impacts of flooding would be exacerbated. The coastal Sindh is prone to storm surges associated with the severe cyclonic storms generated in the adjacent Arabian Sea. A significant number of the cyclonic storms produced in the Arabian Sea move towards North and Northeast and some of them hit Pakistan Coast, resulting in huge losses to life and property in the coastal areas.

Indus Deltaic Creeks are critically located on the path of cyclones of the Arabian Sea. According to statistics, one cyclone is expected in a year in the Arabian Sea. Cyclones have sometimes strong winds over 100 knots with central pressure as low as 986 mb. The winds and low pressure creates storm surges which when combined with high tides, can create destruction in the coastal areas.

Salination of Surface and Ground Water

The impacts of rising sea do not stop at the immediate coast. As sea level rises, there is an increased risk of river banks being overtopped and of flooding of adjacent land further up the estuaries may occur. Saltwater will penetrate further upstream and inland, as was the case in the lower Indus plain. This effect would be particularly evident during the drought conditions that are increasingly likely under climate change.

The sea level rise would enable saltwater to ingress farther inland and upstream in to the rivers, wetlands, and aquifers, which would be harmful to the aquatic flora and fauna, and would threaten human uses of water. Increased salinity has already been cited in most of the coastal areas specially in lower deltaic plain region. The water conditions will become brackish and would causing great economical and health problems in the coastal region. Much of the coastal population gets water from areas that are just upstream which could become salty if sea level rises and the conditions are aggravated. The accessibility of drinking water from ponds for human as well as domestic purposes will diminish. Rising sea level combined with decreased river flow and sediments dispersal would mean a land ward penetration of the salt water wedge within the ground water column. This would severely affect the quality of drinking and agricultural waters in the coastal area.

Mangrove Forests

Mangrove cover in the Pakistan is reported to have decreased, over the years, threatening the survival of the natural resources and thereby the livelihood of a large number of fisherman. Indiscriminate exploitation and deterioration of the coastal resources due to changes in the environmental conditions such as hypersalinity, decreased alluvial flow, pollution, soil erosion and dredging and possible impact of sea level rise and climate change etc. The average consumption of mangrove wood by local communities per head is estimated to be 7 Kg per day, with the estimated total consumption per year in the order of 20,000 tons. Eight mangrove species are reported along the coast of Pakistan, *Avicennia marina* is the most dominant species. While *Ceriops tagal* occurs in localised patches and there are a few plants of *Rhizophora mucronata*. Other species have been reported to be rare or have disappeared from the delta due to human activities coupled with adverse physical and environmental conditions. Silt and clay deposits elevate land and the mangrove plants have limited access to tidal water, the plant growth thus becomes retarded and the mangrove forest deteriorates. The mangrove forest of the Indus Delta are under stress due to changing levels of water and sediment discharge from the Indus and the increasing influence of marine hydrological processes.

CONCLUSION:

The observations and available data of dynamic coastal processes along Pakistan coast clearly indicate that the sea level is rising quite rapidly. This will lead to high investment costs in protective measures. Low-lying deltaic coast of Indus is especially vulnerable to a rising sea level, and to other events such as increased in frequency and intensity of storms, increase in precipitation followed by long spells of drought. Inundation, flooding, erosion and intrusion of seawater are among the likely impacts. Such impacts would affect productivity and seriously compromise economic well being.

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