ASSESSMENT OF SALINITY INTRUSION IN THE CENTRAL COASTAL ZONE OF BANGLADESH

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ABSTRACT

The coastal zone of Bangladesh covers about one-third of country's total land area. The coast can be broadly divided into three regions: the deltaic eastern region, the deltaic central region, and the stable deltaic western region. This study aims to assess the salinity intrusion along the central part of the coastal zone – covering Baleshwar River at the west and Karnafuli River at east. One of the most acute problems of our coastal zone is the salinity intrusion and its rapid increasing extent. Extent of saline intruded area is dependent on the sea level and discharge of fresh water through major river systems. Due to the construction of water controlling structures (like dams, barrages etc.) the supply of fresh water is decreasing day by day. Rising of sea level is aggravating the problem. In this study the vulnerability assessment due to saline intrusion in the surface water, groundwater and soil of central coastal zone of Bangladesh during the year 2000 to 2012 has been done. Based on the trend analysis of historical data, salinities have been simulated for the year 2030 and 2050. Moreover, salinity vulnerability maps for the year 2030 and 2050 using 2000 as base year have been prepared using CVI analysis.

INTRODUCTION

The coastal Zone of Bangladesh consists of 147 Upazilas under 19 districts. It covers an area of 47,201 sq. km (Islam, 2004). This area provides shelter, sustenance and livelihood for approximately 46 million people, with 2.85 million hectares of cultivable land supporting 20% of the rice production of Bangladesh (BBS, 2011).In addition to the resources provided by the coastal zone of Bangladesh, the region is also critical because it contains the world's largest mangrove forest, the Sundarbans, which have been set aside for conservation.

One of the major challenges of our coastal zone is the salinity intrusion. Water circulation in the coastal zone in Bangladesh is largely dependent on the factors like fresh water flow from the river, penetration of tide from the Bay of Bengal and the meteorological conditions like low pressure systems, cyclones, and storms surge and wind (MoWR, 2003). Both climatic and anthropogenic factors are responsible for causing salinity in the river water. However, climate induced factors such as sea level rise is the most pressing cause of salinity in coastal areas. The impact of withdrawal of freshwater water from river at any upstream site especially in dry season may cause salinity intrusion in the interior coast. For example after the commissioning of Farakka Barrage on Ganges river and its unilateral diversion of water during dry period has lead to the inward sifting of salinity lines (like1ppt, 5ppt line etc) in the southwestern region of the Bangladesh (Rahman and Alvee, 2015). This change has a significant impact on the ecosystem, social life and economy of the coastal zone. For example, many precious species of Sundarbans can survive within a very narrow range of salinity. Same goes for many water born creatures and crops. Apart from this, some of the coastal regions are already suffering from acute drinking water problem due to salinity. If the salinity level or the extent of salinity increases further this may lead to serious social impact in those regions.

The objective of the study is to i) assess the historical salinity level of surface water, ground water and soil of the study area, ii) develop scenarios of salinity level of surface water, ground water and soil for the year 2030 and 2050, iii) develop the salinity vulnerability maps for the year 2000, 2030 and 2050. This study is important because if the extent and condition of salinity intrusion is predicted, then it can help the policy makers to plan for countermeasures to address the situation.

STUDY AREA

The area under this study covers the central coastal zone of Bangladesh [Fig. 1]. It consists of 78 Upazilas under 12 districts. The zone is between Baleshwar River at the west to Karnafuli River at the east. The study area covers the districts of Barisal, Bhola, Barguna, Chandpur, Chittagong, Feni, Jhalokati, Lakshmipur, Noakhali, Patuakhali, Pirojpur, Shariatpur totaling an area of about 21475 sq.km (about 46% of total coastal area). There are about 40 major river and channel passes through the area. In addition there are a number of khals. Combined with the rivers and channels they make up a total length of 6378 km. This rivers and channels are very important feature of the area. They plays a vital role of transporting sediment, reduce salinity, navigation and local economy.

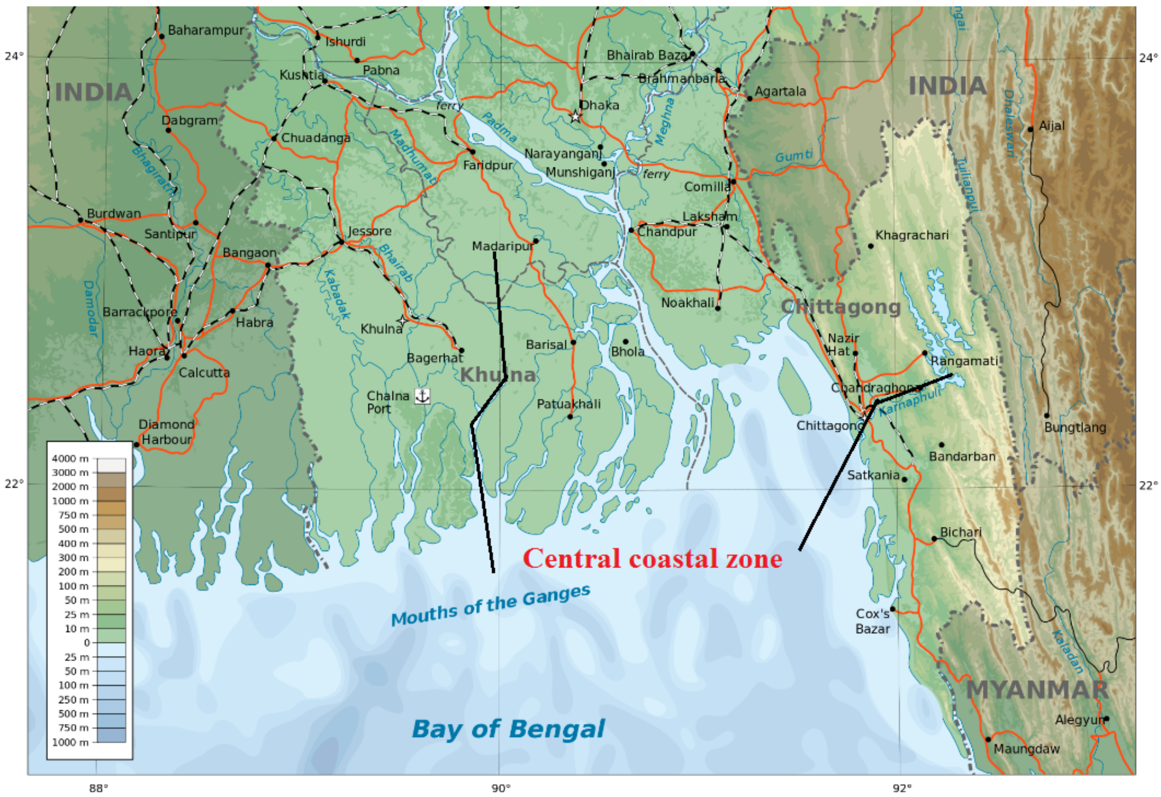

Fig. 1: Study Area: central coastal zone of Bangladesh

METHODOLOGY & DATA COLLECTION

Coastal Vulnerability Assessment towards Sustainable Management of Peninsular Malaysia Coastline has been calculated using coastal vulnerability index (CVI) (Mohamad et al., 2014). The study incorporated six variables to assess the CVI for the study area, which includes geomorphology, shoreline change rate, maximum current speed, maximum tidal range, significant wave height and sea level rise. The ranking is on a linear scale from 1 to 5 in order of increasing vulnerability; value 1 represents the lowest risk ranking assigned to the coastline whereas value 5 ranks the coastline with the highest risk. A total of 1963 km of coastline was evaluated. Vulnerability values of the variables are multiplied and square root of its average value calculates the magnitude of CVI. Similar kind of study was also conducted on Apodi Mossoro estuary, Northeast Brazil (Boori, 2010). In that study the parameters were geomorphology, shoreline change rate, coastal slope, mean tidal range, mean significant wave height and sea level rise.

Methodology

In this study mainly two softwares were used for the data analysis purpose namely ArcGIS-10.2.2 and Microsoft Excel. At first the study area was extracted from upazila shape file prepared by CEGIS using ArcGIS-10.2.2. Surface water, groundwater and soil salinity were analyzed from the year 2000 to 2012. Using Microsoft excel, general trend of change of those parameter were analyzed. Linear interpolation method was done for assessing the values of 2030 and 2050. All the analyzed data were stored in tabular format under the created shape file. Depending on the intensity of salinity each variable was rated from 1 (least vulnerable) to 5 (most vulnerable). Table 1 shows the detail rating of the salinity parameters.

Table 1: Ratings of the variables for CVI Analysis

Variable No.	Variable name	Ranking of Coastal Vulnerabilities				
		Very low	Low	Moderate	High	Very High
		1	2	3	4	5
a	Surface water salinity (ppt)	0- 1	1-2	2-6	6-10	>10
b	Ground water salinity (ppt)	0- 1	1-2	2-6	6-10	>10
c	Soil salinity (ppt)	0- 1	1-2	2-6	6-10	>10

Then using Eq. (1), coastal vulnerability index (CVI) due to surface water salinity, ground water salinity and soil salinity of year 2000, 2030 and 2050 were calculated.

$$CVI=\sqrt{(a\times b\times c)/3} \quad \text{------------------------} \quad (1)$$

Here a= index for surface water salinity, b= index for ground water salinity, c= index for soil salinity. Using the CVI values the vulnerability maps were produced for the year 2000, 2030 and 2050 using ArcGIS-10.2.2.

Data collection

Majority of soil salinity data were collected from Soil Resource Development Institute (SRDI). Rest of the data was taken from PDO-ICZMP report 2005.For surface water and ground water salinity we used data from Bangladesh water Development Board (BWDB) publication and PDO-ICZMP report 2005.

DATA ANALYSIS, RESULTS AND DISCUSSIONS

For soil salinity analysis, data were received from SRDI report of year 2000 and 2009. For the year 2000 both surface water and ground water salinity data were collected from PDO-ICZMP report 2005. Data from Bangladesh water Development Board (BWDB) publication was used for the year 2012. For both cases salinity data for dry season were used. In the case of ground water salinity, salinity values at 30m depth were used.Then using Microsoft excel, trend line was developed [Fig. 2] for each type salinity of each upazila based on the historical data during the period of 2000 to 2012. Then using the CVI equation described earlier, coastal vulnerability index (CVI) for the year 2000, 2030 and 2050 were calculated [Fig. 3].

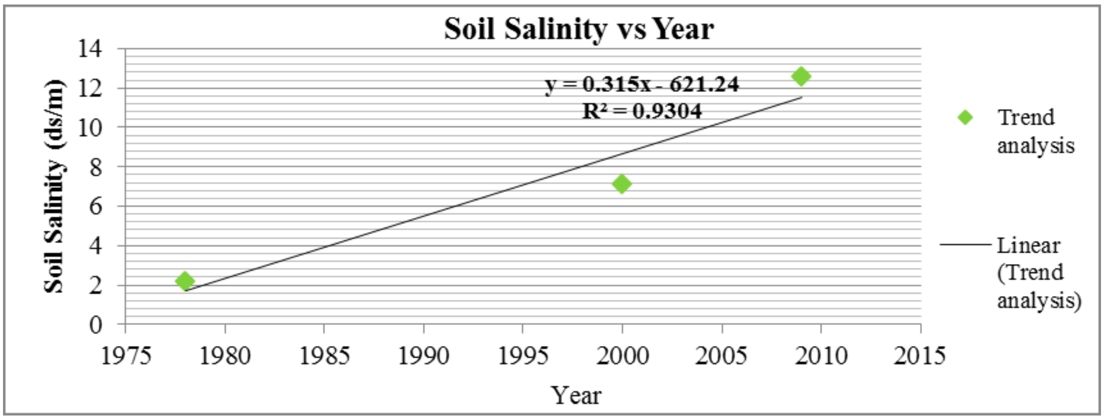

Fig.2: Trend analysis of soil salinity at Patuakhali

O	P	Q	R	S	T	U	V	W	X	Y	Z
GW 00 Index Number	GW 30 Index Number	GW 50 Index Number	SW 00 Index Number	SW 30 Index Number	SW 50 Index Number	Soil 00 Index Number	Soil 30 Index Number	Soil 50 Index Number	CVI 00	CVI 30	CVI 50
1	1	1	1	1	1	2	2	1	0.82	0.82	0.58
1	1	1	1	1	1	1	1	1	0.58	0.58	0.58
2	2	3	2	2	1	1	2	2	1.15	1.63	1.41
1	1	1	1	1	1	2	2	2	0.82	0.82	0.82
2	2	2	1	1	1	1	1	1	0.82	0.82	0.82
1	2	3	1	1	1	2	2	1	0.82	1.15	1.00
1	2	3	1	1	1	1	1	1	0.58	0.82	1.00
2	2	2	1	1	1	1	1	1	0.82	0.82	0.82
1	2	2	1	1	1	1	1	1	0.58	0.82	0.82
1	1	1	1	1	1	2	2	2	0.82	0.82	0.82
1	2	2	1	1	1	2	2	2	0.82	1.15	1.15
2	2	2	2	2	1	2	2	2	1.63	1.63	1.15
1	2	2	1	1	1	1	1	1	0.58	0.82	0.82
1	1	1	1	1	1	1	2	2	0.58	0.82	0.82
2	1	1	4	3	2	2	3	4	2.31	1.73	1.63
2	1	1	1	1	2	1	2	2	0.82	0.82	1.15

Fig.3: CVI Analysis for Salinity (sample calculation)

Salinity maps for surface water, ground water and soil salinity during the year 2000 to 2012 were created using the collected data, which are presented in Fig. 4 and Fig. 5.The predicted salinity values for the year 2030 and 2050, obtained by the trend analysis, are shown in Fig. 6 and Fig. 7 respectively. Using Arc-GIS 10.2.2 CVI index maps for the year 2000, 2030 and 2050 were created based on the CVI values [Fig. 8]. The changes of different vulnerable conditions with respect to the CVI value in different affected areas in central coastal zone in the year 2000, 2030 and 2050 are shown in [Fig.9]. The land areas of central coastal zone under low, medium and high vulnerabilities are found as 62%, 36%, 2% respectively for the year 2000, 61%, 22%, 17% respectively for the year 2030,51%, 24%, 25% respectively for the year 2050. It is very much alarming that highly vulnerable area (based on soil, surface water and ground water salinities) increases by significant amount, which is from 2% to 17% during the period 2000 to 2030 and from 17% to 25% during the period 2030 to 2050.

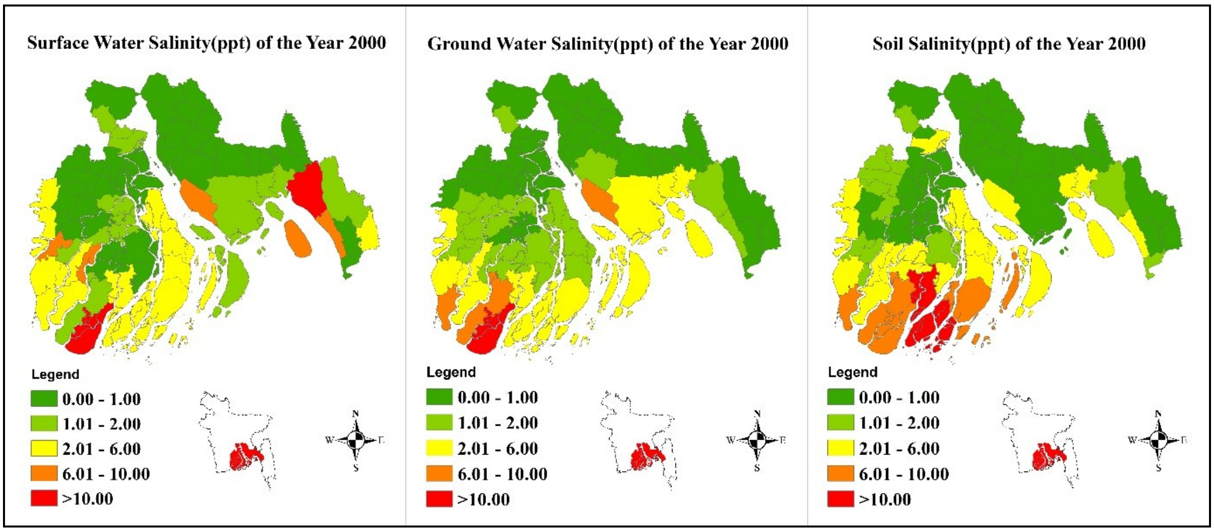

Fig.4: Surface water salinity, ground water salinity and soil salinity for the year 2000

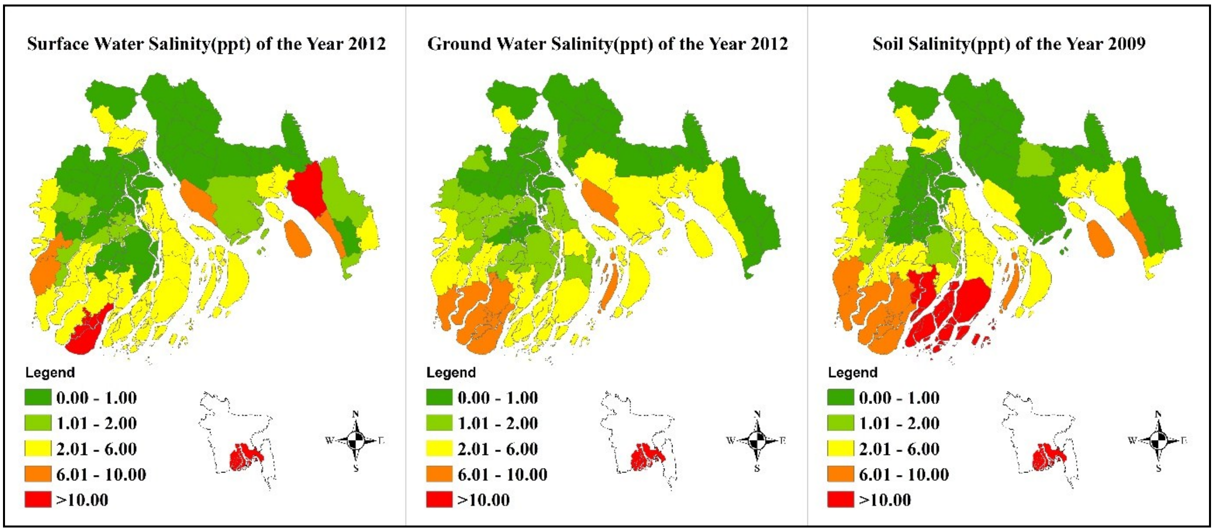

Fig.5: Surface water salinity, ground water salinity 2012 and soil salinity for 2009

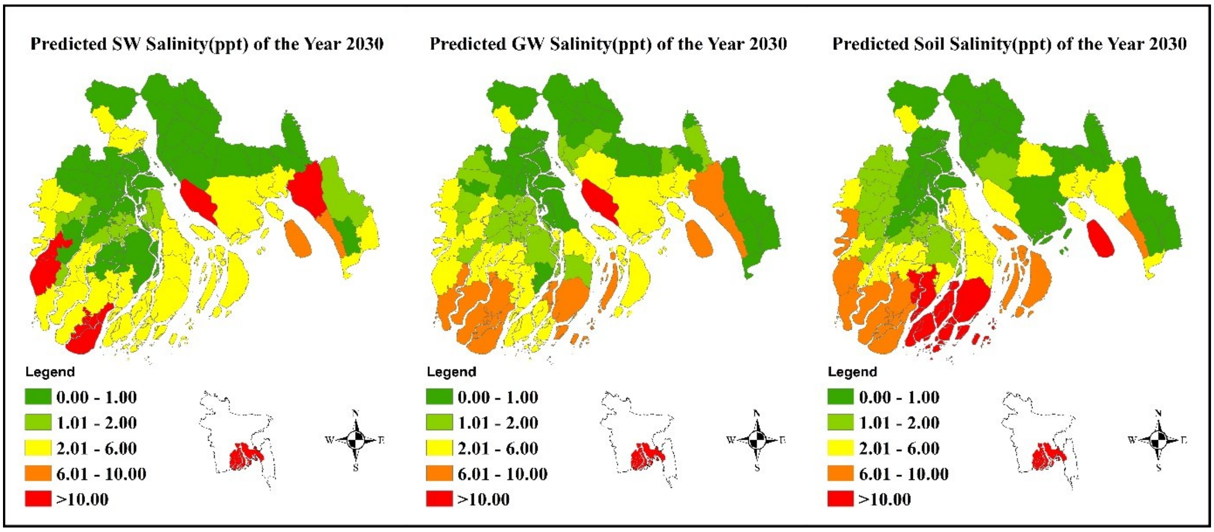

Fig.6: Predicted surface water salinity, ground water salinity and soil salinity for 2030

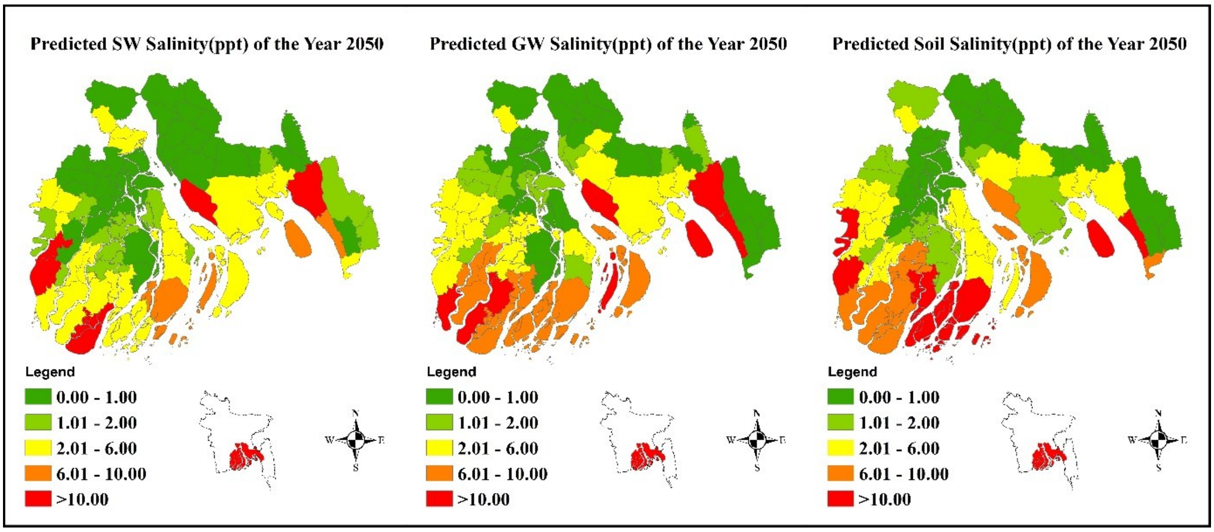

Fig.7: Predicted surface water salinity, ground water salinity and soil salinity for 2050

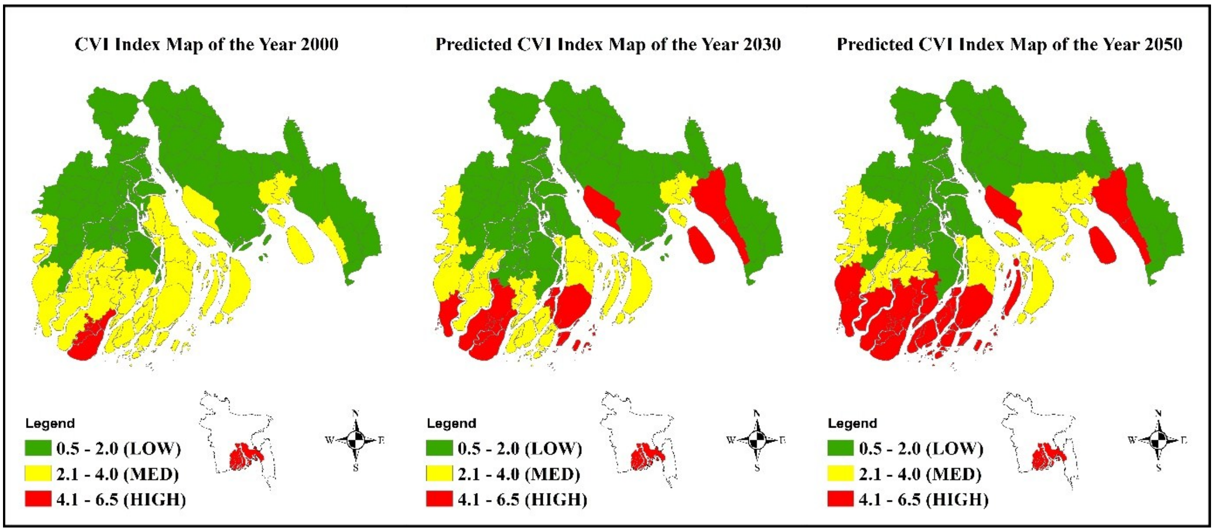

Fig.8: CVI index map for the year 2000, 2030 and 2050

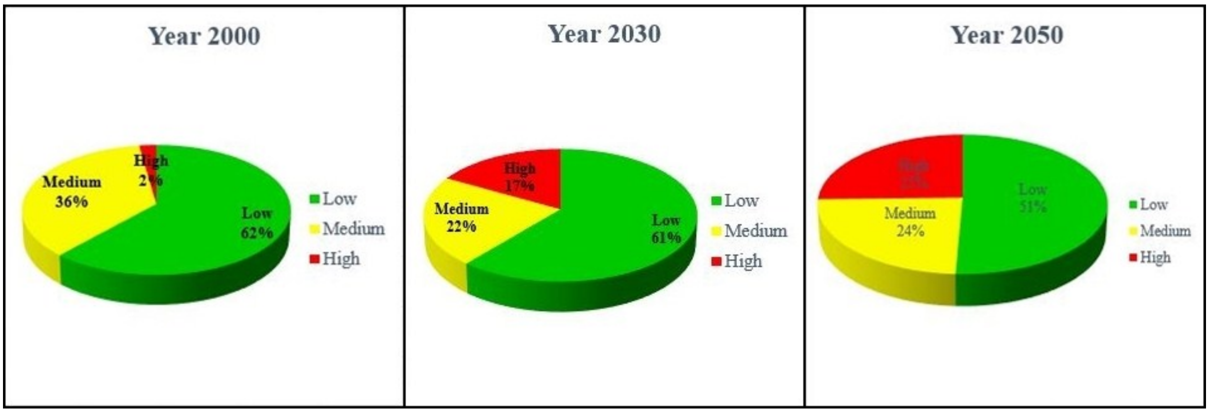

Fig.9: Low, medium and high vulnerable area of central coastal zone based on the CVI values for the year 2000, 2030 and 2050

CONCLUSIONS

Salinities of surface water, ground water and soil in the coastal area are one of the major threats for coastal environment and ecosystem. South-west coastal zone of Bangladesh has been suffering for the salinity intrusion for last few decades. Salinities in the coastal zone of Bangladesh are also increasing. This study investigates the salinity of surface water, groundwater and soil of the central coastal zone of Bangladesh. Historical salinity analysis has been done based on the observed data during the year 2000 to 2012. Trends of the historical changes of salinities are calculated and salinities for the year 2030 and 2050 are simulated following that trends. Observed historical data analysis shows an increasing trend of salinities in the study area. Future scenarios for the year 2030 and 2050 show that around one-fourth of the study area will be under highly vulnerable of salinity. Coastal zone management authorities of Bangladesh should take appropriate measures to overcome the threats of ongoing salinity intrusion and its future alarming incremental effects.

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