Global Warming induced Sea Level Rise on Soil, Land and Crop Production Loss in Bangladesh

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Abstract
Available data have been analyzed to assess impacts of global warming induced sea level rise on loss of soil and land resources and their implications on food security of Bangladesh. Scientists believe that because of sea level rise coastal zone of Bangladesh has already experienced noticeable impacts especially in terms of area of inundation and erosion, saline intrusion, loss of soil and land, loss of crop production in addition to migration of people from vulnerable areas. The loss of land mass and degradation of soil and land resources will adversely affect national food production and thereby food security. Sea level rise impacts are really high for Bangladesh, though the country plays insignificant role in green house gas emission. Development and implementation of adaptation policies and taking initiatives to realize those policies are the right ways to respond to sea level rise impacts in Bangladesh.

Key words
Climate change, sea level rise, soil and land resources, adaptation policies

Introduction
Rising sea level inundates low lying lands, erodes shorelines, exacerbates flooding, and increases the salinity of estuaries and aquifers. Some developing countries are especially exposed to sea level rise due to their low lying nature and limited financial resources to respond. Among the most vulnerable are countries with large populations in deltaic coastal regions such as Bangladesh, Vietnam, China and Egypt. The present paper analyzes the sea level rise impacts on soil and water salinity, agriculture and possible policy interventions in coastal areas of Bangladesh.

Geographical Location and vulnerability of Bangladesh
Bangladesh is situated at the north eastern region of South Asia and is bounded by India to the west, north and north-east and by Myanmar to the south east and the Bay of Bengal to the south. It has an area of 147,570 km^2 and a population of about 129.6 million, giving a population density of 874 per km^2. The country generally enjoys a sub-tropical monsoon climate. The country has a very flat and low topography except in the northeast and southeast regions. About 10% of Bangladesh is hardly 1m above the mean sea level and one-third is under tidal excursions. Huq *et al*. (1995) estimated that 11% of the country's population lives in the area threatened by a 1 m sea level rise.
The country has two contrasting environments to the north and the south. It has the Himalayas and the Khasia-Jaintia hills to the north and the Bay of Bengal and the northern Indian Ocean to the south. Both of these settings control, modify and regulate the weather and climate of the country and the region. The geographical location and geo-morphological conditions of Bangladesh have made the country one of the most vulnerable ones to disasters in the world.

SLR impacts
According to Nicholls and Leatherman (1995), a 1m sea-level rise would affect 6 million people in Egypt, with 12% to 15% of agricultural land lost, 13 million in Bangladesh, with 16% of national rice production lost, and 72 million in China and "tens of thousands" of hectares of agricultural land.
More than direct land loss due to seas rising, indirect factors are generally listed as the main difficulties associated with sea-level rise. These include erosion patterns and damage to coastal infrastructure, salinization of wells, sub-optimal functioning of the sewerage systems of coastal cities with resulting health impacts (WHO 1996, chapter 7), loss of littoral ecosystems and loss of biotic resources.
The SLR will inflict its impacts on Bangladesh in the coastal area and through the coastal area, on the whole of Bangladesh. About 2,500, 8,000 and 14,000 km^2 of land (with a corresponding percentage of 2%, 5% and 10% with respect to the total land area of the country) will be lost due to SLR of 0.1m, 0.3m and 1.0m respectively.

About one-fourth of the population lives in the coastal area. The rest depend in some way or other, on the activities in the coastal area. There will be likely migration of people from the coastal area further inland, thus putting pressure on non-coastal area as well. Thus SLR is going to affect the whole country.
Increase in SLR may cause migration of a lot of people inland, thus raising the population density there and causing socio-economic problems. Because of scarcity of land and high population density, northward migration may be limited, thus exposing these people to more hazardous condition**.**

Salinity intrusion
Sea level rise will bring more coastal area under inundation. This coupled with reduced flows from upland during winters will accelerate the saline water intrusion inland. Coastal waters will become more saline and soil salinity will increase. Not only that, even the ground water aquifers will bear the brunt of salinity intrusion. Winter crops in the coastal area which depend on ground water for irrigation will suffer a lot. Agriculture, forestry and fisheries sectors will be severely affected by increased water and soil salinity.

Extent of soil salinity in 1973 and 2000
Fresh river water withdrawal from upstream, irregular rainfall, introduction of brackish water shrimp

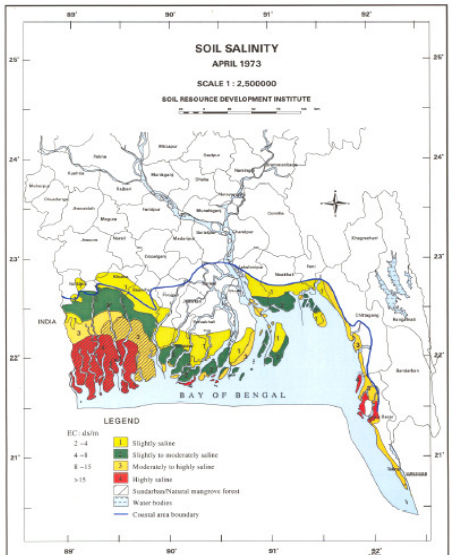

Figure 1. Soil salinity map of Bangladesh 1973. (Source: SRDI 1998)

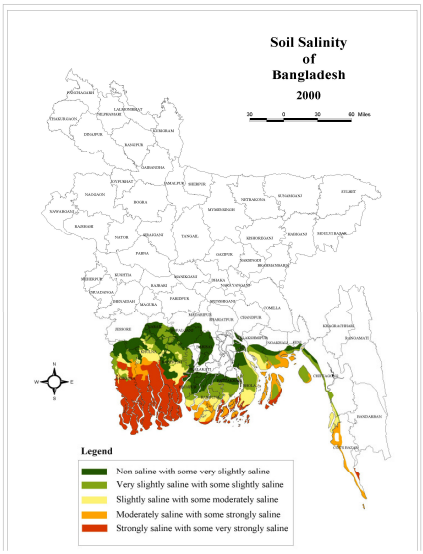

Figure 2. Soil salinity map of Bangladesh 2000 (Source: SRDI 2000)

cultivation, faulty management of the sluice gates and polders, regular saline tidal water flooding in unpoldered area, capillary rise of soluble salts etc. are the main causes of increased salinity affected area in this region. A comparative study between Soil Salinity map of the period of 1973 and 2000 shows intrusion of soil salinity in the coastal region (Figure 1 and 2). The map shows that soils of Jessore, Magura, Narail, Faridpur, Gopalgonj and Jhalakati were newly salinized in 37 years of time expansion. A comparative study between salinity survey in 1973 and 2000 showed that about 0.170 million ha (20.4%) new land is effected by different degree of salinity during last three decades (Table 1).

SLR and Agriculture

Solar radiation, temperature, and precipitation are the main drivers of crop growth; therefore agriculture has always been highly dependent on climate patterns and variations. Since the industrial revolution, humans have been changing the global climate by emitting high amounts of greenhouse gases into the atmosphere, resulting in higher global temperatures, affecting hydrological regimes and increasing climatic variability. Global warming is projected to have significant impacts on conditions food supply (how much food is produced) and food security.
More than 30% of the cultivable land in Bangladesh is in the coastal area. Out of 2.86 million hectares of coastal and offshore lands about 1.0 million ha (SRDI 2000) of arable lands are affected by varying degrees of salinity. Farmers mostly cultivate low yielding, traditional rice varieties during monsoon

Table1. Extent of soil salinity during last three decades (1973-2000) in coastal areas

District	Salt affected area (000'ha)		Salinity class								Salinity increase over 3 decades	
			S1 2.0-4.0 dS/m		S2 4.1-8.0 dS/m		S3 8.1-16.0 dS/m		S4 >16.0 dS/m		Area (000'ha)	Per-cent
	1973	2000	1973	2000	1973	2000	1973		1973	2000		
Khulna	375.04	402.69	48.79	88.97	255.68	118.25	49.84	157.94	20.73	47.53	27.65	7.37
Jessore	0	26.12	0	17.35	0	7.15	0	1.62	0	0	26.12	100.0
Jhalakati	0	3.41	0	2.28	0	1.13	0	0	0	0	3.41	100.0
Barisal	60.74	132.65	27.97	55.12	32.77	42.81	0	29.55	0	5.17	71.91	118.39
Patuakhali	219.05	234.00	165.16	71.16	53.89	71.33	0	78.41	0	13.10	14.95	6.82
Gopalganj	0	10.51	0	5.93	0	3.22	0	1.36	0	0	10.51	100.0
Madaripur	0	1.19	0	0.79	0	0.40	0	0	0	0	1.19	100.0
Faridpur	0	10.06	0	5.78	0	3.12	0	1.16	0	0	10.06	100.0
Noakhali	78.04	78.43	18.84	24.20	53.49	27.32	5.71	19.16	0	7.75	0.39	0.70
Chittagong	100.58	104.90	25.64	15.27	31.36	33.29	24.34	45.80	19.24	10.54	4.32	6.03
Total	833.45	1003.96	286.40	286.85	427.19	298.02	79.89	335.00	39.97	84.09	170.51	20.4

Source: SRDI 2001.

season. Most of the lands remain fallow in the dry season (January- May) because of soil salinity, lack of good quality irrigation water and late draining condition (Karim *et al*. 1990; Mondal 1997 and SRDI 2001). Crop production of the salt affected areas in the coastal regions differs considerably from non saline areas. Because of salinity special environmental and hydrological situation exists which restricts the normal crop production throughout the year. In the recent past, with the increase in degree of salinity in some areas due to saline water intrusion, normal crop production became very risky. Crop yields, cropping intensity, production levels and people's livelihood quality are much lower than other parts of the country, which have enjoyed the fruits of modern agriculture technologies based on high-yielding varieties, improved fertilizer and water management and improved pest and disease control measures (BBS 2001). At the same time food demand in the area is increasing with the steady increase in human population.

Scientists reported that salinity decreased the germination rate of some plants (Rashid *et al*. 2004; Ashraf *et al*. 2002). Ali (2005) investigated the loss of rice production in a village of Satkhira district and found that rice production in 2003 was 1,151 metric tons less than the year 1985 corresponding to a loss of 69 per cent. Out of the total decreased production, 77 per cent was due to conversion of rice field into shrimp pond and 23 per cent was because of yield loss (Table 2).

Table 2. Declining rice production because of soil degradation

Crop nonths covered)	**1985**	**1990**	**1995**	**2003**
	Area under rice and shrimp farming (ha) (% of crop land)			
Aman (HYV); July – November	345.5 (100)	344.6 (100)	332.4 (97.0)	314 (91.9)
Boro (HYV); December - May	200.4 (58)	269.6 (78.2)	122.4 (32.8)	58.2 (17)
One shrimp cycle; December – January	36.5 (10.6)	75.0 (21.8)	210.0 (67.2)	255.8 (91.0)
Two shrimp cycle; December – November	0	0	20.6(3.0)	55.0 (8.0)
Expected total rice production	1373	1689	1679	1673
Observed total rice production	1265	1260	745	522
Decline in rice production due to loss of Area	108	221	670	890
Decline in rice production due to yield loss	-	208	264	261
Total loss of rice production	**108**	**429**	**934**	**1151**

(Adapted from Ali 2005)

A World Bank (2000) study suggests that increased salinity alone from a 0.3 meter sea level rise will cause a net reduction of 0.5 million metric tons of rice production.

Management approaches

To accommodate diverse land uses, changed patterns of land uses with land suitability, land zoning has been proposed as a management approach. Hossain and Lin (2002) suggested that, to reduce social conflict and

promote effective and sustainable resource use land should be zoned on the basis of suitability- the most suitable zone, a moderate suitable zone and an unsuitable zone. The coastal zone policy states that 'actions shall be initiated to develop land use planning as an instrument of control of unplanned and indiscriminate use of land resources' and 'zoning regulation would be formulated and enforced in due course'.

Conclusion

Bangladesh ranks low on just about all measures of economic development. This low level of development, combined with other factors such as its geography and climate, makes the country quite vulnerable to climate change. Higher population density increases vulnerability to climate change because more people are exposed to risk and opportunities for migration within a country are limited. With over 35% of Bangladeshis suffering from malnourishment (Lal *et al*. 2001), the threat of increased hunger from reduction in agricultural production would suggest the inclusion of agriculture as one of the major vulnerabilities facing the country. So, Bangladesh needs policy intervention to deal with climate change induced sea level rise impacts on natural resource management and food security.

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