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Article

Disaster (SIDR) causes salinity intrusion in the south-western parts of Bangladesh

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Abstract: This study investigates the causes of salinity intrusion by disaster (such as SIDR) in the south-western parts of Bangladesh. The present research work was conducted in the Khulna and Satkhira district's rivers like Rupsa, Vadra, Sibsa, Betna, Kholpetua and Morischap and other specific study area was at Gabura and Buri Goalini union of Shyamnagar upazilla under Satkhira district of Bangladesh from June to November, 2015. Salinity intrusion is a major problem and is found increasing day-by-day in the south-western parts of Bangladesh. For this study, data are collected from Bangladesh water development board (BWDB, Dhaka), and through reconnaissance survey with focus group discussion (FGD) in the Gabura and Buri Goalini union under Shyamnagar upazilla of Satkhira district. The data show that the EC and Chloride value in the study area were in the increasing state after SIDR because of the increasing temperature and decreasing rainfall and these values exceed the standard level of Bangladesh and WHO guideline. Further research is to be directed to acquire and quench pursuing to the crucial causes through factorization in a relation to salinity intrusion and disaster issues in the south-western parts of Bangladesh.

Keywords: disaster; SIDR; salinity Intrusion; South-western parts; Bangladesh

1. Introduction

The coast of Bangladesh consists of 19 districts covers with 32% of the country and accommodates more than 35 million people (Huq and Rabbani, 2012). The coastal zone makes up of the flat Ganges delta passed upon large tidal rivers discharging into the Bay of Bengal. Bangladesh is now widely recognized to be one of the country's most vulnerable to climate change and natural disaster. Natural disasters are defined as "a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the capacity of the affected society to cope using only its own resources" (UNISDR, 2004). The coastal areas of Bangladesh are disaster prone because of their geographical location, land characteristics and funnel-shaped characteristics (UNEP, 2001).

Natural hazards that come from increased rainfall, rising sea levels and tropical cyclones are expected to increase as climate changes, each seriously affecting agriculture, water and food security, human health and shelter. It is believed that in the coming decades the rising sea level alone will create more than 20 million climate refugees (Wikipedia, 2015). Salinity intrusion is the major problem in the southwestern-parts of Bangladesh especially Khulna and Satkhira district. Salinity is increasing day-by-day in Khulna and Satkhira district coastal regions due to increasing of tidal wave action and climate change effect in different seasons of the year. The salinity intrusion in water and soil caused by cyclone and storm surge, sea level rise (SLR) and shrimp farming practices has brought devastating consequences for these coastal people. The upstream withdrawal of the Ganges water is the main reason for the increasing salinity in tidal water (Kabir, 1994). Besides salinity has increased due to introduction of brackish water for shrimp cultivation, faulty management of sluice gates, regular saline tidal water flooding in unsoldered area, capillary upward movement of soluble salts due to presence of high saline ground water table shallow depth (SRDI, 2003). The Physical, chemical and biological properties of water has a significant affects on salinity. The movement of saline water in to freshwater aquifer is known as salinity intrusion. Climate induced sea level rise and cyclonic events have already led to an increased salinity in fresh water and soil in the coastal area. A recent study indicates that the salinity affected area has increased from 8330 km^2 in 1973 to 10560 km^2 in 2009 (SRDI, 2010). In the last decade the number of major, devastating cyclones has increased sharply (Rabbani *et al*., 2013). The magnitude of salinity intrusion in coastal areas depends on sensible balance between fresh water flow and saltwater from the sea. In natural disaster case, Bangladesh suffers from floods, cyclones, tornadoes and tidal bores on an annual basis and it is one of the most vulnerable countries of the world to Climate change & sea level rise (CCSLR). In every year the country faces many types of disaster such as SIDR, Aila, Mohasen, Resma etc. Nearly 70 major cyclones have hit the coastal areas of Bangladesh during the last 200 years (Mallick *et al.*, 2009). Almost 900,000 people have died in last 35 years due to catastrophic cyclones (Islam and Ahmed, 2001). In 9th November, 2007 the tropical cyclone SIDR had hit the South-Western part of Bangladesh and resulted in one of the worst natural disasters in Bangladesh. It`s maximum wind speed was 260km/hr and storm surge height 3.0 meter. This cyclone affects the residents, homesteads, roads and embankments in Khulna Satkhira and other coastal districts. Cyclone SIDR affected 30 districts, 200 upazillas, 8923259 people, 743322 acre of Crops, 3363 people dead and 12723 Km road damage (Disaster Management Bureau, 2012). Some of the agricultural land is now under water or have become infertile for the salty water intrusion from sea. The Soil Resource Development Institute (SRDI) of the Government of Bangladesh states of the total, an area of about 4530 km^2 is affected by higher level of salinity (more than 8 ds/m; SRDI, 2010). Salinity is now a day's recognized as an alarming issue in south-west coastal region of Bangladesh and has a serious impact on ecological sustainability. Estuarine floodplains occupy about 18% of the total coastal area located in greater Noakhali, Barisal, Patuakhali and a smaller area of Chittagong districts and the remaining 27% is water bodies (Karim *et al.,* 1982). Intrusion may be aggravated by upstream with drawl of water and reducing size of floodplains or by climate change impacts like a decrease in dry season rainfall and sea level rise. South west coastal regions are most at risk from sea level rise. The increasing rate of salinity in these areas is due to intrusion of sea water. It is estimated that sea level rise in Bangladesh would inundate 18% of the country by 2100. There are also crisis of fresh water for drinking and irrigation purposes as the subsurface water is saline in most of the areas. The sea level along the coastline of Bangladesh is rising at about 3 millimeters a year, consequently saline water intrude into the coastal area and changes the livelihood pattern. In the study the researcher found salinity creates problems to agricultural production and affects the supply of clean water. The aims and objectives of this research work were to determine the salinity intrusion due to disaster (SIDR) as the major responsible causes and possible responsibility of disaster induced salinity intrusion with assumption and proper people's perception in the South-Western parts of Bangladesh.

2. Materials and Methods

2.1. Study area

The present research work was conducted in the Khulna and Satkhira district's rivers like Rupsa, Vadra, Sibsa, Betna, Kholpetua and Morischap. Another specific study area was at Gabura and Buri Goalini union of Shyamnagar upazilla under Satkhira district of Bangladesh (Figure 1). The study period was June to November, 2015.

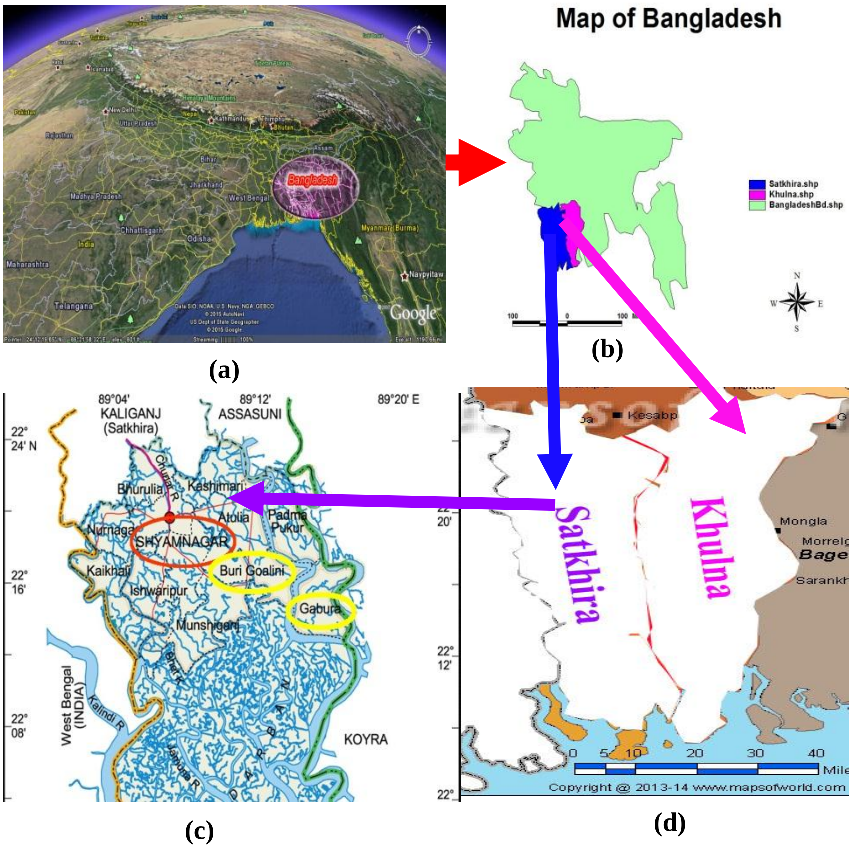

Figure 1. Map showing the location of the study area. (a) World Map; (b) Map of Bangladesh; (c) Khulna division Map with Khulna and Satkhira district (d) Map of Shyamnagar upazilla with Buri Goalini and Gabura union.

2.2. Data Collection

To conducted the fulfill objectives of the study structured questionnaire was prepared. The Prepared questionnaire survey was collected from the study area for primary data collection. Then 100 household-level questionnaire surveys were conducted into two unions Buri Goalini and Gabura with 25-35, 35-45 respondents respectively. These two unions were selected because natural disasters and salinity intrusion are common in them. Two focus group discussions (FGD) were conducted to investigate the reasons behind the causes of salinity intrusion amnestied Disaster (SIDR) had occurred in the study area. The secondary data were collected from Google Earth, Local Government Engineering Department (LGED), Bangladesh Bureau of Statistics (BBS), Salinity data and climatic data were collected from Bangladesh Water Development Board (BWDB), disaster related information was collected from Disaster Management Bureau (DMB). Relevant information's were collected from Different journals, reports, research papers, searching websites from Google, Soil Resource Development Institute (SRDI), Khulna. Central Library of (JUST and KU) and others published and unpublished documents of Government and Non-government Office.

2.3. Data processing and analysis

After collecting the primary and secondary data, it was processed and prepared for analyzed. Data were analyzed with the help of statistical method by the help of Microsoft excel 2007 graphical representation such as column diagrams, pie chart, bar diagrams and Microsoft word 2007, in table presentation.

3. Results and Discussion

3.1. Relationship between rainfall and salinity

3.1.1. Benarpota station at Betna river of Satkhira

3.1.1.1. High tide

In present study, the researcher found that the value of EC (during high tide) increased with time and the value was the highest in 2011 as compared to the value of other years (2008-2010). In the case of rainfall (2007 to 2010) it was found that there was a decreasing tendency of rainfall. As the rainfall decreased, so there was a possibility to increase the concentration of metals in the solution, due to lack of sufficient water, which may responsible for increasing the EC. In the case of 2011 (Figure 2), the EC value was the highest but the rainfall was also the highest. We do not actually know that what are the factors were involved for increasing the EC in spite of increasing rainfall. Further research is needed to find out the actual reason behind it. We surveyed the study region and almost all the people told that the salinity was not as high as today`s salinity level. We strongly believed that the disaster (SIDR) may one of the important causes responsible for the intrusion of salinity in the Satkhira region. The researcher also found that the chloride concentration (during high tide) increased with time and the value was the highest in 2011 as compared to the other years (2008-2010). The rainfall (2007 to 2010) decreased with increasing time and the highest value was in 2011 (Figure 2). It was believed that decrease rainfall may responsible for increasing the value of chloride. It was true at least for the case of up to 2010. In the case of 2011 the other unknown reason may be involved which demand further study.

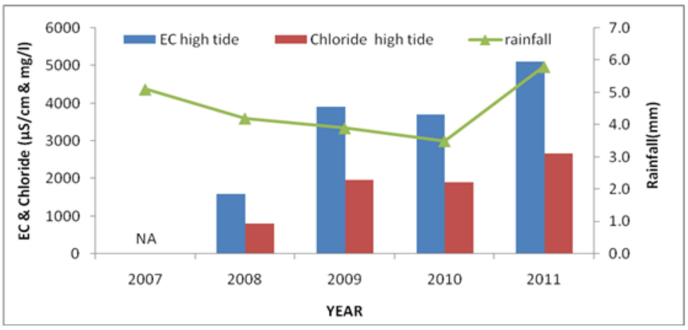

Figure 2. Relationship among rainfall, EC (during high tide) and chloride (during high tide) at Benarpota station of Betna river in Satkhira district.

3.1.1.2. Low tide

In present study, the researcher found that the EC (during low tide) increased with time and the value was highest in 2011 compared to other years (2008-2010). In the rainfall (2007 to 2010) decreased with the time and there was a possibility to increase the concentration of EC (during low tide) and that was occurs. In case of 2011, the EC value was the highest but the rainfall was also the highest. We do not find out this reason. So this study is more needed for next generation. The present research also found that the chloride concentration (during low tide) increased with time and the value was the highest in 2011 as compared to the other years (2008-2010). In the case of rainfall (2007 to 2010), it was found that there was a decreasing level of rainfall (Figure 3). It was believed that decrease rainfall may responsible for increasing the value of chloride. In the 2011 the rainfall was highest and the chloride concentration was highest. This reason is unknown for us and more study to be required in this sector.

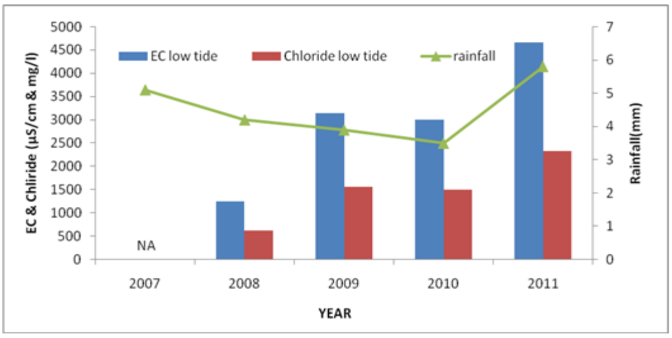

Figure 3. Relationship among rainfall, EC (during low tide) and chloride (during low tide) at Benarpota station of Betna river in Satkhira district.

3.1.2. Kalaroa station of Betna-Kholpetua river in Satkhira

3.1.2.1. High tide

In present study, the researcher found the value of EC (during high tide) increase with time and the value was the highest in 2010 as compared to the value of other years (2008-2009). In the rainfall (2007 to 2010), it was found that there was a decreasing tendency of rainfall. As the rainfall decreased, so there was a possibility to increase the concentration of EC due to lack of sufficient water, which may responsible for increasing the EC. In the case of 2011 (Figure 4), the EC value was the lowest but the rainfall was the highest. It was believed that

increase rainfall may responsible for decreasing the value of EC (during high tide). So this factor actually correct and we said that disaster (SIDR) causes salinity intrusion.
The researchers also found that the chloride concentration (during high tide) in 2008 it was the highest. In 2011 the value was the lowest in as compared to the other years (2008-2010). The rainfall (2007 to 2010) decreased with increasing time and the highest value was in 2011 (Figure 4). We believed that the increasing rainfall is the main factor to decrease the chloride concentration and that is occurring in the graphical representation.

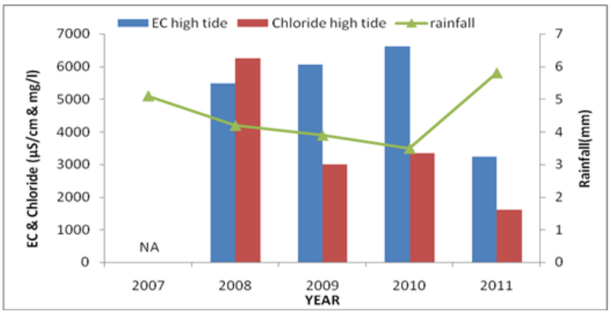

Figure 4. Relationship among rainfall, EC (during high tide) and chloride (during high tide) at Kalaroa station of Betna-Kholpatua river in Satkhira district.

3.1.2.2. Low tide

In the low tide the EC, chloride concentration and rainfall relationship are similar in the high tide in Kalaroa station of Betna-Kholpetua river (Figure 5).

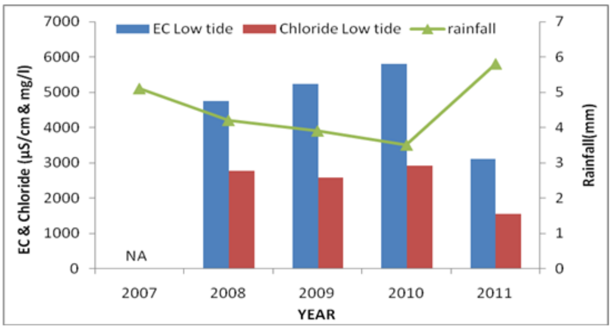

Figure 5. Relationship among rainfall, EC (during low tide) and chloride (during low tide) at in Kalaroa station of Betna-Kholpatua Satkhira district.

3.1.3. Elarchar station of Morichap river

3.1.3.1. High tide

Similar results are shown in Benarpota station at Betna river (Figure 6).

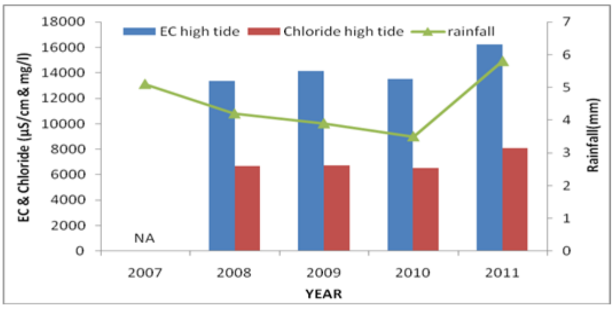

Figure 6. Relationship among rainfall, EC (during high tide) and chloride (during high tide) at Elarchar station of Morichap river in Satkhira district.

3.1.3.2. Low tide

In the low tide same graphical representation are shown in the high tide (Figure 7).

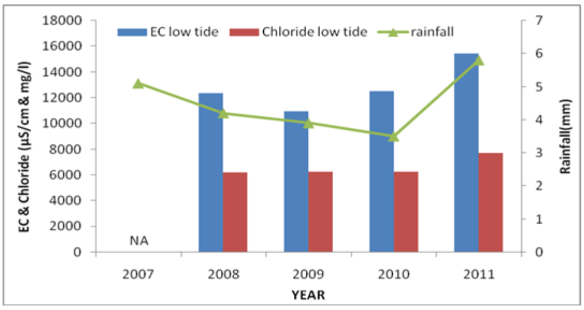

Figure 7. Relationship among rainfall, EC (during low tide) and chloride (during low tide) at Elarchar station of Morichap river in Satkhira district.

3.2. Relationship between temperature and salinity data (Satkhira district rivers)
3.2.1. Benarpota station at Betna river of Satkhira
3.2.1.1. High tide

Our result showed that the EC and chloride ion concentration increased with increasing time and the value was the highest in the year 2011. In 2007, the natural disaster SIDR took place and it increased the salinity. Later on, in the year 2009 the natural disaster AILA took place. Therefore there was a possibility to increase of salinity and the SIDR may also be responsible for incoming salinity; though the supposition needs to be verified (Figure 8).

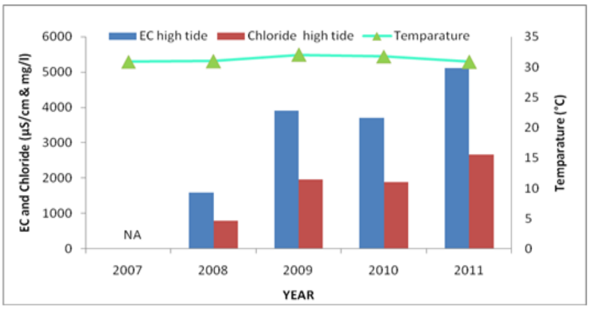

Figure 8. Relationship among Temperature, EC (during high tide) and chloride (during high tide) at Benarpota station of Betna river in Satkhira district.

3.2.1.2. Low tide

In the Low tide similarity to be seen in the high tide of Benarpota station in Betna river (Figure 9).

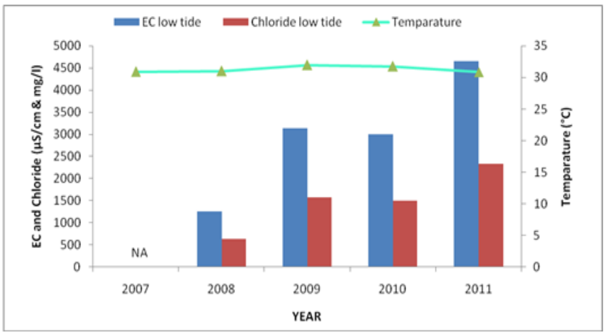

Figure 9. Relationship among Temperature, EC (during low tide) and chloride (during low tide) at Benarpota station of Betna river in Satkhira district.

3.2.2. Kolaroa station at Betna-Kholpetua river
3.2.2.1. High tide

In the high tide of Kolaroa station at Betna-Kholpetua river EC value was increasing with time except 2011 (Figure 10). Because the compare with temperature in EC (during high tide); temperature was lowest in 2011. For this reason the EC (during high tide) value is decreasing with time. In the chloride concentration value 2008 is the highest because the temperature was high in this year. Then some is decreasing in the next years. At last we told that some unknown reason have been occurred and more than study to be needed in this purpose.

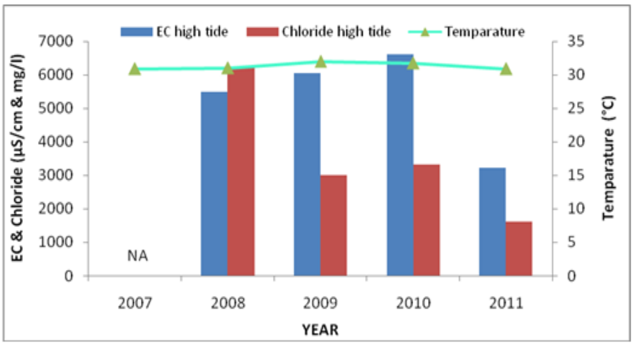

Figure 10. Relationship among Temperature, EC (during high tide) and chloride (during high tide) at Kalaroa station of Betna-Kholpetua river in Satkhira district.

3.2.2.2. Low tide

Similar results have been occurred in the high tide of Kolaroa station at Betna-Kholpetua river (Figure 11).

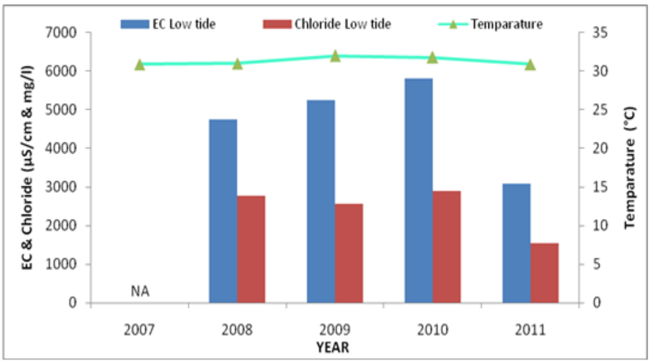

Figure 11. Relationship among Temperature, EC (during low tide) and chloride (during low tide) at Kalaroa station of Betna-Kholpetua river in Satkhira district.

3.2.3. Elarchar station of Morichap river

3.2.3.1. High tide

Similarity shown in high tide of Benarpota station of Betna river (Figure 12).

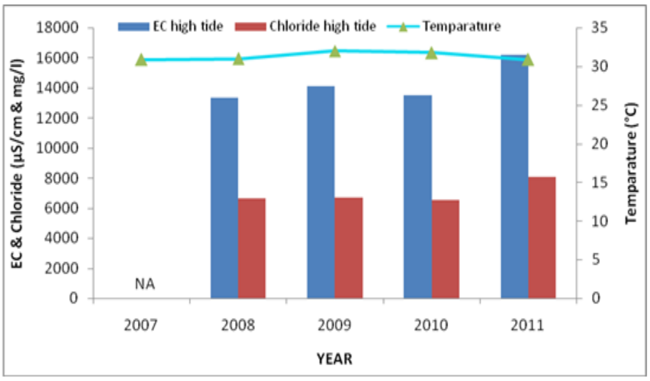

Figure 12. Relationship among Temperature, EC (during high tide) and chloride (during high tide) at Elarchar station of Morichap river in Satkhira district.

3.2.3.2. Low tide

In the EC (low tide) increasing with time and compared to the temperature but in 2010 some decreasing tendency show. These have some unknown factor to be worked (Figure 13).

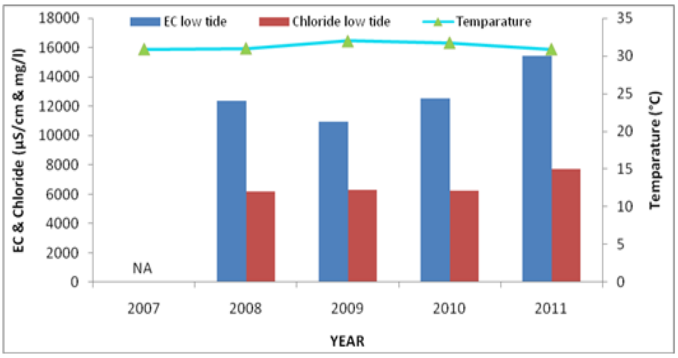

Figure 13. Relationship among Temperature, EC (during low tide) and chloride (during low tide) at Elarchar station of Morichap river in Satkhira district.

3.3. Relationship between temperature, rainfall and salinity data (Khulna district rivers)

In the relationship between rainfall, temperature and salinity data we see that EC (during high and low tide) value increases with time 2008-2009 (Tables 1 and 2). But in 2010 EC value decreases because the rainfall decreases but temperature decreases in 2010. In 2011, EC value also decreases because rainfall increases but temperature same. We know that rainfall increases to decreases EC value. In Chloride concentration (during high and low tide) value increases with time but in 2011 value is decreases because the rainfall is increases as compared to 2008-2010.

Table 1. Relationship between electrical conductivity, chloride (during high and low tide), rainfall and temperature at Rupsha river of Khulna district in different times of the year.

Year	EC (µS/cm)		Chloride high tide (mg/l)		Rainfall (mm)	Temperature (°C)
	High tide	Low Tide	High tide	Low tide		
2007	*	*	*	*	5.79	30.5
2008	5339.80	4696.40	2670.18	2546.58	4.38	31.0
2009	11180.96	10380.81	5523.75	5257.60	5.48	31.9
2010	11145.96	10350.30	6622.71	5620.35	3.71	31.1
2011	7670.00	6902.50	3835.00	3452.75	5.21	31.1
2012	*	*	*	*	4.42	31.7
2013	*	*	*	*	5.64	31.5
2014	*	*	*	*	4.00	31.8
2015	*	*	*	*	*	*

Source: Salinity data were collected from BWDB (Bangladesh Water Development Board, Dhaka 1215 and Climatic data were collected from BMD (Bangladesh Meteorological Department, Khulna). N. B.: (*) Indicated that the data were not available.

Table 2. Relationship between electrical conductivity, chloride (during high and low tide), rainfall and temperature at Bhadra river of Khulna district in different times of the year.

Year	EC (µS/cm)		Chloride high tide (mg/l)		Rainfall (mm)	Temperature (°C)
	High tide	Low Tide	High tide	Low tide		
2007	*	*	*	*	5.79	30.5
2008	9655.56	8692.60	4829.17	4346.30	4.38	31.0
2009	2975.00	2440.00	1487.50	1215.00	5.48	31.9
2010	8276.77	7433.44	4370.00	3716.25	3.71	31.1
2011	8929.58	8485.00	4465.00	4242.00	5.21	31.1
2012	*	*	*	*	4.42	31.7
2013	*	*	*	*	5.64	31.5
2014	*	*	*	*	4.00	31.8
2015	*	*	*	*	*	*

Source: Salinity data were collected from BWDB (Bangladesh Water Development Board, Dhaka 1215 and Climatic data were collected from BMD (Bangladesh Meteorological Department, Khulna). N. B.: (*) Indicated that the data were not available.

In Bhadra river EC (during high and low tide) just decreases in 2009 because the rainfall is highest in the other years 2008-2011 (Table 3).
Similarity is to be shown in Chloride concentration (during high and low tide).

Table 3. Relationship between electrical conductivity, chloride (during high and low tide), rainfall and temperature at Sibsa river of Khulna district in different times of the year.

Year	EC (µS/cm)		Chloride low tide (mg/l)		Rainfall (mm)	Temperature (°C)
	High tide	Low tide	High tide	Low tide		
2007	*	*	*	*	5.79	30.5
2008	12684.34	11716.19	6308.83	5858.00	4.38	31.0
2009	13470.63	12573.13	6736.83	4855.31	5.48	31.9
2010	13734.79	12844.27	6865.83	6391.67	3.71	31.1
2011	12934.58	12364.58	6460.42	4513.75	5.21	31.1
2012	*	*	*	*	4.42	31.7
2013	*	*	*	*	5.64	31.5
2014	*	*	*	*	4.00	31.8
2015	*	*	*	*	*	*

Source: Salinity data were collected from BWDB (Bangladesh Water Development Board, Dhaka 1215 and Climatic data were collected from BMD (Bangladesh Meteorological Department, Khulna). N. B.: (*) Indicated that the data were not available.

In Sibsa river EC (during high and low tide) value increases with time (2008-2010). But in 2011 EC value decreases as compared to 2010 because the rainfall trend is increases in 2011 more than 2010 (Table 3).
Here the Chalna station of Rupsha river (Table 4) shows that EC and Chloride (during high and low tide) value was increasing in 2008-2009. But in 2010 the value decreasing because of the temperature is low rather than 2009. In 2011 the value was also decreasing because the rainfall of this year was more than high other years (2008-2010).

Table 4. Relationship between electrical conductivity, chloride (during high and low tide), rainfall and temperature in Rupsha river at Chalna station of Khulna district in different times of the year.

Year	EC (µS/cm)		Chloride low tide (mg/l)		Rainfall (mm)	Temperature (°C)
	High tide	Low tide	High tide	Low tide		
2007	*	*	*	*	5.79	30.5
2008	9095.27	8243.25	4545.13	4121.63	4.38	31.0
2009	9970.00	9023.13	4955.47	4514.00	5.48	31.9
2010	9706.98	8860.52	4866.56	4428.85	3.71	31.1
2011	8520.00	8240.83	4280.83	4107.92	5.21	31.1
2012	*	*	*	*	4.42	31.7
2013	*	*	*	*	5.64	31.5
2014	*	*	*	*	4.00	31.8
2015	*	*	*	*	*	*

Source: Salinity data were collected from BWDB (Bangladesh Water Development Board, Dhaka 1215 and Climatic data were collected from BMD (Bangladesh Meteorological Department, Khulna). N. B.: (*) Indicated that the data were not available.

3.4. Comparison of EC and Chloride concentration among study area, Bangladesh and WHO standard.

It has been/is found that the salinity of the study area increased for the time being because of the increasing of temperature and decreasing rainfall. A comparison between the EC and chloride value of the study area and the standard water quality value (BD and WHO) was presented. At Betna river of Satkhira in 2008, the high and low tide value of EC and chloride revealed inequality compared to the standard value Bangladesh and WHO. On the following 5 years, the values exceeded the standard value and the salinity intrusion in the area may have been caused by disaster (SIDR). Hypothetically, we can assume that disaster (SIDR) was the most responsible factor for salinity intrusion, because the EC and chloride value increased during and after disaster as compared to 2008. In the Betna-Kholpetua river in Satkhira, we can see from the data that the EC and chloride value of 2008-2011 was found in the exceeding state comparing to the standard level of Bangladesh and WHO guideline.

In the following years, the values have increased after disaster (SIDR) and this may be the assumed reason for salinity intrusion. We found that the EC and chloride concentration increased both in low and high tide with increasing time and the highest value was reduced in 2011 (Table 5). In Elarchar station of Morichap river in Satkhira showed that the increasing values were higher as compared to the other values.

Table 5. EC, Chloride ion concentrations in different station of Satkhira district.

Benarpota station at Betna river of Satkhira								
Year	**EC (μS/cm)**		**Chloride (mg/l)**		**Standard**			
					Bangladesh, 1997		**WHO, 2006**	
	High tide	**Low tide**	**High tide**	**Low tide**	**EC (μS/cm)**	**Chloride (mg/l)**	**EC (μS/cm)**	**Chloride (mg/l)**
2007	*	*	*	*	2000	150-600	*	250
2008	1593.75	1250.00	796.88	625.00	2000	150-600	*	250
2009	3909.38	3136.56	1955.63	1567.41	2000	150-600	*	250
2010	3705.14	3000.90	1893.14	1494.27	2000	150-600	*	250
2011	5111.67	4556.67	2671.25	2327.92	2000	150-600	*	250
Kalaroa station of Betna-Kholpetua river in Satkhira								
2007	*	*	*	*	2000	150-600	*	250
2008	5485.00	4744.91	6254.16	2761.83	2000	150-600	*	250
2009	6061.90	5238.13	3006.00	2572.18	2000	150-600	*	250
2010	6623.40	5800.00	3334.36	2899.80	2000	150-600	*	250
2011	3327.90	3092.70	1614.46	1546.92	2000	150-600	*	250
Elarchar station of Morichap river in Satkhira.								
2007	*	*	*	*	2000	150-600	*	250
2008	13334.00	12384.00	6629.21	6193.67	2000	150-600	*	250
2009	14125.63	10955.00	6725.31	6274.00	2000	150-600	*	250
2010	13508.90	12547.61	6519.00	6242.40	2000	150-600	*	250
2011	16212.50	15430.00	8102.92	7713.34	2000	150-600	*	250

Source: Salinity data were collected from BWDB (Bangladesh Water Development Board, Dhaka 1215. Bangladesh Standard; 1997, WHO (World Health Organization) guideline; 2006. N.B: (*) Indicated that the data were not available.

In Khulna station of Rupsha river in Khulna district 2008-2011, it has been found that the EC and chloride (high and low tide) value exceeds the standard level. The standard water quality values but our study area data represents the EC and chloride values of the salinity affected river were higher than standard values. The major possible reason may have been found 'disaster (SIDR)' but other factors can be responsible which can be analyzed through further measurements. The Bhadra river in Khulna district represents the disproportion of EC and chloride value in consideration of the standard value provided by ECR (Environmental Conservation rules), Bangladesh and WHO as the present values of EC and chloride have exceeded those standard values, the intrusion of salinity have increased in the river. In the Sibsa river in Khulna district showed that the EC and chloride (high and low tide) value were extremely high as compared to permissible level. As the values increased day by day between 2008-2011 years, we can assume that the disaster (SIDR) may have been the reason for the widespread increase of salinity levels in the study area. In the Chalna station of Rupsha river in Khulna district shows that, as the other earlier studies over the river areas, the EC and chloride values were again on the rising in between 2008-2011, it was also found that the EC and chloride (high and low tide) value were higher than standard level (Table 6). That's why we can clearly assume that the disaster (SIDR) is the possible reason for the salinity intrusion and the excess values of EC and chloride in the river water. Further advance measurement and analysis is required to evaluate more possible reasons for the salinity intrusion in the study area.

Table 6. EC, Chloride ion concentrations in different station of Khulna district.

Year	EC (µS/cm)		Chloride (mg/l)		Standard			
					Bangladesh, 1997		WHO, 2006	
	High tide	Low tide	High tide	Low tide	EC (µS/cm)	Chloride (mg/l)	EC (µS/cm)	Chloride (mg/l)
Khulna station of Rupsha river in Khulna district								
2007	*	*	*	*	2000	150-600	*	250
2008	5339.80	4696.40	2670.18	2546.58	2000	150-600	*	250
2009	11180.96	10380.81	5523.75	5257.60	2000	150-600	*	250
2010	11145.96	10350.30	6622.71	5620.35	2000	150-600	*	250
2011	7670.00	6902.50	3835.00	3452.75	2000	150-600	*	250
Bhadra river in Khulna district								
2007	*	*	*	*	2000	150-600	*	250
2008	9655.56	8692.60	4829.17	4346.30	2000	150-600	*	250
2009	2975.00	2440.00	1487.50	1215.00	2000	150-600	*	250
2010	8276.77	7433.44	4370.00	3716.25	2000	150-600	*	250
2011	8929.58	8485.00	4465.00	4242.00	2000	150-600	*	250
Sibsa river in Khulna district								
2007	*	*	*	*	2000	150-600	*	250
2008	9655.56	8692.60	6308.83	5858.00	2000	150-600	*	250
2009	2975.00	2440.00	6736.83	4855.31	2000	150-600	*	250
2010	8276.77	7433.44	6865.83	6391.67	2000	150-600	*	250
2011	8929.58	8485.00	6460.42	4513.75	2000	150-600	*	250
Chalna station of Rupsha river in Khulna district								
2007	*	*	*	*	2000	150-600	*	250
2008	9095.27	8243.25	4545.13	4121.63	2000	150-600	*	250
2009	9970.00	9023.13	4955.47	4514.00	2000	150-600	*	250
2010	9706.98	8860.52	4866.56	4428.85	2000	150-600	*	250
2011	8520.00	8240.83	4280.83	4107.92	2000	150-600	*	250

Source: Salinity data were collected from BWDB (Bangladesh Water Development Board, Dhaka 1215. Bangladesh Standard; 1997, WHO (World Health Organization) guideline; 2006. N.B: (*) Indicated that the data were not available.

4. Conclusions

Salinity is one of the most severe environmental factors in the coastal region of Bangladesh. Bangladesh is considered one of the most vulnerable poorest countries to climate change of the world. From data analysis found that the relationship between salinity data, rainfall and temperature we considered many types of graphical representation, table in Satkhira and Khulna district coastal region river water and the salinity data exceeds the permissible limits of Bangladesh and WHO guideline. Then survey in a region of South-Western Bangladesh was selected. Special emphasis was given on Gabura and Buri Goalini union under Shyamnagar upazilla of Satkhira district. We observed that salinity increases with time. Sometimes salinity decreases because of increasing rainfall or decreasing temperature. With the salinity intrusion to reduce by structural management like coastal embankment projects, dam, sluices and coastal area zoning as non-structural management to change the land use and other activities can be the vision of sustainable livelihood and environment of the coastal region of Bangladesh.

Conflict of interest

None to declare.

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