First time report on the weather patterns over the Sundarban mangrove forest, East Coast of India

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In order to understand the current weather pattern of the Sundarban, a comprehensive data base of meteorological parameters were collected from Satjelia Island of Sundarban and analyzed for a one year period and a long term set up has been commissioned to understand the climate change patterns of the region.

[Key words: Weather pattern, Sea level rise, Mangroves, Sundarbans.]

Introduction

India has been identified as one amongst 27 countries which are most vulnerable due to the impact of climate change and accelerated sea level rise as a consequence of global warming[1]. Intergovernmental Panel on Climate Change (IPCC) projected that the state of tropical forest ecosystems is likely to get worse due to climate change. IPCC predicts that the global mean temperature may increase between 1.4 and 5.8°C by 2100[2]. Among the Indian state, West Bengal become the top in the list of vulnerability owing to the presence of vast low lying mangrove in its south eastern part (Fig.1a). Inhabitants of the Sundarbans have been living with extreme weather events, rising sea levels, changing natural environments, and other stresses for centuries. Lifestyles and livelihoods have been regulated by the monsoons, floods and tropical cyclones since the area was first settled about 250 years back. As per some predictions, a 25cm rise in sea level would destroy 40% of the Sundarbans, and a 45cm rise by the end of the 21st century would destroy 75%[3]. Since the entire area of Sundarban is low-lying, parts of it are regularly being submerged during the high tide resulting saltwater intrusion and coastal erosion. Some researchers predict that top dying of *Sundari* trees is likely to be the consequence of slow increase in salinity over a long period of time[4]. Increase in salinity

also affects the species combination and regular succession patterns in the *Sundarbans* as some non-woody shrubs and bushes replace the tree species, reducing the forest productivity and habitat quality for valuable wildlife[4]. It is estimated that the severe cyclonic storms over the Bay of Bengal has increased by 26 per cent over the last 120 years[5]. Resulting cyclonic storm surges in the coastal area will lead to intrusion of seawater into the ground water system and changes in temperature can reduce the agricultural and fishing income[6]. All of these possible changes will ultimately affect the livelihood of the inhabitants in many ways leading to economic losses and affecting their livelihood. Recently Aila-the severe cyclonic storm (SCS) in May, 2009 caused loss of about 130 human lives and ultimately affected 67 lakh people in West Bengal (of which a considerable size lives in Sundarbans). Nearly 9 lakh houses were destroyed and huge damage of crops and property occurred[7]. A simulation exercise has predicted an increase in occurrence of cyclones in the Bay of Bengal in the increased GHG scenario[8-9]. In this backdrop, a Automatic Weather Station (AWS) (Fig.1.(b)) was installed in Satjelia Island (Lat: 22° 05' 28.97" N and Long:88° 52' 06.82" E) in the midst of Sundarbans adjacent to the reserve forest. The weather parameters viz. air temperature, air

pressure, relative humidity, wind gust, wind speed and direction, solar radiation and rainfall are being monitored on regular basis. Collected weather data from February, 2011 to January, 2012 were used for the present study. The objective of this study was to understand the weather pattern over Sundarban, India in an objective manner and to assess the trend in change of climatic set up so as to predict the future.
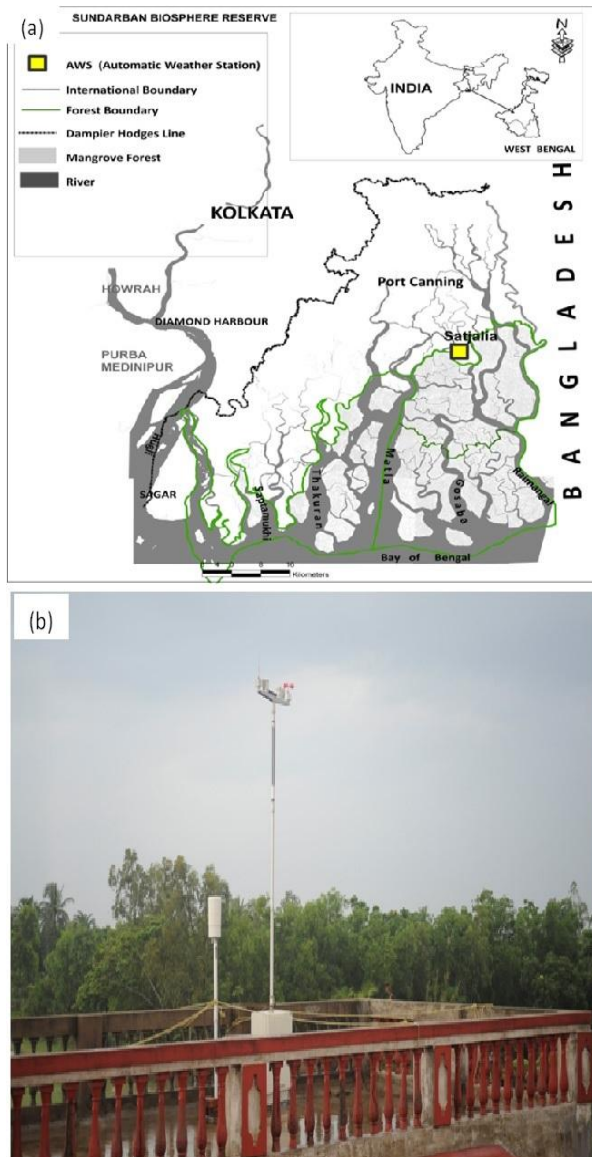

Fig.1.(a). Map showing the study area & (b) AWS

Some parts of Sundarban like Sagar Island, Jambu Deep, Namkhana, Patharpratima, Bkangaduni is susceptible to seasonal ocean currents, tides, waves, winds and cyclones[10]. The monsoonal rainy seasons has shifted to post monsoon season resulting which agricultural productivity affected it would be the direct loss of livelihood and threat

of food security[11]. According to Ananya Roy[10], four disastrous cyclones viz. Sidr, Nargis, Bijli and Aila were originated since 2006. Due to the climate induced cyclonic changes subsequent flooding devastates many households by taking lives, washing away cattle, damaging standing crops and ultimately rendering agricultural land unproductive[11]. A recent study reported that, rate of erosion in Indian Sundarban is showing increasing trend and even inland parts of dense mangrove like Mayadwip, Dalhousi, and Bhanga were also eroded and nearly 44.042 sq.kms of land loss were observed due to frequency and intensity of severe cyclonic storm[12] resulting sea level rise, it is closely related with rise in sea surface temperature which favor the formation of cyclone.

Materials and Methods

The Automatic Weather Station (AWS) make of Aandeera (Norway) was installed at Anpur, Satjelia Island of Sundarban (Lat: 22° 05' 28.97" N and Long: 88° 52' 06.82" E) to monitor the weather parameters of the Sundarbans. Sensors for this station are of the Aandeera half-bridge type (VR22). Hardware of the AWS includes a ground based Cabinet for the Data logger, Data Storage Unit (DSU) Rain gauge and accessories. Cabinet is equipped with a mast that supports a sensor arm for the atmospheric sensors. A Solar Cell Power module was installed as an integrated part of the mast. Atmospheric variables viz. air temperature; air pressure, wind speed, wind direction, relative humidity, solar radiation, net atmospheric radiation and rainfall were observed at twenty minutes interval and calculated to hourly basis and finally deliberated monthly data. Data collected in this method for one year period (from February, 2011 to January, 2012) was taken for the present study.

Result and Discussions

Temporal variation of air temperature in Sundarbans has been recorded from 11.96 to 37.0°C (Fig.2a). Surface water temperature has been raising at the rate of 0.5°C per decade over the past three decades in the *Sundarbans*, eight times the rate of global warming rate of 0.06°C per decade[13]. That makes the *Sundarbans* one of the worst climate change hotspots on the globe. On a global scale, temperature is an important limiting factor but on regional and local scales variations in rainfall, tides, waves and river flow

have a substantial effect on distribution and biomass of mangrove forests[11]. In the present observation, maximum air temperature value was recorded during pre monsoon in the month of June and minimum value was recorded during post monsoon in the month of January, 2012. Air temperature has been gradually increasing from January and reaching peak value in June. Thereafter, air temperature has shown a decreasing trend up to January (2012). From the study it was observed that, three different phases of mean temperature are persisting during the entire study period. The mean temperature is increasing from February through May and then gradually decreasing during till October 2011. Thereafter, sharply decreasing (during post monsoon) till January 2012, due to winter effect. Since, this is the first kind of study in Sundarban, continuous monitoring of air temperature could be useful to understand weather pattern/ assess the climate change/ global warming phenomenon as expressed in Sundarbans. During the study period, maximum atmospheric pressure of 1018.1 mb was recorded during post monsoon in the month of January 2012 and minimum of 1002.3 mb was recorded in the month of June 2011 (Fig.2b). Owing to the summer effect and high temperature, air pressure had decreased from February to May and then gradually increasing up to January due to cooling atmospheric effect and heavy rainfall. During the present study, air pressure shows the decreasing trend during summer season due to hot air and summer effect and increasing trend during northeast monsoon due to the rainfall and cooling effect[14]. A close relationship exist between air temperature and pressure and the low pressure system (LPS) play an important role in the distribution of rainfall during the period of summer season over India[15]. In the present study, 2365.8 mm of Rainfall was recorded in 128 days; minimum (0.2 mm) and maximum (839.8 mm) were recorded in the month of November and August respectively (Fig.4). During monsoon season, 1597.6 mm rainfall was recorded over a time span of 4 months (in 75 days) and monthly rainy days are given in Fig.4. There was no rainfall observed in February and November months during the study period. Interestingly, the rainfall pattern during this year in Sundarbans somehow differs from the overall rainfall pattern over the entire district of South 24-Parganas. As per the record available (Fig.4.b), the maximum rainfall in South 24-Parganas district is recorded in the month of July during monsoon season.
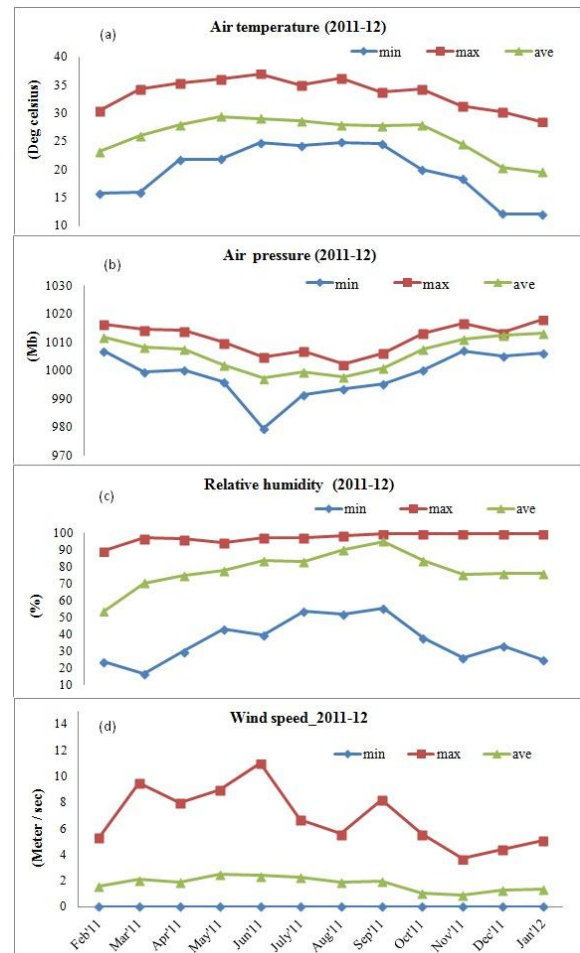

Fig.2. Monthly variations of (a). Air temperature (b). Air pressure (c). Relative humidity (d).Wind speed.

Rainfall determines agricultural productivity of any region in terms of crops to be produced, farming system to be adopted and the nature and sequence of farming operations to be followed and to achieve higher agricultural productivity as well[16]. This is particularly important for a region like Sundarbans, where other than rainfall; no other source of irrigation exists. It has been reported that the pattern of rainfall in Sundarbans has already changed; making conventional cultivation of crops difficult for farmers[11]. In rain fed agriculture, the total amount of rainfall as well as its distribution affects the plant growth[17-19]. It has already been indicated that the average rainfall in Sundarbans comparatively high and the humidity averages 70-80% due to the nearness of the Bay of Bengal. As per the available records, the mean annual rainfall varies from about 1,800mm at Khulna (Bangladesh part of Sundarbans), and 1,920mm at Jhingakali north of the Sundarbans, to 2002mm recorded at the observatory on the western coastal island of Sagar and/or 2,790mm on the Bangladesh coast[20].

Relative humidity (RH) is an important weather parameter which influences the day to day activities of human beings and other living things. Relative humidity measurements increased from 16.7%, in the month of March to 99.5 % in September27 (Fig.2c). From the observed data, the mean annual relative humidity was calculated as 78.4. Maximum RH was recorded due to rainfall effect and minimum RH was recorded during summer due to hot weather, which diminished the RH value. From this, it was understood that, there is an empirical and semi empirical relationships exist between air temperature and relative humidity[21]. The daily temperature fluctuation is influencing the variation of relative humidity. Monthly mean wind speed was recorded from 0.9 to 2.5 m/sec and minimum and maximum were recorded in November and May respectively. Monthly maximum wind speed (11m/sec) was recorded in June and minimum (3.7m/sec) was recorded in November (Fig.2.(d)). Wind speed is high in hot weather condition and low in cold weather, wind flow pattern is influencing the wind speed of the study area. Wind gust was recorded between 7.7 and 20.2 m/sec (Fig.3e). Low wind gust is following the wind speed trend and high wind gust was recorded in March. In the present observation, two distinct wind flow patterns were observed. During pre monsoon season, from March to July, wind flows from South West (SW) through SSW (in May-June) and gradually wind direction was changing to S and SE. Thereafter, flow was changing to NNE in October and NNE direction persisted till January (Fig.3f). Solar radiation (SR) is the radiant energy emitted by the Sun in the form of electromagnetic waves. SR is one of the most important factors affecting climate and environment, and its long-term variation is of much concern in climate change studies. Measurement of solar radiation is of primary importance because it provides the most essential information for evaluation of climate changes and global warming due to its high sensitivity to the anthropogenic disturbances[22]. During the present study, solar radiation recorded from 921.8 to 1549.2 w/sqm (Fig. 3 g). Maximum value was recorded in the month of June 2011 and low value was observed in November 2011. Net atmospheric radiation recorded between 711.3 and 1196.7w/sqm. Maximum and minimum value was recorded in August and November months respectively. Mean solar and net radiation of the study area was 202.5 and 115.82w/sqm (Fig.3h).
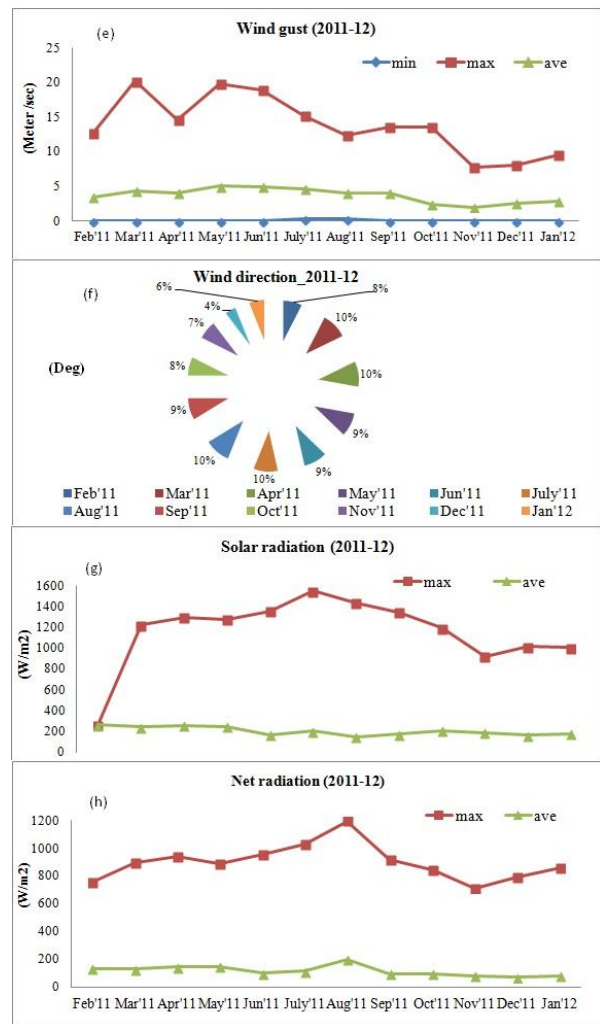

Fig.3. Monthly variations of (e). Wind gust (f). Wind direction (g). Solar radiation (h).Net radiation
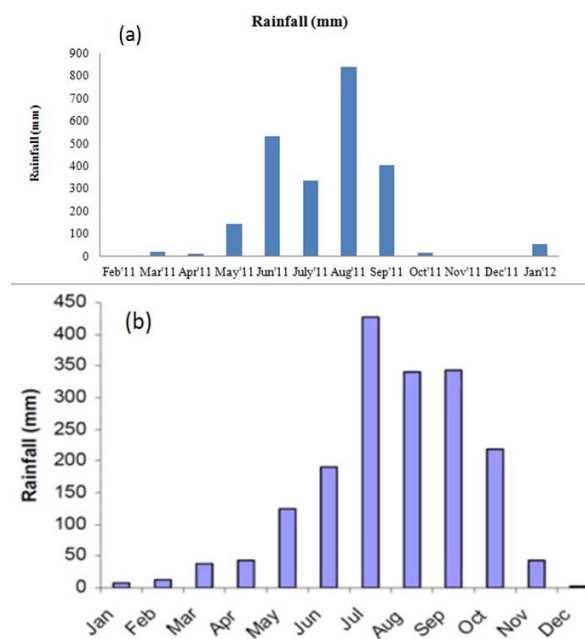

Fig.4.Rainfall in Sundarbans (a) and South 24 Parganas (b)

Conclusion

Sundarbans is already affected by climate change from increasing salinity and extreme weather events like tropical cyclones. A network of automatic weather observatories spatially separated from each other need to be installed over the entire region to demonstrate the spatial variability in weather trends due to varied response to climate change.

Acknowledgement

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