CORRELATION BETWEEN TEMPERATURE CHANGE AND EARTHQUAKE IN BANGLADESH

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ABSTRACT
With more than 160 million people, Bangladesh is ranked as 8th most populous place on earth. Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures and high humidity. Natural disasters such as floods, tornadoes and earthquakes affect the country yearly. Geographical location of Bangladesh makes it ideally suited to earthquake. Scientists have come to recognize that it sits at the juncture of several active tectonic plate boundaries. Study area are selected as Sylhet, Barisal, Cox's bazar, Dhaka, Rangpur and Rangamati district based observatories. The seismic data is of duration between 1988 and 2008. This paper introduced the feasibility of the approach and methods to find a possible correlation between temperature change and earthquake.

Keywords: Temperature; earthquake; tectonic plate; seismic data

INTRODUCTION
In the past, a great number of thermal deviation associated with strong earthquakes were recorded in China. This aroused seismologists to consider the possibility of predicting earthquakes by monitoring the changes in temperature. Analysis of seismicity with temperature shows that strong earthquakes are associated with thermal deviation and measuring temperature can be used to monitor and predict earthquakes. In general, the deviation starts to appear in more than one month before a strong earthquake with covering area of thousands Km^2. Temperature abnormally increases 1^0 C or more in one month, and 2^0 C or more, even 10^0 C in a half month. The epicenter locates within the anomaly area (Huangguangsi; Luo Zhaofu). The Chinese succeeded in warning the local population about a large Earthquake in Haicheng (a city in northern China) in 1975. The magnitude of the Earthquake on the Richter scale was 7.3. As a consequence of the warning, people were moved from several areas within the city to the outskirts. The City's inhabitants numbered 500,000. It was estimated that 90% of the buildings in the city collapsed in the earthquake, resulting in 2,000 people losing their lives. It has been estimated that the warning saved the lives of thousands of people, perhaps as Many as 100,000 (Celin Wangetal., 2006). The notion that earthquake prediction was possible was gaining impetus. The Chinese prediction was based on a number of observations. To name a significant few, they observed small earthquakes, changes in the levels and chemical content of ground water, changes in surface elevation, as well as changes in the magnetic field and electrical signals. Koshiyama (1976), who was actually involved in a survey, at the time of the measurement, particularly the deviated ground disturbance just before (probably one or two hours) the Tonankai earthquake of 7 December, 1944. According to his description, a strong wind was blowing, so the author further examined the weather conditions and observed the velocity of the wind and the atmospheric temperature at the Hamamatsu weather station. This figure does not show any anomalous weather condition during the period before and after the Tonankai earthquake. In particular, the velocity of the wind was not very high immediately prior to the earthquake. So it is not reasonable to attribute the systematic anomalous change in levelling data to a change in weather conditions. In Northern areas of Pakistan, from 1961 to 2005, collected data in this period shows increase in earthquake frequency. The main factors for increase in earthquake frequency can be the temperature. Increase of temperature is

causing glaciers to melt thus releasing pressure on Earth below which in turn possibly rebounds, causing earthquakes (Usman, M., Qureshi, S.N. and Amir, 2010). Some recent research has found a correlation between a sudden relative spikes in atmospheric temperature 2-5 days before an earthquake. It is speculated that this rise is caused by the movement of ions within the earth's crust, related to an oncoming earthquake. Scientists analyzing the March 11, 2011 earthquake in Japan reported a sudden spike in the temperature in the atmosphere above the quake site detected just before the event. Bangladesh is extremely vulnerable to seismic activity. Accurate historical information on earthquakes is very important in evaluating the seismicity of Bangladesh. Information on earthquakes in and around Bangladesh is available for the last 250 years. The earthquake record suggests that since 1900, more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This brings to light an increased frequency of earthquakes in the last 30 years. This increase in earthquake activity is an indication of fresh tectonic activity or propagation of fractures from the adjacent seismic zones. So, it is important to know about the trend of earthquake that has occurred in the past so that we can prepare ourselves for the future. At a glance, several factors that were incorporated with earthquakes are temperature variation, wind velocity, changes in the levels and chemical content of ground water, changes in surface elevation as well as changes in the magnetic field and electrical signals. The aim of this paper is to find out possible relationship between temperature variation and earthquake to know about the possible trend of earthquakes ahead.

METHODOLOGY

The temperature data and seismic data contains twenty year period from 1988 to 2008. To find temperature change, maximum temperature of the specific day on which earthquake occurred and maximum temperature of five days before it is found out. The temperature data is provided by Bangladesh Meteorological Department and seismic data are collected from Earthquake-report.com website. Following recent earthquakes in Bangladesh were taken into study (Data courtesy: NOAA Natural Hazards database).

Table 1: List of Earthquakes in Bangladesh (1988-2008)

Date			**Earthquake location in Bangladesh**		**Earthquake Parameters**	
Year	Month	Day	Location	Zone	Focal Depth (Km)	Magnitude
1988	February	6	Sylhet	I	33	5.8
1989	June	12	Barisal	III	6	5.1
1999	July	22	Cox's Bazar	II	10	4.2
2001	December	19	Dhaka	II	10	4.5
2002	June	20	Rangpur	II	40	4.5
2003	July	26	Rangamati	II	10	5.7
2007	November	7	Rangamati	II	29	5.1
2008	January	12	Rangamati	II	34	5.0

Table 2 contains date and temperature data for selected areas collected from Bangladesh Meteorological Department

RESULT AND DISCUSSION

Figure 1 to 8 summarizes graphical representation for the data obtained from table 1 and table 2. The earthquake ensued in February 6, 1988 at 14:50 hit Sylhet with a magnitude of 5.8. [Fig. 1] shows temperature data of previous five days before that earthquake. Temperature variation is in ascending order until the day earthquake occurred. [Fig. 2] Shows ascending and descending variation of temperature just before the day earthquake hit Barisal with a magnitude of 5.2.

Table 2: TEMPERATURE DATA AND DATE OF EARTHQUAKE ENSUED

Place	Date and Maximum temperature (^{0} C)						Temperature Difference
Sylhet	1/2/88	2/2/88	3/2/88	4/2/88	5/2/88	6/2/88	1.7
	27.8	28	28.3	30	30	28.3	
Barisal	7/6/89	8/6/89	9/6/89	10/6/89	11/6/89	12/6/89	2.1
	32.6	34	34.5	33	33	32.4	
Cox's Bazar	17/7/99	18/7/99	19/7/99	20/7/99	21/7/99	22/7/99	2
	32	31.5	29	28.1	31	30	
Dhaka	14/12/01	15/12/01	16/12/01	17/12/01	18/12/01	19/12/01	1.2
	24.5	26.7	25.7	26.9	26	25.7	
Rangpur	15/6/02	16/6/02	17/6/02	18/6/02	19/6/02	20/6/02	1.5
	28.5	29.5	30.5	29	27.9	29	
Rangamati(2003)	21/07/03	22/07/03	23/07/03	24/07/03	25/07/03	26/07/03	0.2
	31.8	31.8	34.5	33.4	33.6	34.7	
Rangamati(2007)	2/11/07	3/11/07	4/11/07	5/11/07	6/11/07	7/11/07	1
	31.5	27.2	30.4	29.5	29.4	30.5	
Rangamati(2008)	7/1/12	8/1/12	9/1/12	10/1/12	11/1/12	12/1/12	0.2
	26.4	26.6	27.2	27	27.8	27.6	

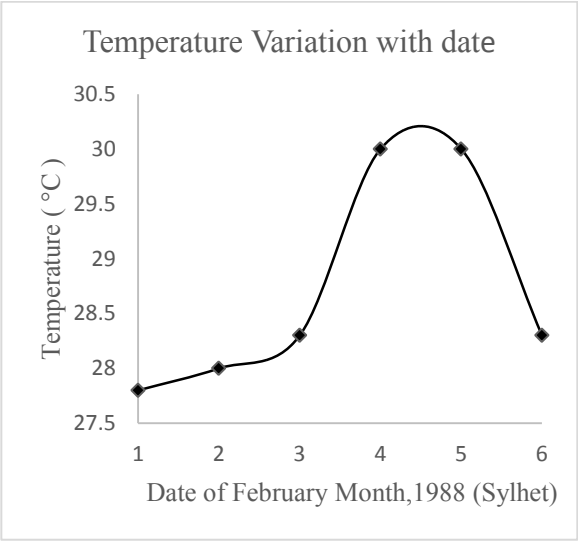

Fig. 1: Temp. Data for 1/2/1988 to 6/2/1988

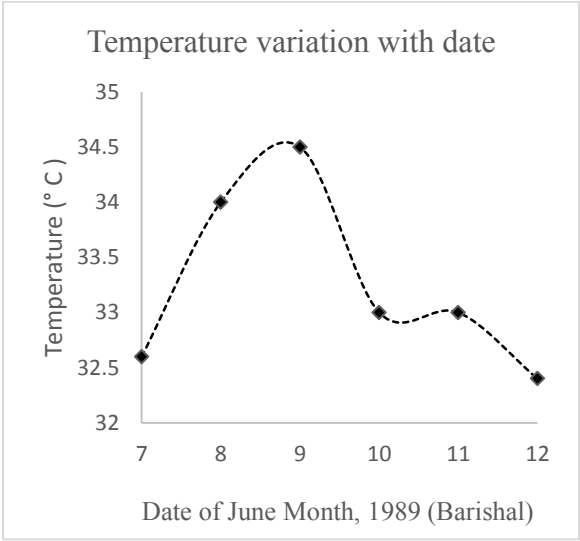

Fig. 2: Temp. Data for 7/6/1989 to 12/6/1989

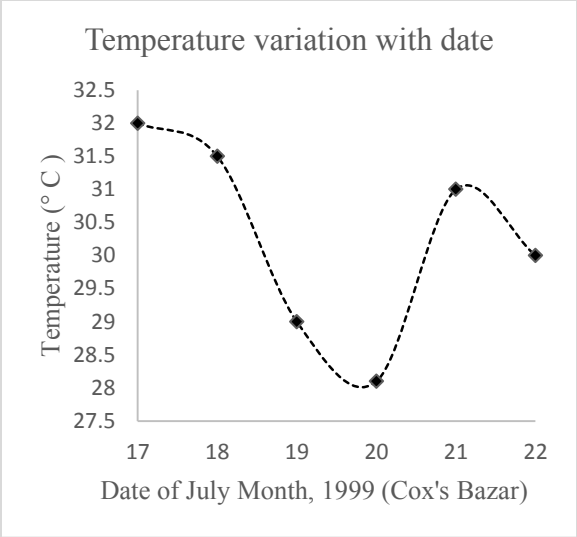

Fig. 3: Temp. Data for 17/7/1999 to 22/7/1999

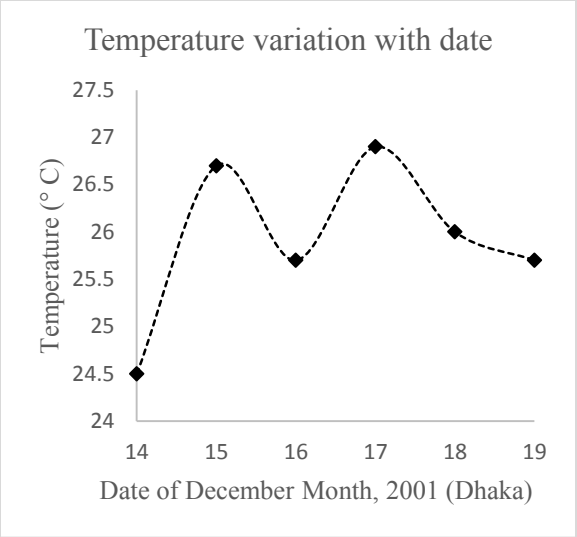

Fig. 4: Temp. Data for 14/12/2001 to 19/12/2001

On 22 July, 1999 at Maheshkhali Island in Cox's Bazar, earthquake occurred with a magnitude of 4.2. It was severely felt around Maheshkhali Island and the adjoining sea. Focusing into the temperature variation in [Fig. 3], temperature continued to fall down up to 20th July, but raised to 31^0 just before the day earthquake occurred. The earthquake of December 19, 2001 with magnitude of 4.5 and focal depth of 10 km was located very close to Dhaka city. [Fig. 4] shows temperature variation close to sine curve type for this earthquake.

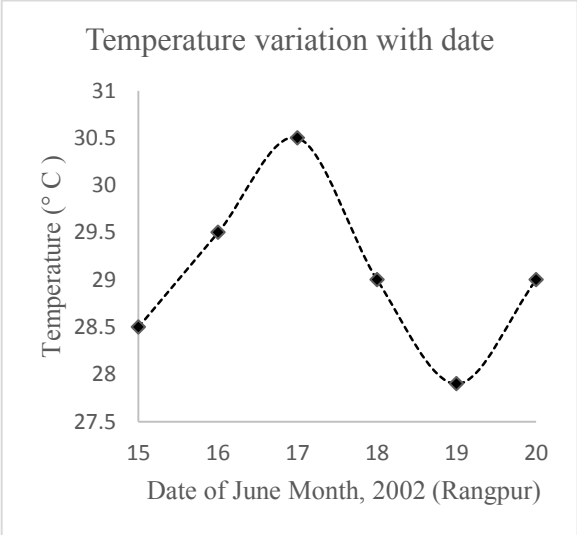

Fig. 5: Temp. Data for 15/6/2002 to 20/6/2002

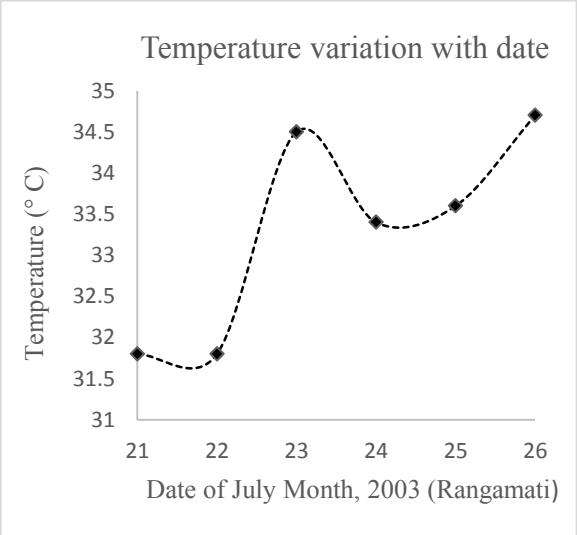

Fig. 6: Temp. Data for 21/7/2003 to 26/7/2003

Fig. 5 shows sine curve variation of temperature for the earthquake occurred in 20/6/2002 in Rangpur.

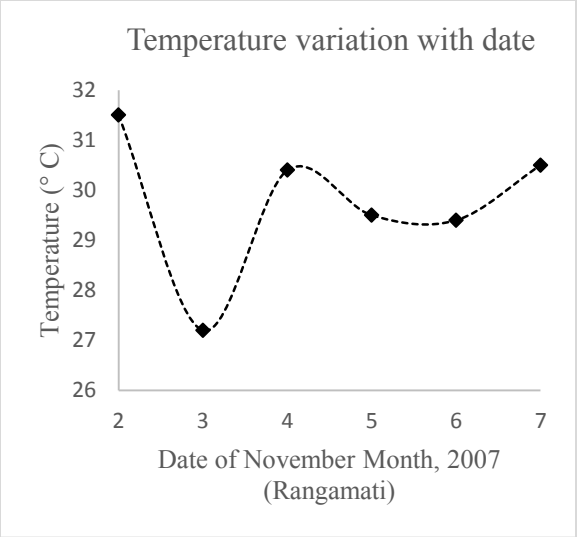

Fig. 7: Temp. Data for 2/11/2007 to 7/11/2007

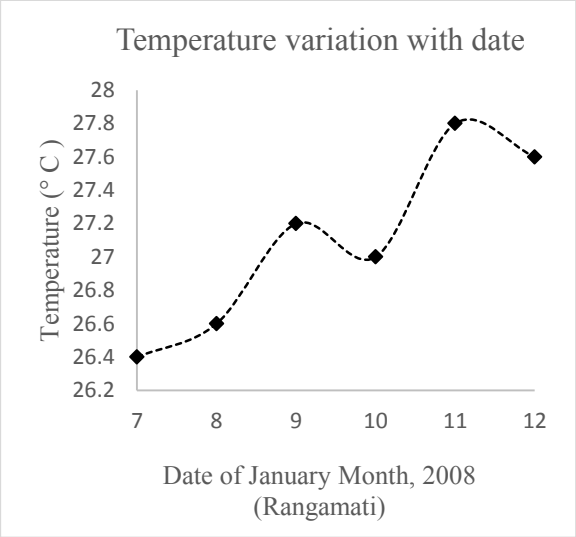

Fig. 8: Temp. Data for 7/1/2008 to 12/1/2008

Fig. 6, 7, 8 shows temperature variation with date for earthquakes occurred in 2003, 2007, 2008 respectively for Rangamati district. Of them, Fig. 6 and Fig. 7 temperature variations are quite similar trend.

Considering temperature difference obtained from table 2, following graph is plotted.

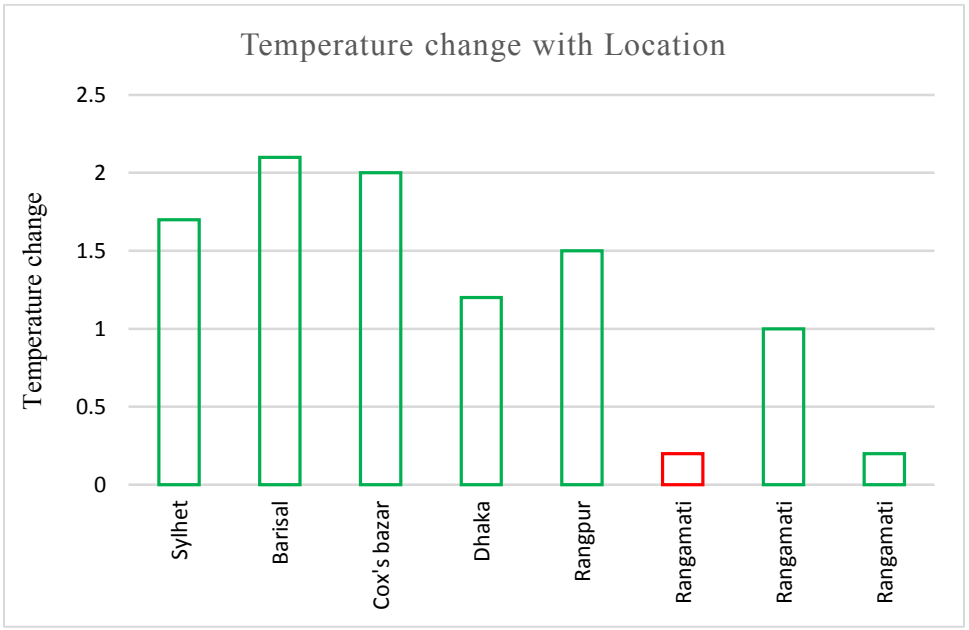

Fig. 9. Temperature change data with different earthquake location in Bangladesh

Fig. 9 shows temperature change for different earthquake location in Bangladesh. Green line indicates decrease in temperature and red line indicates increase in temperature. Temperature decrease for Sylhet, Barisal, Cox's Bazaar, Dhaka, Rangpur, Rangamati (2007) and Rangamati (2008) district is 1.7^0, 2.1^0, 2^0, 1.2^0 and 1.5^0, 1^0 , 0.2^0 C respectively. Only increase in temperature change is 0.2^0 C for Rangamati District earthquake in 2003.

CONCLUSIONS:

Bangladesh is extremely vulnerable to seismic activity. Accurate historical information on earthquakes is very important in evaluating the seismicity of Bangladesh. Information on earthquakes in and around Bangladesh is available for the last 250 years. The earthquake record suggests that since 1900, more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This brings to light an increased frequency of earthquakes in the last 30 years. This increase in earthquake activity is an indication of fresh tectonic activity or propagation of fractures from the adjacent seismic zones. From analysis, considering earthquakes occurred in 2003, 2007 and 2008 with temperature change (positive and negative) following graph is obtained for Rangamati district which is located in zone 3 of earthquake zoning map.

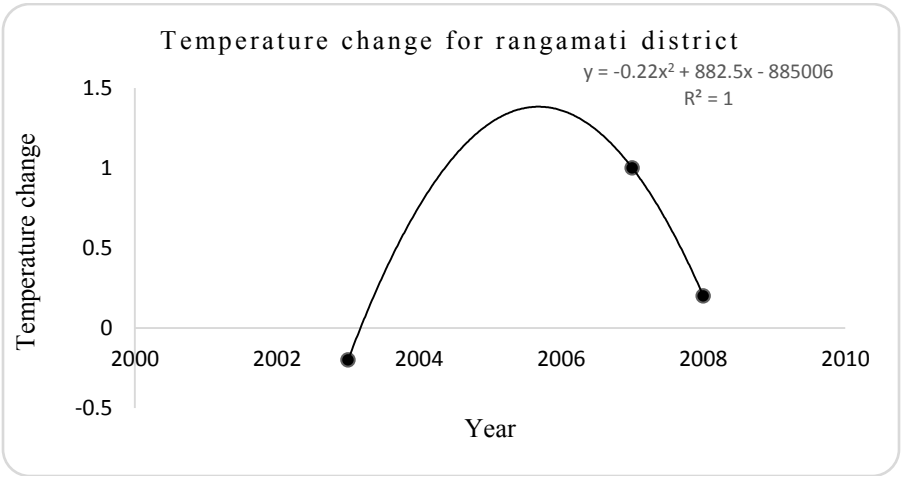

Fig. 10. Temperature change data (positive and negative) for Rangamati District

From Fig. 10, if obtained trend line (polynomial of second order $y= -0.22\ x^2+882.5x-885006$ of $R^2=1$) is further analysed, it can lead to predict earthquakes ahead. Other temperature data can lead to be decisive in finding correlations between temperature change and earthquake for other zones.

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