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Climatic Variability And Its Trend Over Different Region Of Bangladesh

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ABASTRACT

Bangladesh is a small country of South Asia which is considered as one of the most vulnerable countries in the world to climate change and it is affected by severe weather and climate events, which have tremendous impacts on the national economy. In this paper, the recent climatic variability over Bangladesh has been studied. The data of precipitation and surface air temperature for the period 1981-2003 has been used. The time series analysis was applied to investigate the variability and trend over six regions (North west & east, Middle zone, Coastal, Island and Hilly region) of Bangladesh. As a topical county there is small temperature variation in Bangladesh. But there is regional variation between northwest and south zone. In winter there exists a north-south temperature gradient which reverses during summer (pre-monsoon and monsoon). There is an extreme large seasonal variation from winter- to summer- monsoon in Bangladesh. In all seasons the difference of maximum and minimum temperature is higher in the north zone than in the south zone. A remarkable correlation was discovered between this temperature range and the rainfall occurrence. All seasons the mean maximum temperature is increasing except in winter for the northwest and middle zone (-0.004 °C/year and –0.007 °C/year). Hilly region is showing highest increasing rates of mean maximum Temperature in all season (+0.075 °C/ year in winter, +0.064 °C/year in Pre monsoon, +0.055 °C/ year in Monsoon, +0.068 °C/year in Post monsoon); Where as in all season mean minimum temperature is decreasing only hilly region. Overall the temperature is increasing in whole of the country. We also find a positive trend in the rainfall, especially large during the summer monsoon and in the southern zone (in Hilly region, increasing rate of rainfall +17.78 mm/year). The northwest area on the contrary is characterized by decreasing rainfall values both in winter and summer. So we can conclude that the northwest is clearly becoming more arid. May be this is enhanced by the large scale deforestation processes going on.

INTRODUCTION

Bangladesh, a small country of 145,452 km2, extends from 20°45′ N to 26°40′ N, and from 88°05′ E to 92°40′ E (Ahmed S., 2006) and Bangladesh is considered as one of the most vulnerable countries in the world to climate change (IPCC, 2007). The country enjoys the monsoon climate which is the major component of Global climate system. The country is highly vulnerable to floods, tropical cyclones, sea level rise. All these disasters are temperature and rainfall related phenomena.(Miah N.M 2003). So change to temperature precipitation are expected to result in those disasters. In this research it has been found that the precipitation and temperature of the country is changing and the maximum temperature shows a remarkable increasing rate except winter. Increasing rate is higher in south zone than other zone. Overall whole country temperature is increasing as same as global temperature is increasing. It also found that the seasonal variation for both maximum and minimum temperature is rather small where as for rainfall extremely large between winter and summer. In winter there exists a north –south temperature gradient which reverses during summer (pre monsoon and monsoon).In monsoon rainfall is higher in northeast and south zone than other region and the trend of monsoon precipitation is positive in all region of the country except the northwest region (-3.05 mm year); not only it northwest is showing decreeing rate in winter as well So we can say, that the northwest is clearly becoming more arid. There could be more, if China dams the Brahmaputra River in Tibet in 2009 (as it has indicated it will) to divert water to the Yellow River and surrounding areas. (Gunter. G.B , 2008). This research will help the country identify and assess the present status of several climate changes. At the same time comprehensive environmental management plans can be made by using the data and results.

METHODOLOGY

- Temperature and Rainfall data were obtained from BMD.
- Series of 23 years monthly and seasonal mean maximum and minimum temperature and rainfall data from 23 selected station of Bangladesh have been analyzed for the variation and trends over the three zones (6 regions)
- Time series analysis was applied to investigate trend.
- Missing data-overcome by average values obtained by linear interpolation technique
  - graphs were created by MS-Excel.
  - maps created by Arc View software

CLIMATE OF BANGLADESH

- Bangladesh has a tropical monsoon climate characterized by a cool dry season from November through February, pre-monsoon hot season from March through May, the rainy summer monsoon from June through mid-October and a short and mild autumn season from mid October to mid November (Ahmed, 2003a)
- The north-south extent of the country is influenced by some of the most relevant mechanisms of the global climate system, such as the ENSO, MJO, and winter & summer circulation.
- ***In winter**, the upper air westerly jet stream reaches as far south as the southern slope of the Himalayas. This causes the surface-level flow of cool and dry continental air from the upper Gangetic plain toward the Bay of Bengal (Ahmed and Kim 2003).*
- ***In summer**, the moisture laden air flows from the Bay of Bengal toward the interior of northwest India, flowing up the Gangetic valley with (tropical easterly jet stream) in the upper air (Ahmed and Kim, 2003)*

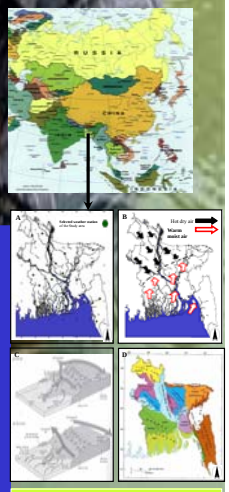


Fig. 1. (A) Study area (B) Zone of discontinuity in pre monsoon season over Bangladesh (C) **The airflow patterns over southern Southern Asia in (a) winter and (b) summer** (Robinson, Peter. J.,et al 1999) and **(D)** Physiographic Map of Bangladesh (Alam, et al. 1991).

PHYSIOCLIMATE OF CLASSIFIED ZONE

1. **Northern Zone:**
   - ***1.1North West Region:** It is located near the foothills of the Himalayas and* The contiguous plain of west Bengal and the Gangetic plain lies to its west. *Relatively dry, shortest duration of the summer monsoon, least number of rain days and least amount of seasonal rainfall Temperature is higherin pre monsoon and coolest) in winter.*
   - ***1.2North East Region:** It is located near the foothills of the Meghalaya Plateau (windward side) which add an orographic effect on the monsoon rainfall*

2.Middle Zone: It is central part of the country and consists of flat plains**.** High temperature and heavy rainfall is Characteristics of the zone.

3.Southern Zone: it is located near Bay of Bengal. This zone (southeast) is the entry and exit point of the Bay of Bengal Branch of the South Asian Monsoon (Spate and Learmonth, 1984; Ahmed and Karmaker, 1993; Ahmed, 1994). Relatively wet, longest duration of summer monsoon. High humidity, heavy rainfall and less temperature variation between day and night ; are characteristics of Southern zone

- ***3.1Costal Region***
- ***3.2Islands***
- ***3.3Hilly Region***

RESULT AND DISCUSSIONS

Seasonal Variation of Temperature

In winter & post monsoon The northwest (max temp 25.48 °C & mini temp 12.21°C) region is clearly the coolest region of the country, Because in mid latitude western jet stream settles south of the Himalayan's that enters into Bangladesh through the northwest corner of the country and. Due to low moisture content of the atmosphere over the region mean minimum temperature is lowest as well.

Pre-monsoon is hottest season (April is hottest month) of country. In pre monsoon and monsoon seasons, the mean maximum temperature, is highest in the middle zone (33.38 °C).

In pre monsoon and monsoon, Island and coastal area (south zone) are showing highest mean minimum temperature where hilly is showing lowest in both season.

There are several reasons for this reversal in regional temperature gradient as compared to the winter season:

(a) During the pre monsoon season, the sun is nearly vertical over middle zone,

(b) Coastal regions and islands are slightly cooler due to the maritime effect, (for same reason, the mean minimum temperature is higher)

(c) Hilly regions are slightly cooler because of the elevation, and

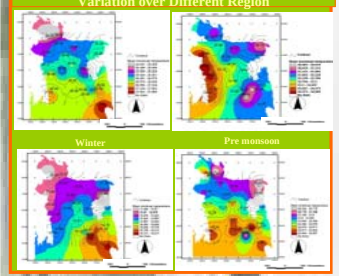
(d) The northern regions are slightly cooler because the sun shines at a smaller angle over the northern regions resulting in lesser intensity of the sun over these

(Ahmed, R., 2005)

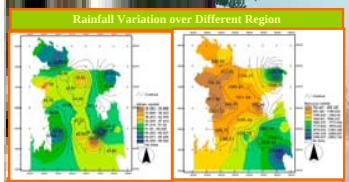
Seasonal variation of rainfall

There is large seasonal variation between winter & summer. Average total rainfall in winter is 49.44 mm. where as in monsoon 1368.36 mm. The northwest region is showing higher winter rainfall than any other region of the country due to the remnants of the Mediterranean disturbances enter the sub-continent through the northwestern corner and causes precipitation along their travel path. Heavy rainfall and long consecutive days of rainfall characterize the monsoon season. As during monsoon the surface wind blows from the southwest direction and carries a lot of moisture from the Bay of Bengal and North Indian Ocean this causes a lot of precipitation over Bangladesh and adjoining countries. Southeast and Northeast receive higher rainfall than other region due orographic effect and coastal process.

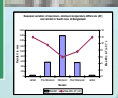
Mean Maximum and Minimum Temperature Variation over Different Region



Rainfall Variation over Different Region



A (-) correlation between AT and the rainfall.AT is lower in south zone & Summer monsoon



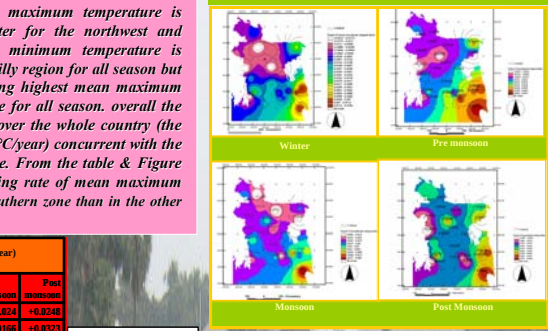
- Rajshahi is (Northwest region) hottest station in pre monsoon & monsoon (34.64 °C & 32.80 °C)
- Cox's Bazer (Southeast region) & Sylhet (Northeast region) receives highest monsoon rainfall (2593.41 mm & 2250.26 mm) due to coastal hill and orographic effect.

Fig. Seasonal variation of the mean max & min Temperature and Rainfall in different region

Trend of Temperature

In all seasons the mean maximum temperature is increasing except in winter for the northwest and middle zone and mean minimum temperature is increasing as well except hilly region for all season but again this region is showing highest mean maximum temperature increasing rate for all season. overall the temperature is increasing over the whole country (the rate of max temp is +0.028°C/year) concurrent with the global temperature increase. From the table & Figure it is clear that the increasing rate of mean maximum temperature is higher in southern zone than in the other zones.

Mean Maximum Temperature Trend

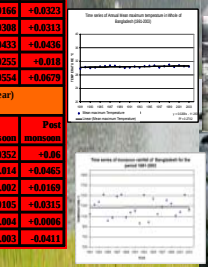


Mean Maximum Temperature Trends (°C/year)

Regions	Winter	Pre monsoon	Monsoon	Post monsoon
Northwest	-0.0004	+0.0076	+0.024	+0.0248
Northeast	+0.0131	+0.0166	+0.0166	+0.0323
Middle zone	-0.0069	+0.0034	+0.0308	+0.0313
Coastal	+0.0361	+0.0375	+0.0433	+0.0436
Islands	+0.0076	+0.0488	0.0255	+0.018
Hilly	+0.0754	+0.0635	+0.0554	+0.0679

Mean Minimum Temperature Trends (°C/year)

Region	Winter	Pre monsoon	Monsoon	Post monsoon
Northwest	+0.0281	+0.0481	+0.0352	+0.06
Northeast	-0.0129	+0.023	+0.014	+0.0465
Middle zone	+0.0019	+0.0102	+0.002	+0.0169
Coastal	+0.0014	+0.0093	+0.0105	+0.0315
Islands	-0.0368	-0.006	-0.004	+0.0006
Hilly	-0.0444	-0.045	-0.003	-0.0411



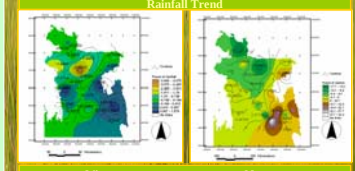
Rainfall Trends in mm/year

Regions	Winter	Monsoon
Northwest	-1.01	-3.05
Northeast	-0.83	0.09
Middle zone	-0.73	0.72
Coastal	-0.13	3.82
Islands	0.16	12.18
Hilly	0.93	17.78

Trend of Rainfall

Restricting ourselves to the two extreme seasons (winter and summer-monsoon) we find that the precipitation trends in the monsoon season are positive in all the regions of the country except the northwest region (-3.06 mm/ year) So we can conclude that in the monsoon period the rainfall is increasing in all regions except in the northwest region. The northwest is clearly becoming more arid. May be this is enhanced by the large scale deforestation processes going on.

Rainfall Trend



CONCLUSION

- The seasonal variation for both maximum and minimum temperature is rather small. But for the rainfall, is extremely large between winter and summer. In winter there exists a north-south temperature gradient and a south-north precipitation gradient which reverses during the other seasons.
- A remarkable negative correlation discovered between the temperature range and rainfall occurrence.
- The maximum temperature shows a remarkable increasing trend in all seasons except in winter for the northwest and middle zone. It was found in this study that trend in the south zone is higher than other zone of the country. Overall the temperature of whole of the country is increasing as same as global temperature is increasing
- A positive trend in the rainfall was found, especially large during the summer monsoon and in the southern zone. The northwest area on the contrary is characterized by decreasing rainfall values both in winter and summer.

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REFERENCE

Ahmed, R., (2005) Personal communication with Professor Rafique Ahmed, Dep. of Geography and Earth Science, University of Wisconsin-La Crosse, La Crosse, Wisconsin 54601, USA.
Ahmed, R. (2004) Abhawa O Jalabayu Bijnan" (in Bangla), Gyankosh Prakashani (publishers), Dhaka, Bangladesh.
Ahmed, R., ed. (2003b) Climate of Bangladesh. In Abhawa O Jalabayu Bijnan[Meteorology and Climatology], 3rd edition. Rajshahi, Bangladesh: University of Rajshahi.
Ahmed, R. (2003a) Climate of Bangladesh. In S. Islam, ed., Banglapedia, Vol. 3, 45–48. Dhaka, Bangladesh: Asiatic Society of Bangladesh.
Ahmed, R., Kim,K. (2003) Variations of Daily Rainfall in Bangladesh during the summer monsoon seasons., Physical Geography, , 24, pp. 295–318.
Ahmed, R. and Karmakar, S. (1993) Arrival and withdrawal dates of the summer monsoon in Bangladesh. International Journal of Climatology, Vol. 13, 727–740.
Ahmed, A. S. M. S., Mustin, A. A., Begum, Q. N., and Chowdhury, A. M. (1996) El-Niño southern oscillation and the rainfall variation over Bangladesh. Monsoon, Vol. 47, 157–162.
Ahmed, R. (1998) Probabilistic estimates of rainfall extremes in Bangladesh during the pre-monsoon season. Indian Geographical Journal, Vol. 64, 39–53.
Ahmed, R. (1994) Variabilities of rainfall and duration of the summer monsoon, and their relationships with monsoon onset dates in Bangladesh. Proceedings of the International Conference on Monsoon Prediction and Variability, Trieste, Italy, May 9–13, Vol. 1, 320–327. WMO/TD No. 619, World Climate Programme, WMO, Geneva.
Brammer, H. (1990) Floods in Bangladesh-I: Geographical background to 1987 and 1988. floods. Geographical Journal, Vol. 56, 2–22.
Climate Change (2007), Synthesis Report, Intergovernmental Panel on Climate Change, IPCC
Climate Change (2001), Synthesis Report, Intergovernmental Panel on Climate Change, IPCC
Chowdhury et al (1997), Consequences of global warming and sea level rise in Bangladesh, Marine Geodesy, 20, 13-31
Chowdhury, M.H.K., Dewsharma, S.K., (1992) Climate Change in Bangladesh- A statistical review report on IOC-UNEP, workshop on impacts of Sea Level Rise due to Global Warming, NOAMI, 16-19 November, Bangladesh pp.15
Chang, C. P. and Krishnamurti, T. N. (1987) Reviews in Monsoon Meteorology. London, UK: Oxford University Press
Das, P. K. (1986) Monsoons. WMO Paper No. 613. Geneva, Switzerland: World Meteorological Organization.
Gunter, G.B, (2008) Effective and Efficient Adaptation Policies in Climate Change in Bangladesh: International Planning Workshop. Bellagio, Italy
Haq, M. S. (1974) Climate of Bangladesh. In A. F. M. Kamaluddin, ed., Studies in Bangladesh Geography. Savar, Bangladesh, and Dhaka, Bangladesh: Department of Geography, Jahangir Nagar University
Huq, S. and Asaduzzaman, M., (2004). Overview. In Vulnerability and Adaptation to Climate Change forBangladesh, S. Huq, Z. Karim, M. Asaduzzaman, and F. Mahtab (eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands.
Haynes, Robin. (1982) Environmental Science Methods, Chapman and Hall Ltd, 11 New Fetter Lane, London EC4P 4EE, UK. Chapman and Hall Ltd, 733 Third Avenue, New York NY 10017 USA.
Islam N (2008) Sidr Cyclone in Bangladesh
Islam, N et al, (2002). International Workshop on Arsenic Issue in Bangladesh. Geological Survey of Bangladesh. Government of the People's Republic of Bangladesh, Ministry of Local Government, Rural Development and Co-operative Local overnment Division.
Karmakar (2008), BMD, Variation of Temperature and Rainfall in Bangladesh
Miah, M.N., (2003) Variation of temperature in Bangladesh. SAARC Meteorological Research Centre, Dhaka, Bangladesh
NERC Centre for Atmospheric Science (2007).Tropical Climate. Reading University
Quadir et al (2003) Climate change an its Impacts on Bangladesh Floods over the Past Decades, SAARC Meteorological Research Centre, Dhaka, Bangladesh
Robinson, Peter. J., Henderson-Seller, Ann. (1999) Contemporary climatology, Pearson Education Limited,
Sarker, M. S. H., (2005) "Temperature and Precipitation Changes in Bangladesh'-MSc thesis in Vrije University Brussels Belgium
Spate, O. H. K. and Learmonth, A. T. A. (1984) India, Pakistan and Sri Lanka. New Delhi, India: Munshiram Manoharlal.