Bangladesh J. Environ. Sci., Vol. 45, 61-70, 2023 @ BAED ISSN 1561-9206

IMPACTS ASSESSMENT FROM FLAMING TEMPERATURE AND RELATIVE HUMIDITY ON HUMAN HEALTH IN SOME AREAS OF BANGLADESH

H. I. Murtuza, R. Afrin*, M. B. Latif, S. S. Chowdhury and M. M. M. Hoque
Department of Environmental Science and Resource Management
Mawlana Bhashani Science and Technology University, Tangail, Bangladesh
*Corresponding author's mail: afrin.mbstu038@gmail.com

ABSTRACT

Heat Index (HI) combines air temperature and relative humidity to determine how hot it actually feels. It has become a matter of great concern in the context of Bangladesh climatology along with most other countries. This paper demonstrates the trend analysis of extreme temperature and relative humidity and assessment of heat index effect on human health by dividing the whole Bangladesh into four regions (South-west region, central region, North-west region, east region). Bangladesh experiences highest value of HI in the month of May-August when it crosses 38˚C. Heat-related illness is already thought to be the leading cause increasing patients especially diarrheal diseases and heat stroke in hospital among meteorological phenomena. This includes classical heat stress in addition to heat-induced episodes of pre-existing illnesses such as respiratory, cardio-vascular, nervous system etc. The trend drawn with the help of average HI anomalies from 1987-2017 has shown tremendous rise in apparent temperature in central and North-west region.

Key words: Heat index, apparent temperature, relative humidity, trend analysis, human health.

Introduction

The 21st climate scenarios produced by several global climate models anticipate a frequency increase in the duration and intensity of the heat waves (Monteiro *et al.*, 2012). Bangladesh is a country that is seriously threatened by climate change (Huq, 2001), which is expected to bring an increase in frequency and intensity of heat waves in the future (Kirtman *et al*, 2013). Evidence points to a substantial mortality increase during hot weather, with stronger heat effects found in cities and among the elderly, children and men (Burkart and Endlicher, 2011). In Bangladesh, the ongoing spell of heat wave is one of the longest (24 days at a stretch) in 30 years. The highest temperature so far this year was recorded 41.2˚C in Rajshahi. It is the highest since April 15, 1964, when it was recorded 44.5˚C in Jessore. Heat waves do indeed lead to more deaths in Bangladesh. Few researches have been on Bangladesh climate condition by (BCAS, 1994; BUP, 1994 and Bangladesh Climate Change Country Study Program, 1997) etc. and all have the same view that Bangladesh is one of the foremost countries extremely susceptible to the unpleasant effects of global warming. The average annual temperature of Bangladesh is expected to increase by 1.4 ± 0.6˚C by 2050 (Solomon, 2007). An estimated 1,300 excess deaths occurred annually during extreme summer heat from 1975 to 2004 (Kalkstein *et al*, 2010) and more than 65,000 people end up in emergency rooms each summer with heat-related illnesses (Hess *et al.*, 2014). Sometimes the mean heat index value ranges from 42° to 59 °C in different parts of the country as result health ailments are reflected through dehydration, heatstroke/exhaustion, and aggravation of cardiovascular diseases in elderly people and reduced work capacity and productivity (Elahi, 2016). This article discusses historical trends and future climate projections in day and night-time heat indices for the Bangladesh. The objectives of the study are: i) Trend analysis of extreme temperature and relative humidity of Bangladesh, ii) Assessment of comparative heat index all over the country and iii) Impacts assessment of heat index effect on human health.

Materials and Methods

The real time data of monthly dry bulb temperature and relative humidity for a period 1987-2017 were obtained from Bangladesh Meteorological Department (BMD), Dhaka in order to calculate heat index. HI was calculated for 13 stations out of 35 stations of BMD. Health data were collected from National Institute of Cardiovascular Disease Bangladesh from 2001 to 2016.

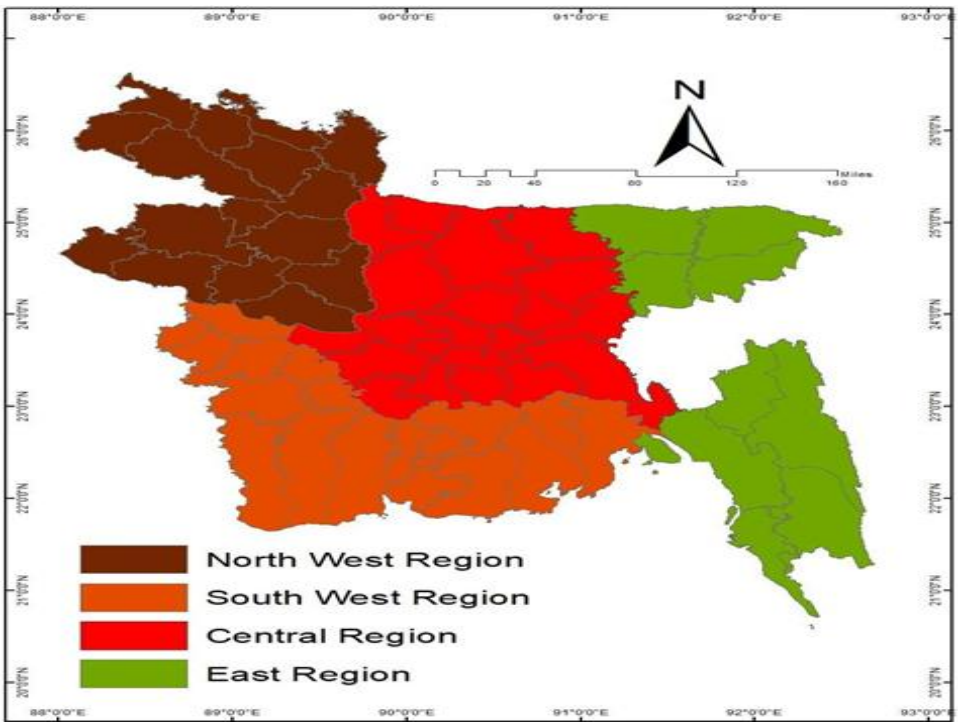

Fig.1. Map showing the study areas (Modified by ArcGIS)

Data Analysis: In order to have a basis for assessing future impacts of climate change, it is necessary to obtain a quantitative description of the changes in climate to be expected (climate scenarios). According to IPCC-TGICA (2007), a popular climatologically baseline period is the 30-year "normal" period as defined by the World Meteorological Organization (WMO). In the present study, 1987–2017 have been considered as the study period. Trend analysis is done by Microsoft Excel. Heat index is as sets by using heat index chart (Fig 2) and following equation:

Relative Humidity %	Air temperature °C										
	21	24	27	29	32	35	38	41	43	46	49
0	18	21	23	26	28	31	33	35	37	39	42
10	18	21	24	27	29	32	35	38	41	44	47
20	19	22	25	28	31	34	37	41	44	49	54
30	19	23	26	29	32	36	40	45	51	57	64
40	20	23	26	30	34	38	43	51	58	66	
50	21	24	27	31	36	42	49	57	66		
60	21	24	28	32	38	46	56	65			
70	21	25	29	34	41	51	62				
80	22	26	30	36	45	58					
90	22	26	31	39	50						
100	22	27	33	42							

Serious risk to health - heatstroke imminent
Prolonged exposure and activity could lead to heatstroke
Prolonged exposure and activity may lead to fatigue

Fig. 2. Heat index chart

The resulting equation could be considered a heat index equation (Rothfusz, 1990).

HI = -42.379 + 2.04901523T + 10.14333127R– 0.22475541TR – 6.83783 × 10-3T2 -5.481717×10-2R2+ 1.22874×10-3 T2R + 8.5282×10-4TR2 – 1.99×10-6T2R2

Where, T = ambient dry bulb temperature (°F), R= relative humidity. Because this equation is obtained by multiple regression analysis (Steadman 1979), the HI has an error of ±1.3°F. The formula is valid only when air temperature and relative humidity are higher than 27°C (80°F) and 40%, respectively.

Statistical Analysis: At the end of data collection, data were compiled, tabulated and analyzed. The statistical analyses were done for this manuscript by using MS Office Excel-2007 and IBM SPSS Statistics 20. The local units were converted in to standard units.

Results and Discussion

Monthly Maximum, Minimum and Average Temperature: The monthly trend of temperature throughout January to December during the period of 1987-2017 is in Table 1. The observations affirmed that the highest values for the maximum (38.44˚C) and average temperature (37.72˚C) recorded in the month of April at South-west and central region, respectively. On the other hand, the highest value of minimum temperature (24.21˚C) was in the month of August at North-West region. This phenomenon noted the coastal zones of Bangladesh like South-West regions of Bangladesh are warmer than that of North-western zone. Hence, unbearable cool is visible in the North-west region of Bangladesh. Increased temperature caused several health- related issues including childhood diarrhea, heat strokes, cardio vascular disease etc. Monthly maximum peak at 38.44˚C during April.

Table 1. Monthly Maximum, Minimum and Average Temperature of south west, central, North-west and east area region in Bangladesh (1987-2017)

Month	South-west			Central			North-west			East		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
Jan	29.11	8.67	18.89	27.88	8.38	18.13	26.94	6.82	16.88	30.91	10.11	20.51
Feb	32.96	11.31	22.13	31.54	10.96	21.25	30.40	9.11	19.75	33.36	12.08	22.72
Mar	36.90	15.55	26.22	35.81	14.79	25.30	35.18	13.03	24.11	36.26	15.60	25.93
Apr	38.44	19.51	28.98	37.72	18.73	28.23	37.37	17.27	27.32	36.39	17.87	27.13
May	37.02	21.23	29.80	37.17	20.44	28.80	37.50	20.06	28.75	36.86	19.59	28.22
Jun	34.76	23.08	30.04	35.95	22.69	29.32	36.42	22.12	29.27	36.47	21.30	28.89
Jul	34.65	23.98	29.37	34.56	24.16	29.36	35.02	23.94	29.48	36.20	22.49	29.35
Aug	35.04	23.94	29.30	34.83	24.09	29.46	35.67	24.21	29.94	36.03	22.68	29.36
Sep	34.61	23.55	29.29	35.21	23.68	29.44	35.23	23.63	29.13	36.38	22.20	29.29
Oct	32.45	19.95	27.28	34.85	20.19	27.52	34.31	18.87	26.59	36.21	19.68	27.94
Nov	29.45	14.80	23.62	32.54	14.99	23.77	31.41	13.12	22.26	34.46	15.46	24.96
Dec	29.15	10.49	19.82	29.08	10.87	19.98	28.42	9.28	18.85	31.34	12.14	21.76

Max = Maximum, Min = Minimum, Ave = Average

However, Monthly minimum the highest rise of temperature of 23.94˚C during August. Moreover, monthly average the highest rise of temperature of 30.04˚C during June in South-west region of Bangladesh during 1987-2017. In central region of Bangladesh during 1987-2017, monthly maximum peak at 37.72˚C during April. However, Monthly minimum the highest rise of temperature of 24.16 ˚C during July. Moreover, monthly average the highest rise of temperature of 29.46˚C during August. In North-west region of Bangladesh from the analysis over the period of 1987-2017, the maximum temperature had observed

37.51°C in the month of May where average temperature was 29.94˚C in the month of August and minimum temperature was observed 24.21˚C during August. Monthly maximum peak at 36.86 ˚C during May. However, Monthly minimum the highest rise of temperature of 22.69 ˚C during August. Moreover, monthly average the highest rise of temperature of 29.36˚C during August in east region of Bangladesh during 1987-2017.

Annual Trends in Temperature and Relative Humidity

South-west region: In the month of January to February the average temperature was increasing where the relative humidity (RH) decreasing trend (Fig. 3), then temperature increasing as well as relative humidity from March to October and then temperature fall with a decreasing trend of humidity from 1987-2017. It reveals that the winter season is being shorter and temperature fall with RH. Again, annual average temperature was changed with an increasing trend where the RH falling in a decreasing trend during 1987 to 2017 (Fig. 3) the east region of Bangladesh. The trend showed that the temperature and RH increase in an increasing rate 0.006 and decreasing rate -0.006 respectively. A study was conducted about RH depends on the temperature and pressure of the atmosphere. A preliminary graphical inspection of the RH over the south-western region of Bangladesh indicated a progression from relatively moist patterns during 1950–1970 to relatively dry patterns during1970-1985 and back to the moist patterns over the course 1985-2010.

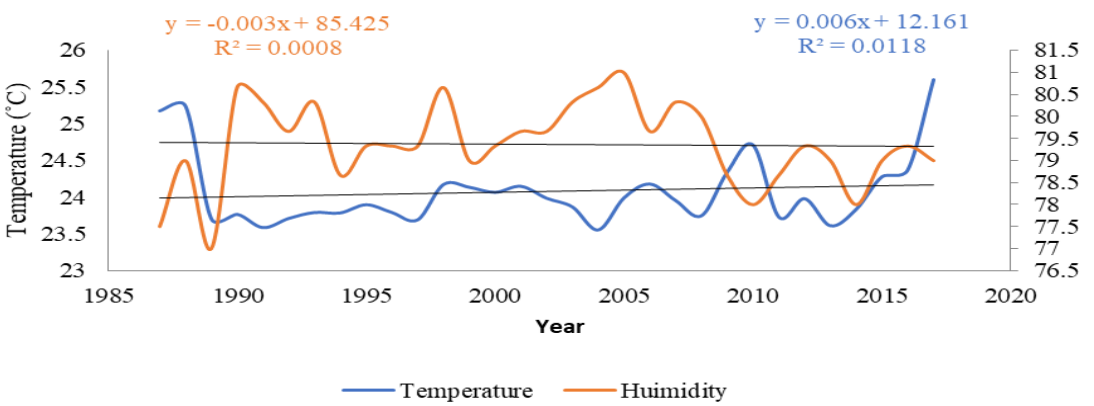

Fig. 3. Trend analysis temperature and humidity in the South-west region during (1987-2017)

Central region: In the month of January to March, the average temperature was increasing where the RH decreasing trend (Fig. 4), then temperature increasing and RH from March to September and then temperature fall with a decreasing trend of humidity from 1987-2017. It reveals that the winter season is being shorter and temperature fall with RH. Again, annual average temperature was changed with an increasing trend where the RH falling in a decreasing trend during 1987 to 2017 (Fig. 4) in the central region of Bangladesh. The trend showed that temperature increase at the rate of 0.0113 on the other hand RH decreases at the rate of -0.0829. The mean temperature rises, RH falls and the average temperature falls, relative humidity rises.

North-west region: In the month of January to March the average temperature were increasing where the RH decreasing trend (Fig. 5) then temperature increasing as well as RH from March to June and then temperature fall with a decreasing trend of humidity from 1987-2017. It reveals that the temperature in the winter season fall immediately as well as RH. Again, annual average temperature was changed with an

increasing trend as well as RH increase during 1987 to 2017 (Fig. 5). In the North east region of Bangladesh at the rate of 0.0097 and 0.0635, respectively.

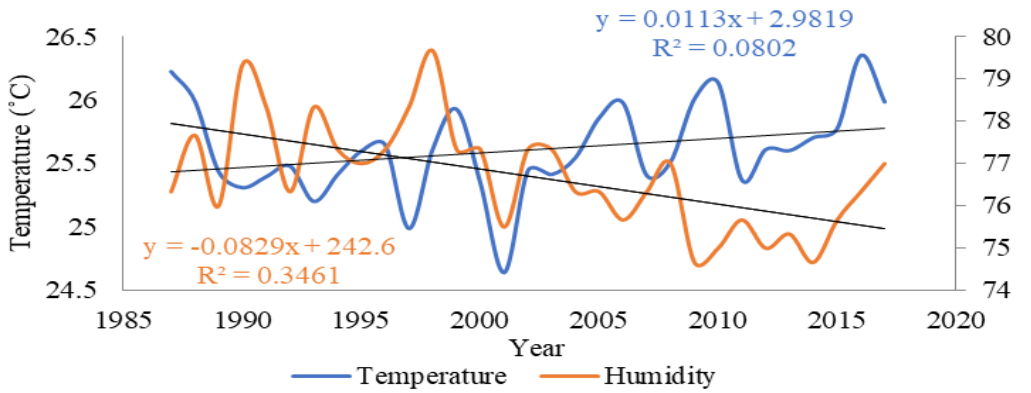

Fig. 4. Trend analysis annual average temperature and humidity in Central region during (1987 2017)

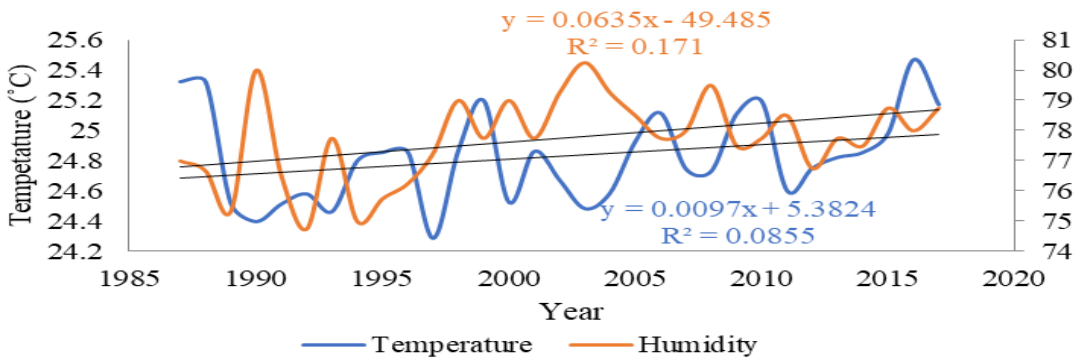

Fig.5. Trend analysis temperature and humidity in the North-west region during (1987-2017)

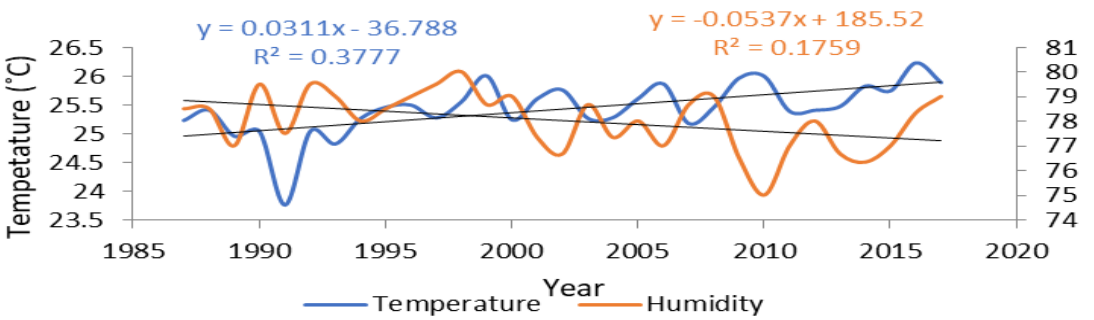

Fig.6. Trend analysis temperature and humidity in the East region during (1987-2017)

East region: In the month of January to February the average temperature was increasing where the RH decreasing trend (Fig. 6), when temperature and relative humidity went on a consistent rate from February to October and then temperature fall with a decreasing trend of humidity from 1987-2017. Again, annual average temperature has changed with an increasing trend where the RH was falling in a decreasing trend during 1987 to 2017 (Fig. 6) in the East region of Bangladesh at the increasing rate 0.0311 and decreasing rate -0.0537.

Increase in heat index (HI): Analysis of HI shows that most of the country is under the effect of HI and annual mean HI value ranges from 18-40 ˚C in different parts of the country and in summer which increase range from 30-45 ˚C, causes serious discomfort to the people of the country. Bangladesh experiences highest value of HI in the month of May- August when it crosses 38˚C in some parts of the country which causes many people to die due to heat stroke. HI has increased in almost all part of the country. The trend drawn with the help of average HI anomalies from 1987-2017 has shown tremendous rise in apparent temperature in central and NWR. The results are shown in Figs. 7-10. It is observed that the HI values increase every 10 years interval all the four regions. In west region the increase of heat is slightly increase where the highest is 37 ˚C in 2008 -2017.In 1987-1997 these are the lowest HI.

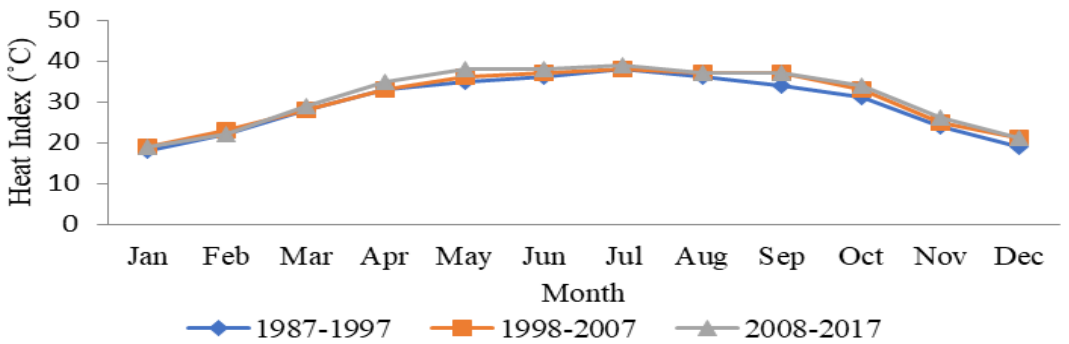

Fig.7. Monthly variation of heat index in the South-west region (1987-2017)

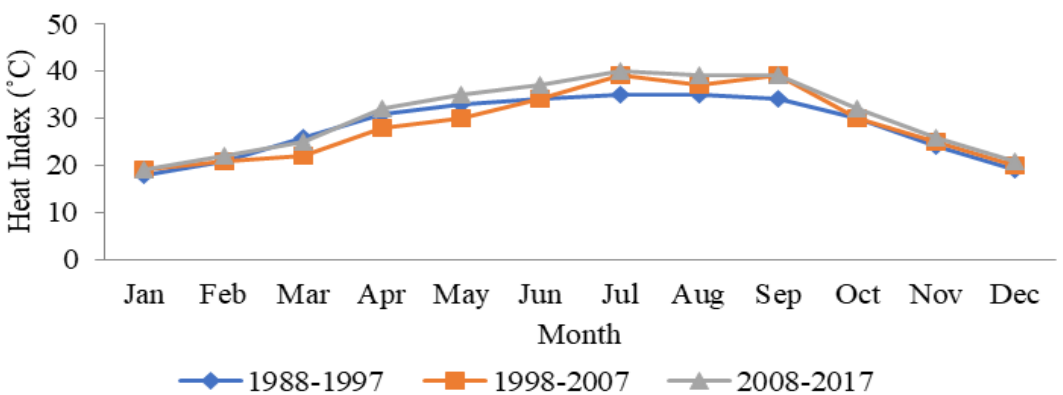

Fig.8. Monthly variation of heat index in the Central region (1987-2017)

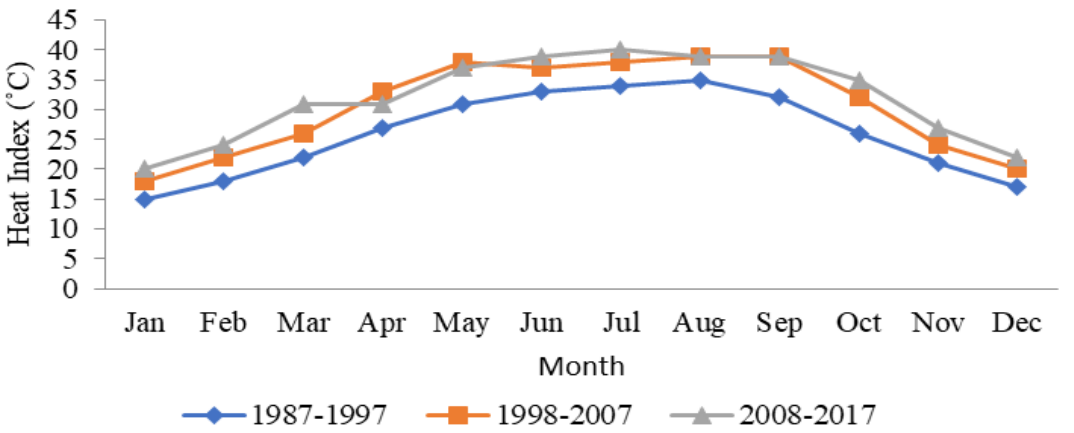

Fig.9. Monthly variation of heat index in the North West region (1987-2017)

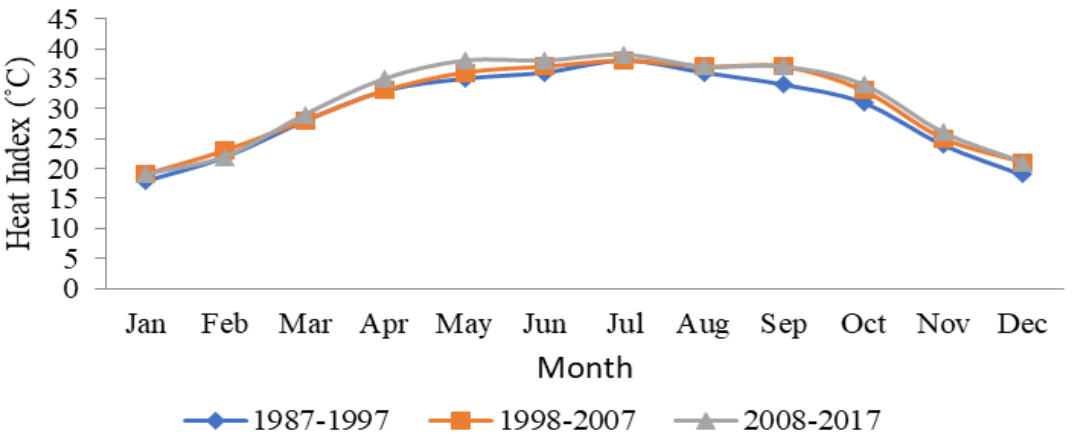

Fig.10. Monthly variation of heat index in the East region (1987-2017)

In central region the HI is much more increase the other part of the region which is more than 2.25˚C where more uncomfortable for human being. In central region the HI is much more increase the other part of the region which is more than 2.25˚C where more uncomfortable for human being. In East region, the areas have moderate increase in the HI, which does not significantly affect human health. The HI in over the over the country is gradually increasing from 1987 to 2007. In March to September when RH is high then HI is also increasing gradually in this month. Bangladesh experiences highest value of HI 8 in the month of May when it crosses 45°C in some parts of the country, which causes many people to die due to heat stroke. Heat index has increased in almost all part of the country. The trend drawn with the help of average (AMJJAS) HI anomalies from 1987-2017 has shown tremendous rise in apparent temperature in central and NWR. In East region HI are not too differ in this region last 30 years. It is almost same in this region.

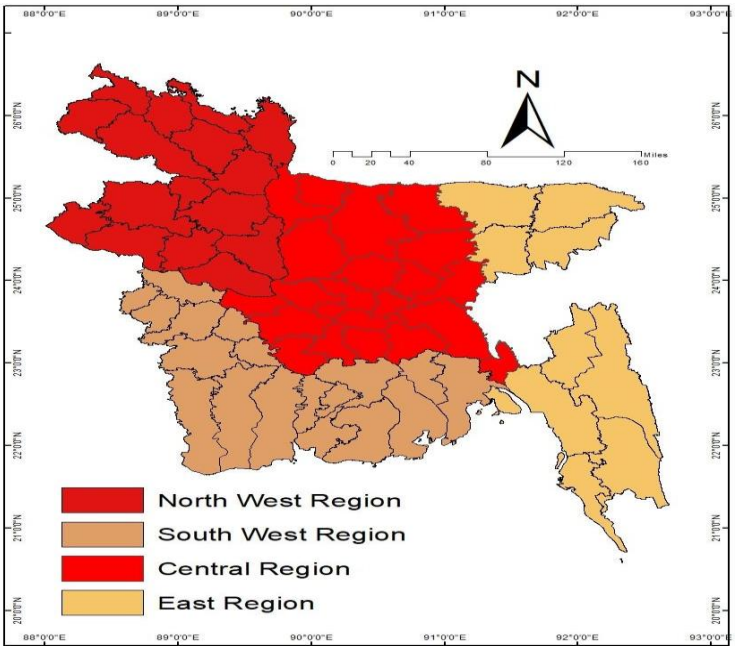

Fig.11. Average heat index anomalies in different parts of Bangladesh (1987-2017)

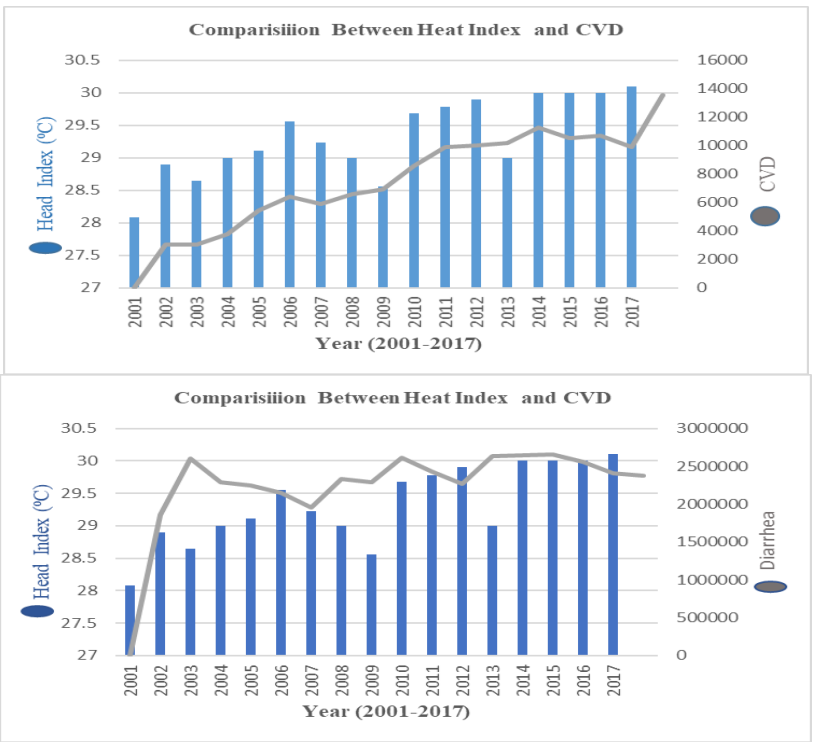

Fig.12. Comparison between heat induced disease and heat index in Bangladesh (2001-2017)

Disease occurred due to HI increase: The monthly incidence of diarrheal and cardiovascular diseases increases with the increase of temperature as well as HI every year during wet season (Nissan *et al*., 2017). So, the pattern of occurrences of these diseases shows increasing trend during 2001-2017 (Fig. 12).

Conclusion

Heat index has become a matter of great concern in the context of Bangladesh climatology along with most other countries. The heat index analysis from 1987-2017 in Bangladesh portrays the significant augment of both temperature and relative humidity in past 30 years. Mean heat index value ranges from 35-45˚C in different parts of the country in summer. Average (AMJJAS) heat index anomalies from 1987-2017 has shown tremendous rise in apparent temperature in SWR, CR, and NWR. Climate variables were associated with the occurrence of childhood diarrhea. Increased temperature and humidity were associated with increased rate of diarrhea morbidity, heat stroke and cardiovascular disease, whereas the relative humidity was inversely related with rate of diarrhea. From 2000 to 2017 Diarrheal disease increases about 52.90% and whereas CVD is 357.03%. The amount of heat index increases up to 7.18%from 2000 to 2020.

References

Bangladesh Climate Change Country Study Program, 1997. Assessment of vulnerability and adaptation to climate change. Final report, Department of Environment, Govt. of Bangladesh.

BCAS-RA-Approtech, 1994. Vulnerability of Bangladesh to Climate Change and Sea Level Rise: Concepts and Tools for Calculating Risk in Integrated Coastal Zone Management; in Four Volumes (Summary report, Main reports and Institutional report), Bangladesh Centre for Advanced Studies (BCAS), Resource Analysis (RA), and Approtech Consultants Ltd., Dhaka.

Burkart, K. and Endlicher, W. 2011. Human bio-climate and thermal stress in the megacity of Dhaka, Bangladesh: application and evaluation of thermo-physiological indices. In *Health in mega cities and urban areas*, Physica, Heidelberg, 153-170 p.

Elahi, K.M. 2016. Climate change and health impacts in Bangladesh. In *Climate Change and Human Health Scenario in South and Southeast Asia,*207-219.

Hess, J. J. 2014. Summertime Acute Heat Illness in U.S. Emergency Departments from 2006 Through 2010: Analysis of a Nationally Representative Sample, *Environ. Health Perspectives*, 122 (11): 1209-1215.

Huang, C., Barnett, A.G., Wang, X., Vaneckova, P., FitzGerald, G. and Tong, S. 2011. Projecting future heat-related mortality under climate change scenarios: a systematic review. *Environ. Health Perspectives*, 119(12): 1681-1690.

Huq, S.,2001. Climate change and Bangladesh.

IPCC-TGICA, 2007. General Guidelines on the Use of Scenario Data for Climate Impact and Adaptation Assessment, Version2. Prepared by T. R. Carter on behalf of the Intergovernmental Panel and Climate Change, Task Group on Data and Scenario Support for Impact and Climate Analysis; Cambridge University Press: Cambridge, UK.

Kalkstein, L. S. and Smoyer, K. E. 1993. *The impact of climate on Canadian mortality: Present relationships and future scenarios*. Atmospheric Environment Service.

Kirtman, B., Power, S. B., Adedoyin, A. J., Boer, G. J., Bojariu, R., Camilloni, I., Doblas-Reyes, F., Fiore, A. M., Kimoto, M., Meehl, G. and Prather, M. 2013. Near-term climate change: projections and predictability.

Rothfusz, L. P. 1990. The heat index equation. Technical attachment, Scientific Services Division NWS Southern Region Headquarters, Fort Worth, TX, SR 90-23.

Monteiro, A., Fonseca, L., Almeida, M., Sousa, C., Velho, S. and Carvalho, V. 2012. Atlasda saúde e da doença–vulnerabilidades climáticas e socioeconómicas na Grande ÁreaMetropolitanado Porto eConcelho do Porto. *Volumes I*, 167.

Nissan, H., Burkart, K., Coughlan de Perez, E., Van Aalst, M. and Mason, S. 2017. Defining and predicting heat waves in Bangladesh. *J. Applied Meteo. Climat.*, 56(10): 2653-2670.

Rajib, M. A., Mortuza, M. R., Selmi, S., Ankur, A. K. and Rahman, M. M. 2011. Increase of heat index over Bangladesh: impact of climate change. *World Acad Sci. Eng. Technol.*, 58:402-405.

Solomon, S. 2007, December. IPCC (2007): Climate change the physical science basis. In *A GUF all Meeting Abstracts*.

Steadman, R.G. 1984, A Universal Scale of Apparent Temperature, *J. Clim. Appl. Meteorol*., 23: 1674-1687.

Steadman, R. G. 1994. Norms of Apparent Temperature in Australia, *Aust. Met. Mag*., 43:1–16.

Steadman, R.G. 1979. The assessment of sultriness. Part I: A temperature-humidity index based on human physiology and clothing science. *J. Applied Meteorol.*, 18(7): 861-873.

Thacker, M.T., Lee, R., Sabogal, R. I. and Henderson, A. 2008. *Overview of deaths associated with natural events,* United States, 1979-2004. *Disasters,* 32(2): 303-315.

Woodward, A., Smith, K.R., Campbell-Lendrum, D., Chadee, D.D., Honda, Y., Liu, Q., Olwoch, J., Revich, B., Sauerborn, R., Chafe, Z. and Confalonieri, U. 2014. Climate change and health: on the latest IPCC report. *The Lancet*, 383(9924):1185-1189.