Research Paper

The Study of Recent Cold Conditions in Bangladesh During 1990 to 2019

Gazi Mamunar Rashid[1,*], Md. Abdullah Elias Akhter[2] and M. A. K. Mallik[3]

[1]Department of Mathematics, Khulna University of Engineering & Technology, Khulna, Bangladesh
[2]Department of Physics, Khulna University of Engineering & Technology, Khulna, Bangladesh
[3]Bangladesh Meteorological Department, Agargaon, Dhaka, Bangladesh.
[*]Corresponding author's email:g.r.mamun1972@gmail.com

Abstract
A cold wave is a weather phenomenon that is distinguished by marked cooling of the air, or with the invasion of very cold air, over a large area. In the present study, mild cold to severe cold wave frequencies have been studied for the winter season (December to February) over most of the stations of Bangladesh for the period 1990-2019 and also for the three decades. The highest numbers of cold wave days are found in Srimangal of all types of events during winter season. The significant highest very severe cold wave days were found in Sayedpur (4 days) among the 30 years after that Srimangal (3 days). The mostly very severe cold wave occurred at Sayedpur in 2013, this year happen 9 days out of 14 of very severe cold days in last 30 years. At Middle decadal period, cold days was less about all of the divisions except Chattogram and Sylhet divisions. January is the highest cold month in Bangladesh. Cold day in Bangladesh is decreased of all divisions except Barishal and Khulna divisions but the mild moderate cold days are gradually increasing there. Overall Northwestern part and Srimangal region cold day has found from spatial distribution. The highest 5 coldest places are Srimangal, Rajshahi, Chuadanga, Ishurdi and Dinajpur and the corresponding highest coldest years are 1993,1995, 2001, 2011 and 2013, respectively.
Key words: Cold day, Decade, Trend analysis, spatial distribution, Divisions.

I. Introduction

Bangladesh is a tropical country, this region normally temperatures fall about 10 degrees Celsius (°C) during January. Mild (8.1-10°C) & moderate (6.1-8°C) cold wave occurs in this month. Severe (4.1-6°C), especially very severe (>=4°C) cold is rare happened in Bangladesh (JNACP, 2014). The cold wave is defined in the occurrence of extremely low temperature of a large area and a number of cold days in succession association with the incursion of dry, cold winds from the north into the sub-continent. The northern parts hilly region of India and adjoining plains area, are influenced by transient disturbances in the mid-latitude westerly's which often have weak frontal characteristics. These are known as western disturbances (Barnett et al. 2012; Bhatla et al. 2016). A cold surge, alternatively called a cold wave or northern winter monsoon surge, is a primary subsystem of the East Asian winter monsoon (Ou et al. 2015; Tao et al. 2020). All the cold events resulted in a huge amount of damage and great economic loss (Samra et al. 2003). Crop yields in the cold wave year were lower of different percentage (Samra et al. 2003). Extreme temperature events (mainly heat and cold waves) caused significant adverse impact on mortality from plenty of diseases worldwide (Chen et al. 2020). In this century, extremes cold are observed at mid-latitudes (Tao et al. 2020). Basically, the northwestern part of Bangladesh is getting so much of cold wave rather than southeast part. Rangpur, Dinajpur, Rajshahi, Thakurgaon, Nilphamari, Kurigram, Lalmonirhat, Gaibandha areas are the coldest part in winter season in Bangladesh. North and southwest parts of the Bangladesh experienced a few cold waves (UNDP Bangladesh, 2010).

Some studies have suggested that Arctic warming, along with decreased sea ice, has resulted in a wavier jet stream and slower Ross by waves because of a reduced meridional gradient of the air temperature. This favor blocking over higher latitudes, which leads to more frequent and intense cold spells in the multitudes

over the Northern Hemisphere (Ma & Zhu, 2019). The evidences of impacts of climate change across the world and also the geographical location of Bangladesh have experienced different types of adverse phenomena that there has been an increase in climate extremity such as heat wave, sudden moderate cold wave (Pradhan et al. 2019; Karmakar et al. 2019; Spinoni et al. 2015). Though cold day in Bangladesh is gradually decreasing of all divisions, but mild cold wave at Barishal and moderate cold day at Khulna division are increasing. From 1990 to 2019 last 10 years all types of cold wave recorded more than others decadal period. Among 30 years, 1995 is the highest coldest year and 2009 is the lowest cold day recorded year. From spatial distribution, it shows coldest area which are Srimangal and Northwestern part of Bangladesh.

So, now according to the experts' opinion of Bangladesh Meteorological Department (BMD), it can easily be stated that, Bangladesh is currently experiencing a severe cold wave. Northern and southwest parts of the country experienced a rapid fall in temperature on 1 January, 2010. Temperatures have remained low since, with cold winds and serve fog. Poor people in the northern region of the country are the worst affected. The impact of the cold wave has resulted in a significant rise in respiratory illnesses, and in some cases death. BMD has predicted that a further one or two severe cold waves (04°C - 06°C) is likely to sweep across the northern and central parts of the country during the remainder of January (UNDP Bangladesh, 2010).

Objectives: The selective objectives of this paper are to-
i) find out the number of cold days during 1990-2019,
ii) observe the cold day condition of decade period and also observe those division wise, and
iii) detect mild, moderate and severity of cold events using spatial distribution.

II. Data and Methodology

The 1990-2019's of cold day data have been taken from the Climate Section of the Bangladesh Meteorological Department (BMD). Cold day data are found out from the daily minimum temperature. There are four types of cold waves counted by the BMD. Those are mild (8.1-10°C), moderate (6.1-8°C), severe (4.1-6°C) and very severe (>=4°C). One missing data are replaced by the average value of nearest data, but 2 or more missing value at a time are replaced by the surrounding station areas average value. All of the data have been calculated using excel and Arc GIS software. FORTRAN language has been used for the calculating cold day duration.

III. Result and Discussion

3.1 Mild and moderate cold days feature of all divisions of different duration of Bangladesh:

The total numbers of mild and moderate cold day's features of all divisions at different duration of Bangladesh are shown in Fig. 1(a-g). It shows, at middle decadal period, all types of cold days were less at all divisions. The highest number of mild cold and moderate cold days shows at Rangpur (483 & 139 days) and Khulna (482 & 188 days) divisions at 2010-2019 duration. The lowest number of mild cold and moderate cold days are observed less 224 & 30 days in Barishal division.
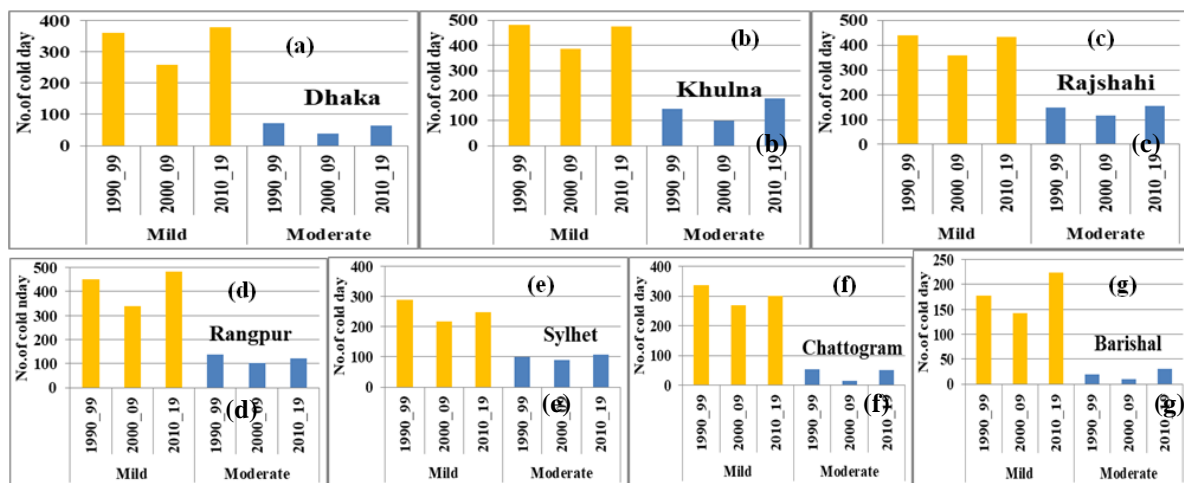

Fig. 1(a-g): Mild and moderate cold days feature of all divisions of different duration of Bangladesh

3.2 Severe and very severe cold days feature of all divisions at different duration of Bangladesh:

The Severe and very severe cold days feature at all divisions of different duration of Bangladesh are displayed in Fig. 2(a-g). It is very important that there is no severity in Barishal division. The highest number of

severe and very severe cold days are at Rangpur division (18 & 7 day) at 2010-2019 period but in Rajshahi divisions 1990-1999 shows very severity. On the other hand at Sylhet divisions all of the decadal period has showed very severity though it is no majority. At Dhaka and Chattogram divisions no very severity days among 30 years has found.
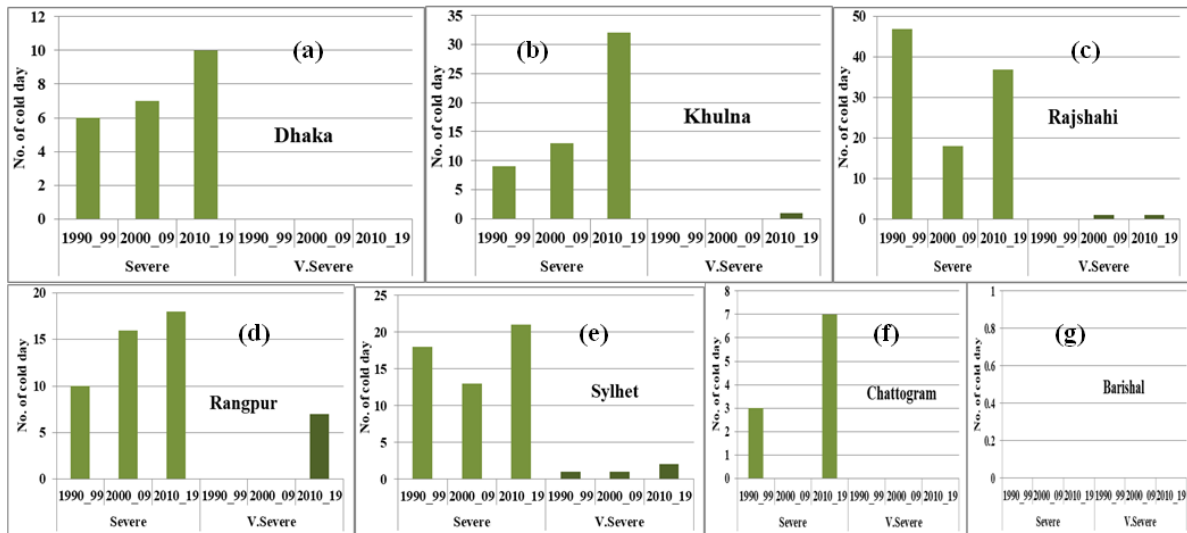

Fig. 2(a-g); Severe and very severe cold days feature at all divisions of different duration of Bangladesh

3.3 Mild cold days variation and trend analysis:
Mild cold days variation and trend analysis has been showed in Fig. 3(a-g). It shows all of the division mild cold wave is decreasing except Barishal division where number of cold wave day is increasing.
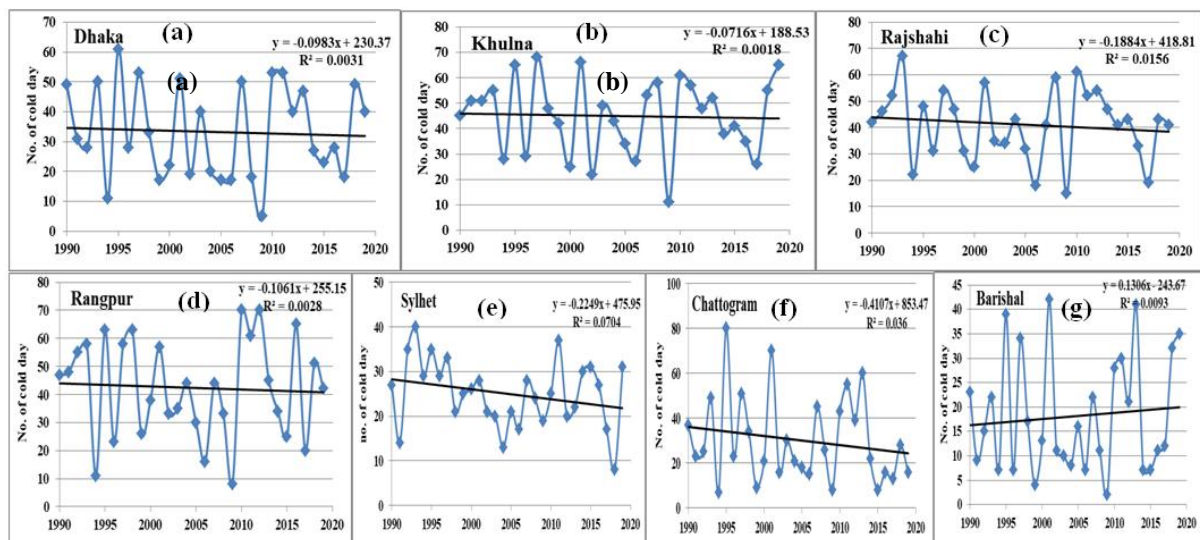

Fig. 3(a-g): Mild cold days variation and trend analysis from 1990-2019

3.4 Moderate cold days variation and trend analysis:
Moderate cold days variation and trend analysis are shown in Fig. 4(a-g). It shows most of the divisions moderate cod wave days are decreasing except Khulna and Barishal divisions. Here due to last 5/6 years increasing number of cold days, trend became increasing.
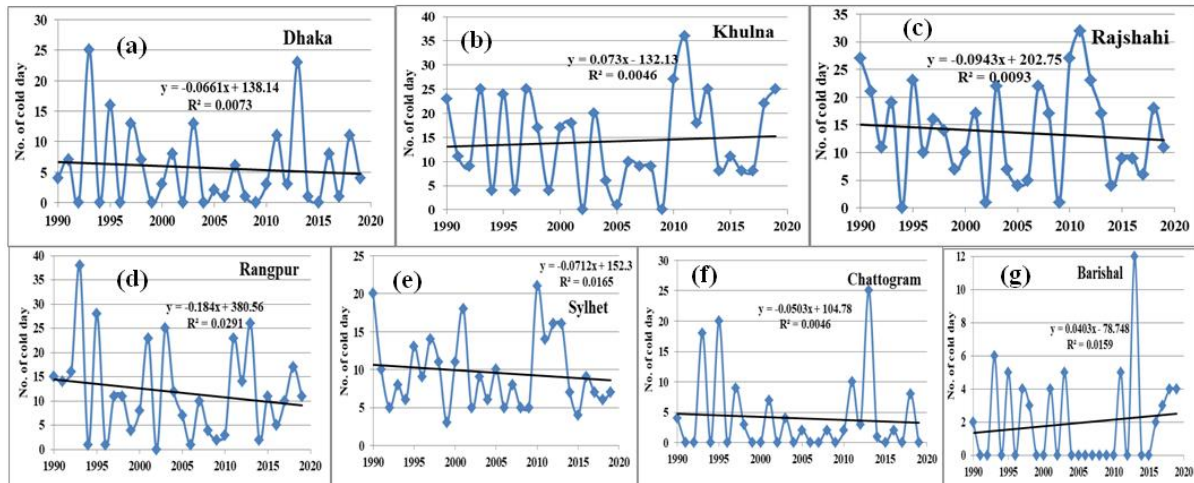
Fig. 4(a-g): Moderate cold days variation and trend analysis from 1990-2019

3.5 Coldest and less cold year of 34 stations in Bangladesh:

Coldest and less cold year of 34 stations from 1990-2019 in Bangladesh showed in Fig. 5 (a-e). It has been seen the highest coldest year is 1995 where no. of cold day is 551 and lowest is 2009 where no. of cold day is 76. If we observe separately of all types of cold day, the highest no. of cold days moderate, severe and very severe cold days (204) is 2013 except mild cold days where highest days 391 in 1995.
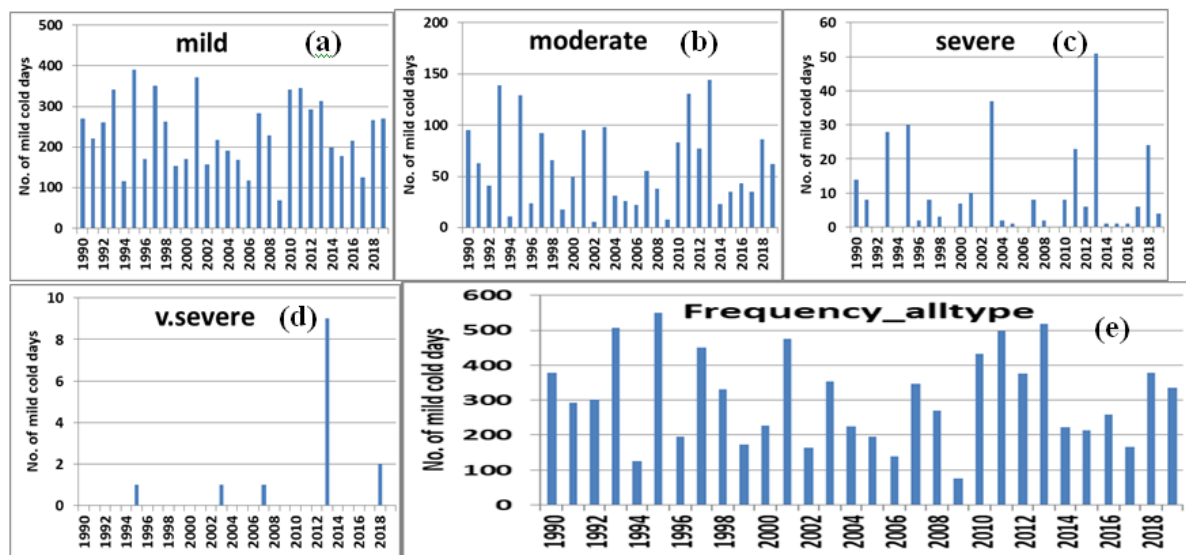

Fig. 5(a-e): Coldest and less cold year of 34 stations in Bangladesh

3.6 Division wise 3 days or more duration cold wave and its frequency:

Division wise 3 days or more duration cold wave has been showed in Fig. 6(a-f). Here it shows in December highest cold wave place in Srimangal at all winter month. It shows , in December highest cold wave takes place at Tangail in Dhaka, Srimangal in Sylhet, Dinajpur in Rangpur, Ishurdi in Rajshahi, Chuadanga in Khulna, Barishal in Barishal and Cumilla in Chattogram division, in January, Tangail in Dhaka, Srimangal in Sylhet, Sayedpur in Rangpur, Rajshahi in Rajshahi, Chuadanga in Khulna, Barishal in Barishal, Sitakunda in Chattogram divisions and in February, Tangail in Dhaka, Srimangal in Sylhet, Dinajpur in Rangpur, Rajshahi in Rajshahi, Chuadanga in Khulna and Sitakunda in Chattogram divisions. The graph also shows that, highest number of total days are not all time highest number of frequency. Overall Srimangal is the coldest place among all the places in Bangladesh during 1990-2019.
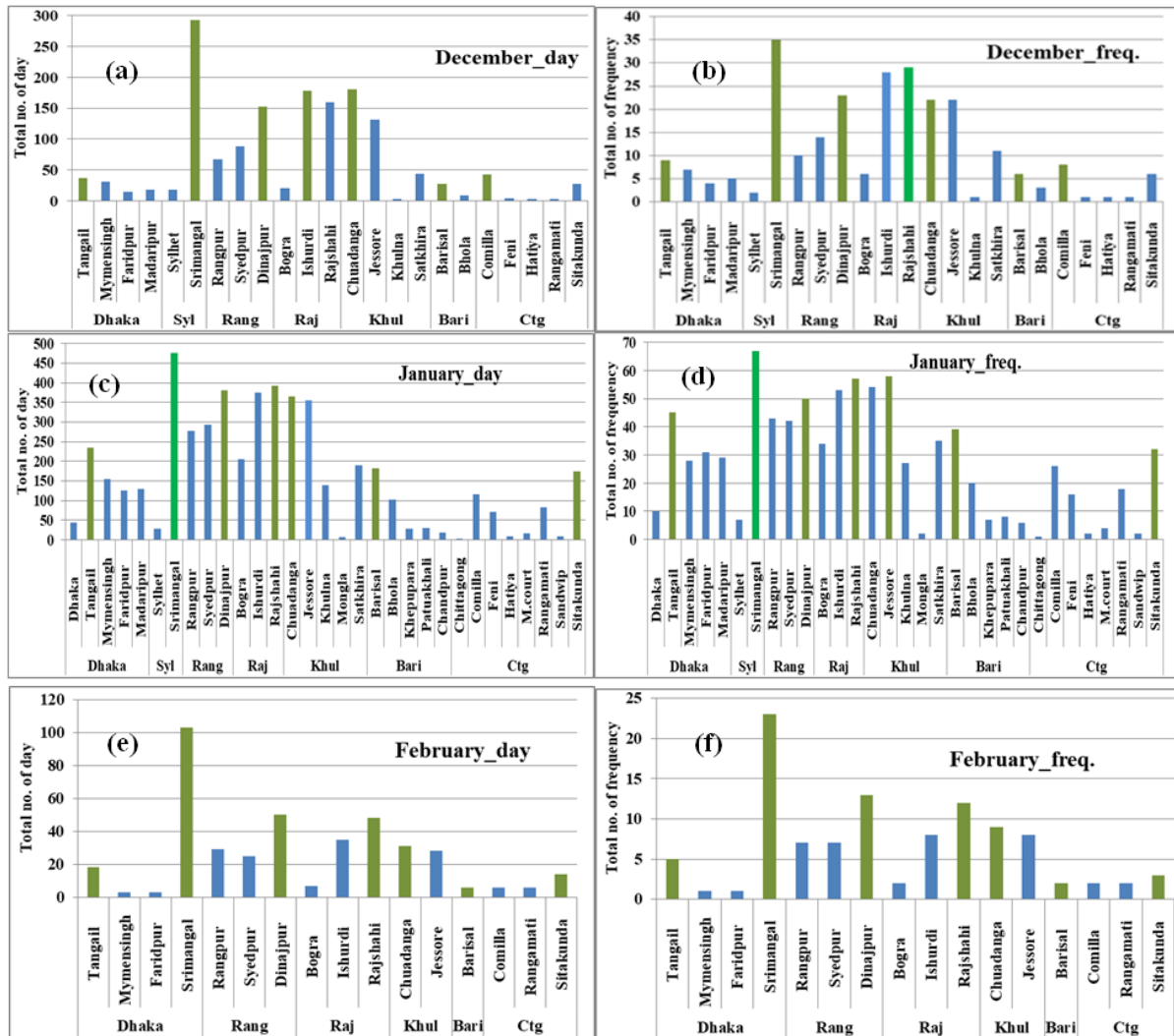
Fig. 6(a-f): Division wise 3 days or more duration cold wave from 1990-2019

3.7 Spatial distribution of Monthly and seasonal cold days in Bangladesh:

Mild cold and moderate cold wave from December to February are shown in Fig. 7(a-c) and Fig. 7(d-f). Here less than 6 days mild cold wave are shown in Fig. 7(a-c) at northwestern part of Bangladesh in December. In January shows at the same place but that average mild cold days are 8-10 days. But in February the average mild cold days 1day over Bangladesh except Srimangal region. In Fig. 7(d-f), the moderate cold days are shown which is same as the northwestern part of Bangladesh but that average days is December to February 2, 5 and less than 1 day respectively. Here it can be described that less than 1 day in February which is average moderate cold day and it is not available of all year. Moreover, all of the cases, it has been seen Srimangal is the coldest among 34 stations region in Bangladesh.
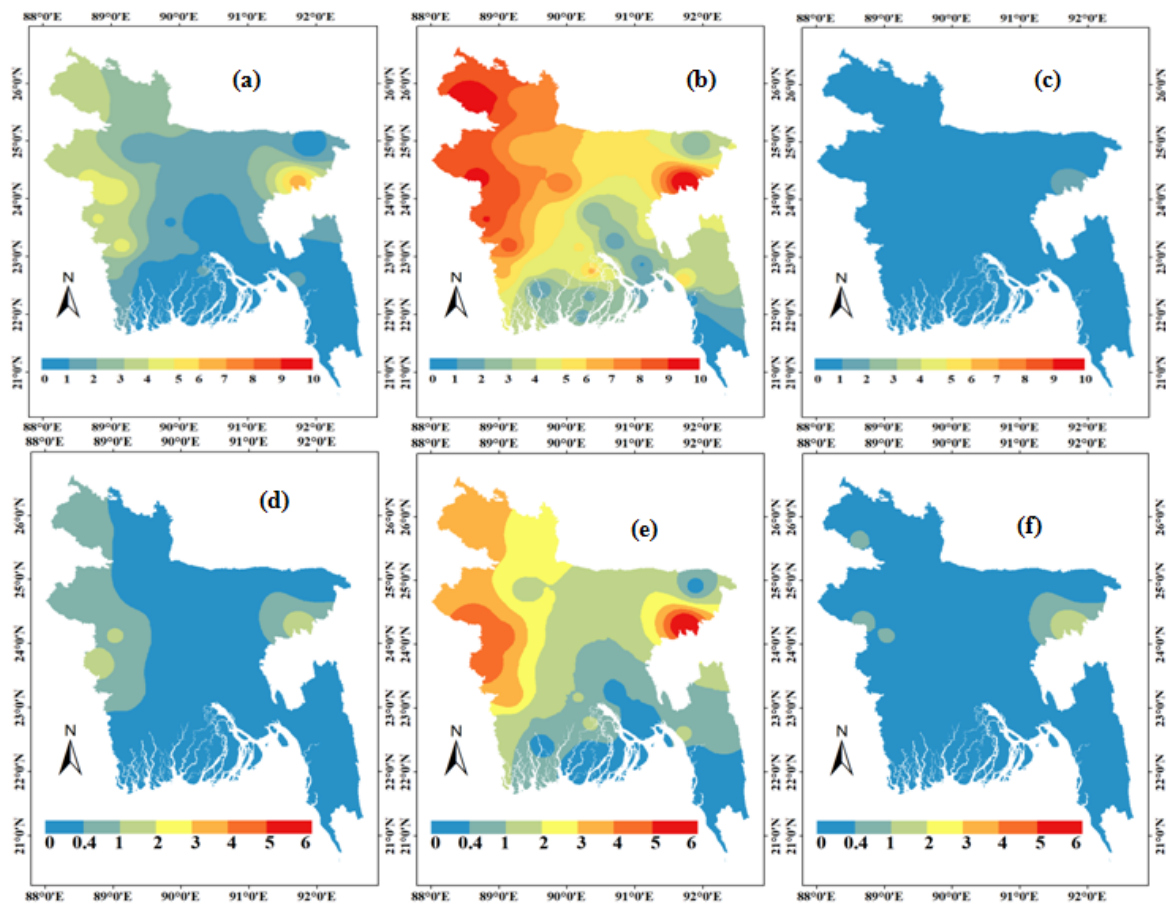
Fig. 7(a-f): Spatial distribution of mild (a-c) and moderate (d-f) cold wave at December to February in 1990-2019

Severe and very severe in January and winter mild- moderate cold days figure has been given in Fig. 8(a-d). Here Fig. 8(a) shows that the average severe cold days in Bangladesh are maximum 2 days which are shows at Chapainababgang and Srimangal. In January, very severe cold days is rare case whereas there are no average very cold days in Bangladesh. Here there are total very severe cold only 14 days among 30 years. Most of them are North Bengal and Sylhet region except 1 day of Chuadanga. In winter the average maximum mild cold is 22 days and the average maximum moderate cold are 9 days. Overall it can undoubtly be said that Northwestern part and Srimangal region cold is the highest cold area and southern part of Bangladesh face very few cold days that means this area is warm area.
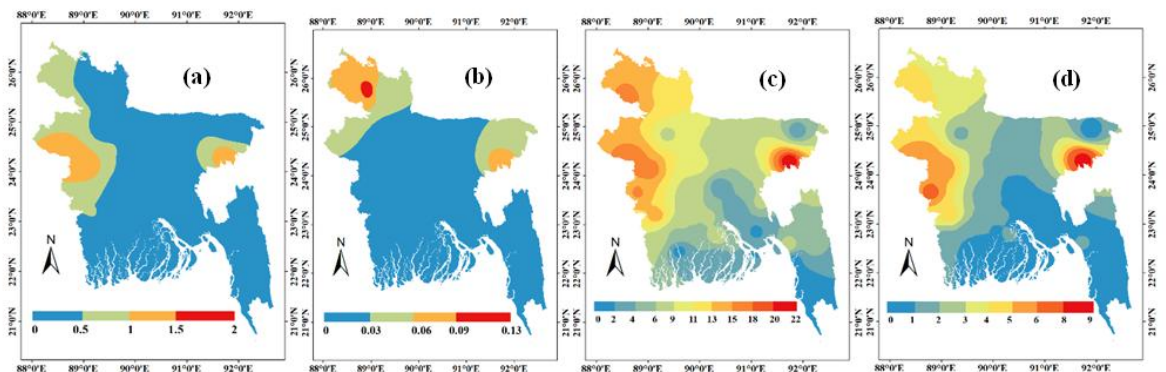

Fig. 8(a-d): Spatial distribution of severe and very severe (a-b) in January and mild-moderate (c-d) in winter cold days of Bangladesh in 1990-2019

IV.   Conclusion:

The highest number of cold wave nights is found in Srimangal (3 days) of all types event during winter season. The significant highest very severe cold wave days were found in Sayedpur (4 days) among the 30 years after that Srimangal. The mostly very severe cold occurred at Sayedpur in 2013, this year was happened 9 days out of 14 of very severe cold days in 30 years. At middle decadal period, cold days were less about all of the division except Chattogram and Sylhet divisions. January is the highest cold month in Bangladesh. Cold day is decreasing of all divisions except Barishal but for moderate cold day at Barishal and Khulna divisions. Overall Northwestern part and Srimangal region cold day has found from spatial distribution. The highest mild 5 coldest places are Srimangal, Rajshahi, Chuadanga, Ishurdi and Dinajpur and highest mild coldest years are 1993, 1995, 2001, 2011 and 2013 and less 5 mild cold places are Cox'sBazar, Kutubdia, Teknaf, Mongla, Chattogram, Chandpur and Sandwip and less 5 mild cold years are 1994,1999, 2002, 2009, 2017 respectively.

References:

[1].   Barnett, A. G., Hajat, S., Gasparrini, A., & Rocklöv, J. (2012). Cold and heat waves in the United States. *Environmental research* 112: 218-224.

[2].   Bhatla, R., Gupta, P., Tripathi, A. & Mall, R. K. (2016). Cold Wave/Severe Cold Wave Events during Post-Monsoon and Winter Season over Some Stations of Eastern Uttar Pradesh, India. *Journal of Climate Change* 2(1): 27–34. DOI 10.3233/JCC-160003

[3].   Chen, J., Zhou, M., Yang, J., Yin, P., Wang, B., Ou, C-Q. & Liu, Q. 2020. Author response for "The Modifying Effects of Heat and Cold Wave Characteristics on Cardiovascular Mortality in 31 Major Chinese Cities", DOI:10.1088/1748-9326/abaea0/v2/response1

[4].   Karmakar S., Das M. K., and Alam M. R. (2019). Study on Heat Waves and Associated Large-scale Circulations in Bangladesh. National Oceanographic And Maritime Institute (NOAMI) (Final Report, June 2019), DOI: 10.13140/RG.2.2.13090.86720

[5].   Ma, S. & Zhu, C. (2019). Extreme Cold Wave over East Asia in January 2016: A Possible Response to the Larger Internal Atmospheric Variability Induced by Arctic Warming. *Journal of Climate* 32(4): 1203–1216. DOI- 10.1175/JCLI-D-18-0234.1

[6].   Ou, T., Chen, D., Jeong, J. H. Linderholm, H. W. & Zhou, T. (2015). Changes in winter cold surges over Southeast China: 1961 to 2012. *Asia-Pacific J. Atmos. Sci.* 51: 29–37 https://doi.org/10.1007/s13143-014-0057-y

[7].   Pradhan, B., Sharma, P., & Pradhan, P. K. (2019). Impact of Cold Wave on Vulnerable People of Tarai Region, Nepal. In (Ed.), Climate Change and Global Warming. https://doi.org/10.5772/intechopen.82201

[8].   Pre-Disaster Secondary Data, The JNA Consolidation Project, Bangladesh (supported by ACAPS), (2014): Cold Wave

[9].   Samra, J. S., Singh Gurbachan, Ramakrishna, Y. S. (2003). Cold Wave of 2002-03-Impact on Agriculture, Natural Resource Management Division, Indian Council of Agricultural Research. Web: http://dryland.ap.nic.in

[10].   Spinoni, J., Lakatos, M., Szentimrey, T., Bihari, Z., Szalai, S., Vogt, J. V., & Antofie, T. (2015). Heat and cold waves trends in the Carpathian Region from 1961 to 2010. *International Journal of Climatology* 35: 4197–4209. DOI: 10.1002/joc.4279

[11].   Tao, W., Ni, Y., Lu, C. (2020). Cold Waves in East China and Their Response to Two Types of Arctic Amplification. *Atmosphere* 11(6), 612: 1 – 17 https://doi.org/10.3390/atmos11060612

[12].   UNDP Bangladesh, Situation Report: Cold Wave Bangladesh, 6th January 2010. (Source: UNDP's pre-qualified NGOs, DRRO offices and media report as at 6 January 2010)