The Recent Scenario and Trend of Cold Waves over Bangladesh

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ABSTRACT

This study computes cold waves situation taking minimum temperature in consideration collecting from all the meteorological stations throughout Bangladesh during the period 1991-2021. At times, Bangladesh especially the Rangpur, Rajshahi, and the Sylhet division experiences the coldest situation and the temperature decreases up to 3ºc even less than that. Srimongal is the station that faces all the three conditions of cold wave namely mild cold wave, moderate cold wave, and severe cold wave during the period took in consideration. In our country Wind enters into the country through the Himalayan foot hills and it causes cold waves situation throughout the country. Cold wave is weather phenomena which has tremendous impact on socio-economic infrastructure, agriculture, livestock, and forestry and also so on. At Srimangal, all the three conditions of cold wave namely mild cold wave, moderate cold wave, and severe cold wave during the period took place in consideration. Moderate and severe cold wave situation is increasing in the last decade comparing with other two decades. It is observed that different parts of Bangladesh experience different intensity of cold waves. During the period 2001-2010, all the station faced less mild cold wave conditions except in the Jessore station. Jessore, Chuadanga, and Rangpur were hit by more moderate cold wave situation during 2011-2021 than the other two decades. This study examines the variation of the frequency and categories of the cold waves over the country during the period 1991-2021. Daily minimum temperature of 32 stations across Bangladesh are used during the winter season (December to February) and the data are collected from Bangladesh Meteorological Department (BMD) for 30 years. Recent trends and potential causes of cold waves were not fully reported to the esteemed research community and academics. As the climate changes and becomes a hot topic, the current characteristics of cold waves and their potential mechanism in Bangladesh are still unknown. To address these issues, our study aims to investigate the recent scenarios and trends and variability in the frequency of minimum temperature that causes cold waves situation across Bangladesh.

Keywords: Cold wave, Weather phenomena, Intensity, Take places, Climate change

1. INTRODUCTION

Due to the topographic position of Bangladesh, it experiences cold wave situation of various categories that affect the activities in different industries like agriculture, livestock as well as social, environmental aspect. The cold wave is defined as of the extremely low temperature in association with the incursion of dry cold winds from the north into the sub-continent [1]. The northern and northeastern parts of Bangladesh face the cold wave situation severely during the winter season. During this time, Bangladesh and the adjoining area of India are influenced by transient disturbances in the mid-latitude westerlies which often have weak frontal characteristics which are known as western disturbances. It is analyzed the time series of mean annual temperature over a set of eight Indian stations [2]. Negative effects of weather and climate extreme events can harm ecosystem in many obvious ways resulting into large losses of human life, agriculture, engineering structure and it increase costs associated with them. It is found in many studies that exposure to temperature extremes is associated with an increased risk of mortality [13-18]. It is studied that the remarkable changes in the frequency and intensity of extreme events, including floods, may occur when there are only small changes in climate [3]. The trends in temperature time series of 125 stations distributed over the entire India was studied [4]. The extreme temperature and rainfall events were studied over Varanasi using 30 years daily surface data of temperature and rainfall from 1981 to 2010 (June to September) [5]. It has been showed that during the period 1911-1961 most severe cold wave events occur in Dras in March 1911 [6]. Air temperature plays an important role and it has the ability to prevent the energy exchange process over the surface of the earth. A variety of efficient trend estimation methods was used to estimate regional changing process of temperature extremes [7]. Temporal

patterns of climate stations are also examined located in Belgium and their associations with the changes of climate means for the duration 1952-1953. In the present study, the frequency of cold wave days has been analyzed for the winter season and each month from December to February over Bangladesh during 1991-2021 and also for the three decades. It is explored that the northern region of Bangladesh is experiencing an annual temperature rise of 0.4-0.6˚C during the period 1989-2019 that is very alarming for us because of its negative effect [8]. It is studied about secular trends in the annual mean maximum and minimum temperature over India and concluded that there is no general tendency for an increase or decrease in this temperature [9]. There is a direct interrelation between ambient temperature and mortality has been demonstrated in many parts of the world [10-12]. The extreme cold waves events resulted in a huge amount of damage and great economic loss irrespective of color, caste, region across the world. Therefore, researchers have started to focus on extreme cold waves situation and their possible contributory synoptic as well as other factors. The objective of the study is to explore the cold wave situation in various categories and their trends over the whole region of Bangladesh. Recent trends and potential causes of cold waves were not fully reported to the esteemed research community and academics. However, so far, no earlier studies have focused on the recent trends of different types of cold waves in Bangladesh. As the climate changes and becomes a hot topic, the current characteristics of cold waves and their potential mechanism in Bangladesh are still unknown. To address these issues, our study aims to investigate the recent scenarios and trends and variability in the frequency of T_{min} that are responsible for producing cold waves.

2. STUDY AREA AND METHODOLOGY

2.1 Study area

Bangladesh situated in the south Asia that is surrounded by West Bengal in the western part of Bangladesh, Assam in the northeastern part, Himalaya in the northern part, and Bay of Bengal in the southern part of Bangladesh. To the southeast part it shares a boundary with Myanmar. It has a longest sea beach of length 155 kilometers of the world. Bangladesh has an area of 147,570 square kilometers with a remarkable amount of cultivable land across the country. The southeast portion of the country has low elevation form mean sea level whereas the low hills situated in Sylhet division and the highlands are in the north and northwest part. The most of the parts of the country experience the cold waves situation especially the northern and southeast part of Bangladesh (figure-1). To conduct the study regarding the cold wave situation across Bangladesh, Data on minimum temperature have been collected from 32 stations from Bangladesh Meteorological Department (BMD) throughout Bangladesh for the duration of 1991-2021.

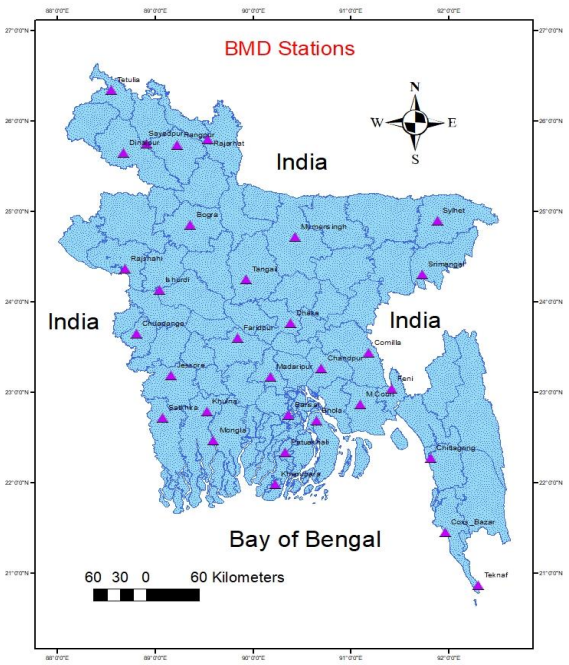

Figure 1: Location of BMD stations across Bangladesh

2.2 Data and Methodology

The data on daily minimum temperature of 32 stations across Bangladesh are used during the winter season (December to February) and the data are collected from Bangladesh Meteorological Department (BMD) for the period 1991-2021. Frequency of cold wave days has been calculated as per BMD criteria for the duration 1991-2021 and this duration has been farther divided into three decades such as 1991-2000, 2001-2010 and 2011-2020 including January and February of 2021. The decades are denoted as D1, D2 and D3 respectively and are shown in the figure. It may be noted that some stations have not been recorded for some couple of months for which these stations are not taken in our consideration. The minimum temperature are categories in different classes.

Minimum temperature in different categories such as daily, monthly, and annually have been collected from Bangladesh Meteorological Department (BMD) for 30 years during the period of 1991-2021.

In Bangladesh, the cold waves are classified as the following [19]:

Table 1: Types of cold waves

Types	Minimum Temperature(°C)
Mild cold wave	8-10
Moderate cold wave	6-8
Severe cold wave	4-6
Extreme cold wave	<4

2.3 Climatology of cold wave across Bangladesh

Bangladesh experiences moderate to severe cold waves frequently almost in every year during the winter season. These cold waves affect the health and livelihoods of the people, especially the children, women and elderly people. The cold waves enter Bangladesh through west-northwest region of the country mainly; cold wave is also found to enter through the Srimangal-Sylhet region including northern part of Bangladesh. Most of the region of north northeastern part is affected by various extreme events especially by cold wave and fog. Agricultural sectors, livestocks, fisheries sectors are dangerously suffered from the negative impact of cold wave ambient. As the Himalaya region, source of cold air, is very near to the northern and northeastern part of Bangladesh, cold wave situation is occurred in those regions. At times, Bangladesh experiences very severe cold wave but, in some years, moderate to very severe cold waves move through the northern part of the country and when it moves through the central part to southern part its intensity gradually decreases. These cold waves and heat waves affect the health and livelihoods of the people, especially the children, women and elderly people throughout the country. The cold waves and heat waves hit Bangladesh through west-northwest region of the country mainly; cold wave is also found to enter through the Srimangal-Sylhet region [1].

3. RESULT AND DISCUSSION

3.1 Frequency of Mild Cold Wave (MCW) days over Bangladesh during 1991-2021

The study on mild cold wave situation shows that maximum frequency of days is 605 found at Srimangol station whereas Dinajpur, Rajshahi, Ishurdi, Chuadanga is experienced the nearly same frequency of days during 1991-2021 (Figure 2). The second highest frequency is 480 days recorded at Rajshahi station during the study period. It is also observed that there is no mild cold wave situation occurred at Chattogram, Cox's Bazar, Kutubdia and

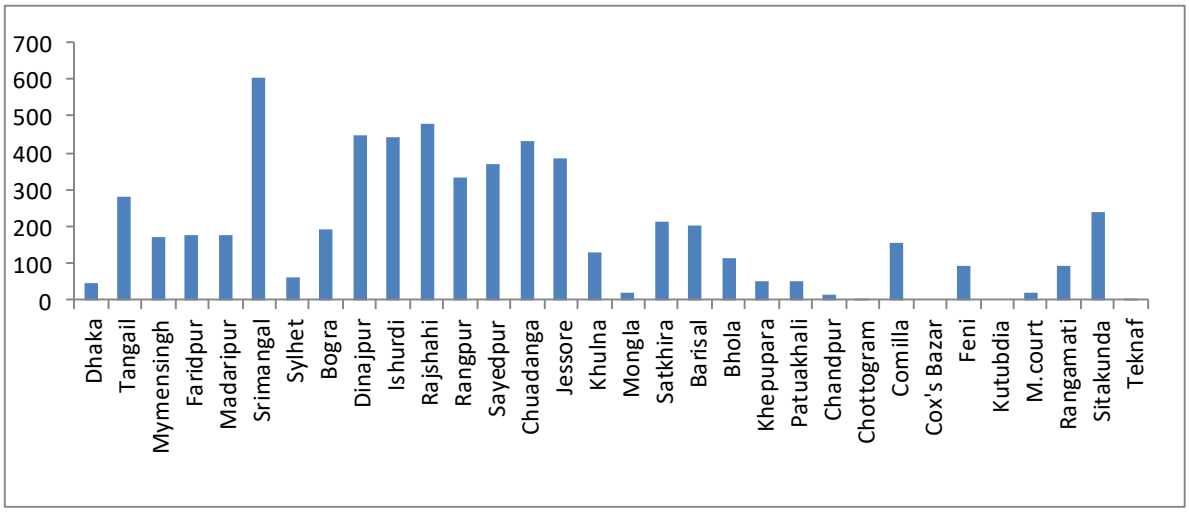

Figure 2: Frequency of MCW days during 1991-2021

Teknaf during the period 1991-2021 shown in Figure 2.

3.2 Frequency of Moderate Cold Wave (MoCW) days over Bangladesh during 1991-2021

The study shows that the highest maximum frequency of MoCW days is 248 days found at Srimangol, and the 2nd highest maximum frequency of MoCW days is found in Chuadanga which is 172 days whereas Dinajpur, Rajshahi, Ishurdi, Jessore experience nearly the same frequency of MoCW days during 1991-2021 shown in Figure 3. The figure also clarify that no MoCW situation hit the stations named Chattogram, Cox`s Bazar, Kutubdia, and Teknaf. Chandpur is the station that faces the lowest frequency of days during the period.

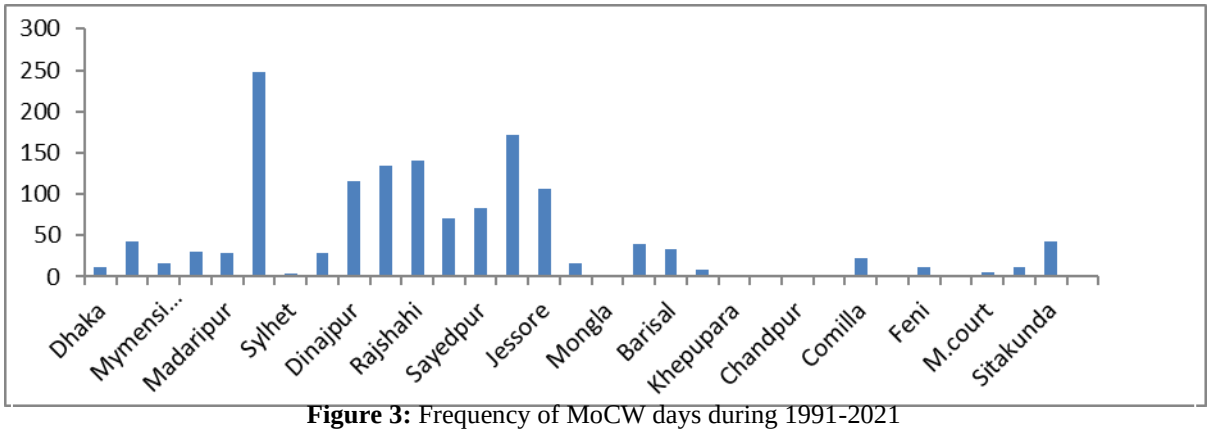

Figure 3: Frequency of MoCW days during 1991-2021

3.3 Frequency of Severe Cold Wave (SCW) days over Bangladesh during 1991-2021

In Figure 4, it is shown that the highest maximum frequency of SCW days is 41 found in Srimongal is 41 days whereas Rajshahi, Isurdi and Chuadanga experience the nearly same frequency of days during 1991-2021. The second highest frequency is found in Ishurdi and no severity in cold waves situation occurred in southwestern, southeastern part Bangladesh including Dhaka.

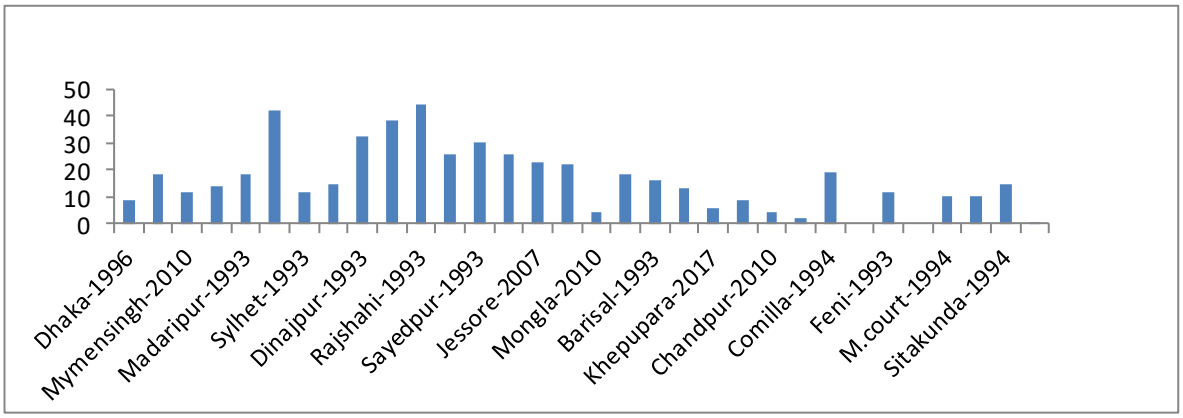

Figure 4: Highest MCW year during 1991-2021

3.4 Scenario of the highest mild cold wave year over Bangladesh during 1991-2021

The highest mild cold wave **(**MCW) events occurred in 1993 during 1991-2021 at Rajshahi (44), Srimangal (42) Isurdi (38), Dinajpur (32), Rangpur (26), Sayedpur (30), Faridpur (14), Madaripur (18), Sylhet (12), Barisal (15), Feni (12) and the 2nd highest MCW occurred in 1994 at Chottogram (2), M.court(10), Comilla (19), Sitakunda (15).

3.5 Scenario of the highest MoCW year over Bangladesh during 1991-2021

The highest MoCW occurred in 2012 during 1991-2021 at Faridpur (4), Sylhet (2), Sitakunda (15), Bhola (2), Mongla (1), Khepupara (2), Patuakhali (2), Chandpur (2), Feni (5) and the 2nd highest MoCW occurred in 1994 at Chattogram (2), M. Court (10), Comilla (19), Sitakunda (15). The scenario has been depicted in the following figure 5.

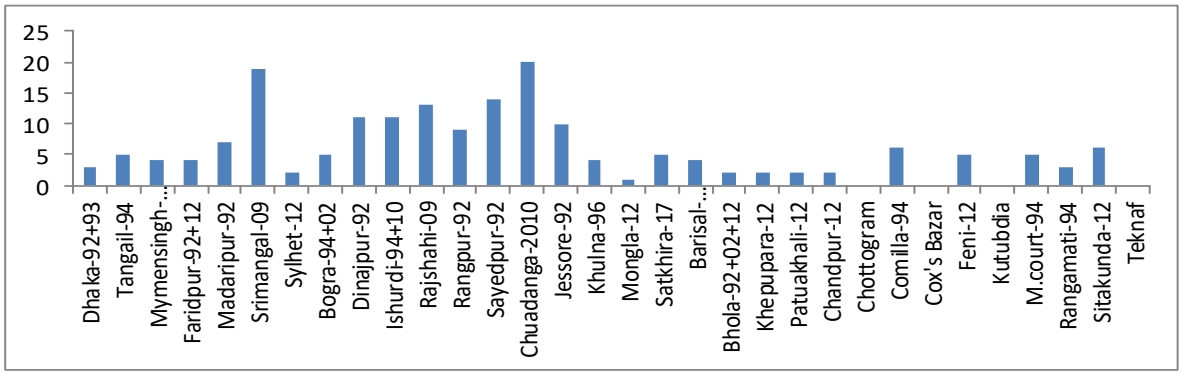

Figure 5: Highest MoCW year during 1991-2021

3.6 Scenario of the highest SCW year over Bangladesh during 1991-2021

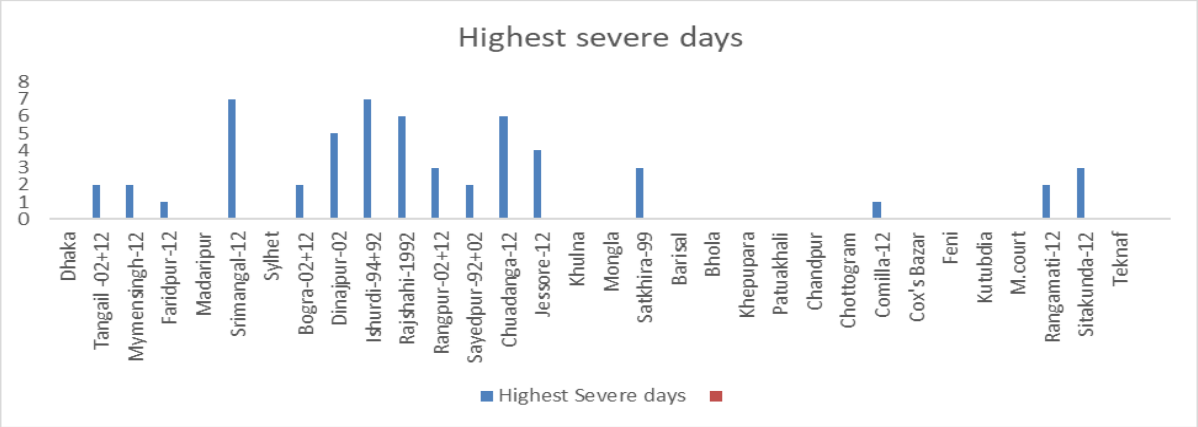

Figure 6: Highest SCW year during 1991-2021

The highest severe cold wave days was 7 both in Ishurdi and Srimongol. The highest SCW found in 2012 during 1991-2021 at Mymensingh (2), Jessore (4), Sitakunda (3), Comilla (1) and the 2nd highest SCW occurred in 2002 at Dinajpur (5), Syedpur (2).

3.7 Decadal Variation of Mild Cold Wave during 1991-2021

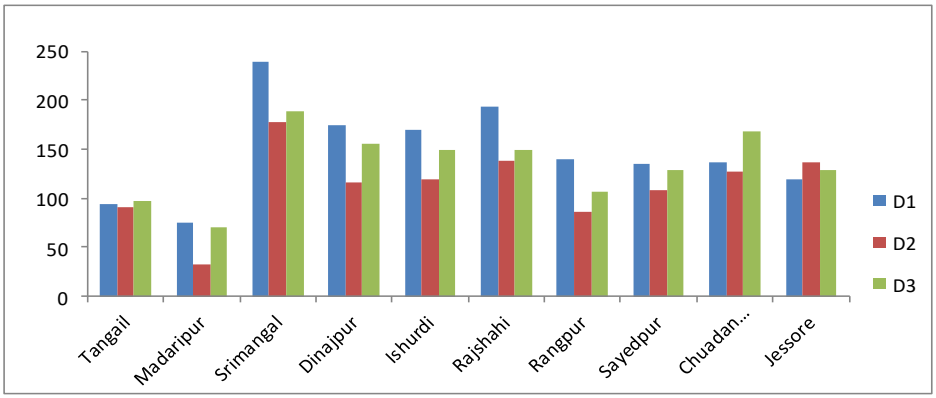

Figure 7: Mild cold wave days over ten different stations for D1, D2, D3.

Figure 7 shows the variation of mild cold wave events for different decades during the winter season. It is observed from the following figure that D2 experiences less mild cold wave situation among the three decades except Jessore. Some stations experiences more cold waves situation during the period D1 Srimangol along with Dinajpur, Madaripur, Ishurdi, Rajshahi, Rangpur, and Syedpur.

3.8 Decadal Variation of Moderate Cold Wave during 1991-2021

Figure 8 shows the variation of MoCW events for different decades during the winter season. Jessore, Chuadanga, and Rangpur was hit by more moderate cold wave situation during D3 than the other two decades.

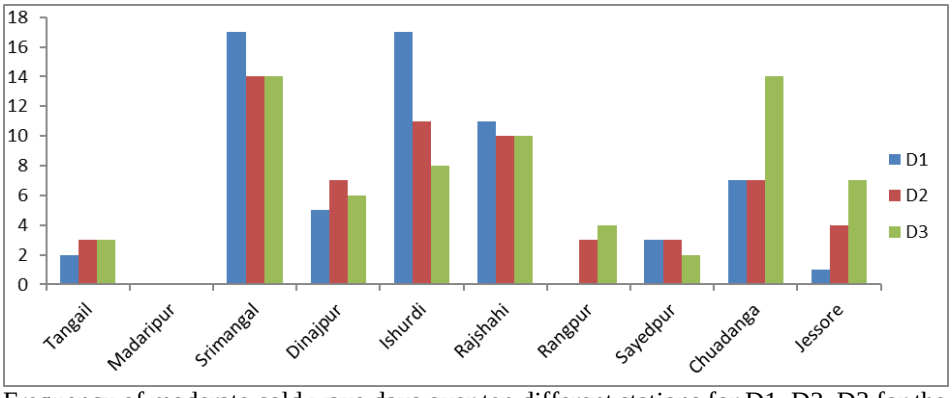

Figure 8: Frequency of moderate cold wave days over ten different stations for D1, D2, D3 for the winter season.

3.9 Decadal Variation of severe cold wave during 1991-2021

Figure 9 shows the variation of SCW events for different decades during the winter season. It is seen that the variation of SCW events for different decades during the winter season. Jessore, Chuadanga, and Rangpur was hit by more moderate cold wave situation during D3 than the other two decades.

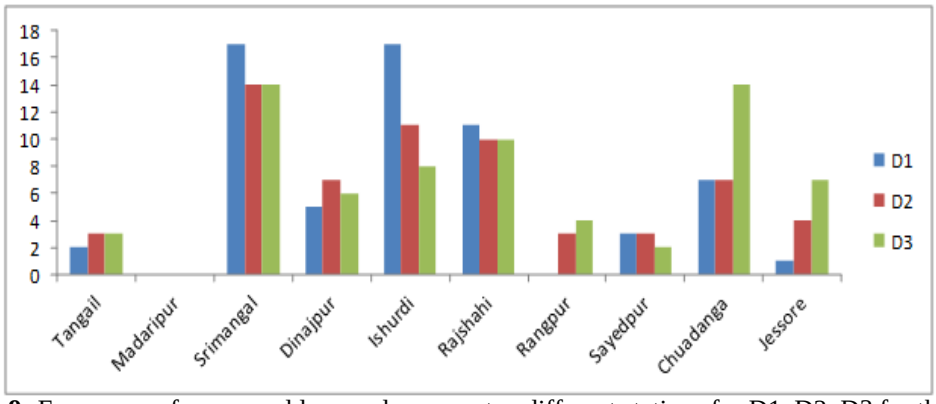

Figure 9: Frequency of severe cold wave days over ten different stations for D1, D2, D3 for the winter season.

4. Propagation of cold wave

It has been found that the cold waves are formed over central India that enter into Bangladesh through the western part. In this time the westerly/northwesterly wind become very strong that causes the advection of warm air in Bangladesh. The primary centre of maximum temperature surrounding the country lies over India extended to West Bengal and adjoining Bangladesh (figure-10). During the period 1991 to 2021 cold waves days are gradually invading the northwestern and western part of Bangladesh. From the figure that has been prepared using GIS, it is observed that the tendency of getting cold waves as well as the cold waves spell is propagating somewhat towards northeastern part of Bangladesh. The main region of facing cold wave is the western and northwestern part of the country. During this period the lowest minimum temperature was recorded 2.6ºC Tetulia station on 8 January 2018.

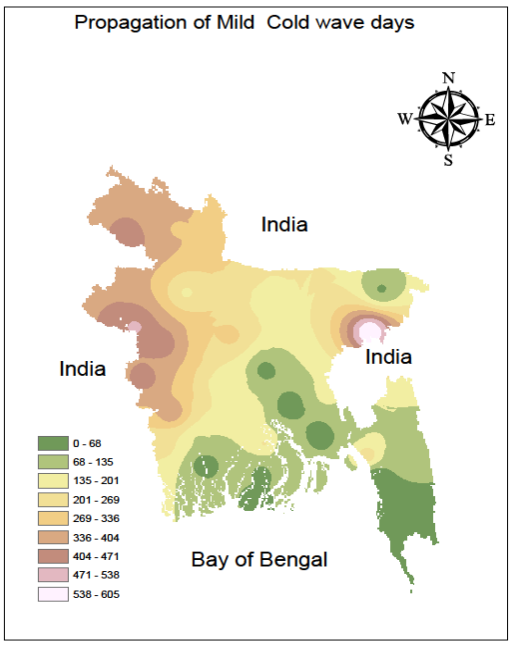

Figure 10: Propagation of Cold wave days.

3.10 Variation of Cold Wave Events during December for 1991-2021

The variation of mild cold wave, moderate cold wave, and severe cold wave in the month of December, January, and February are depicted in the following figures-11 (a-c), 12(a-c and 13(a-c)

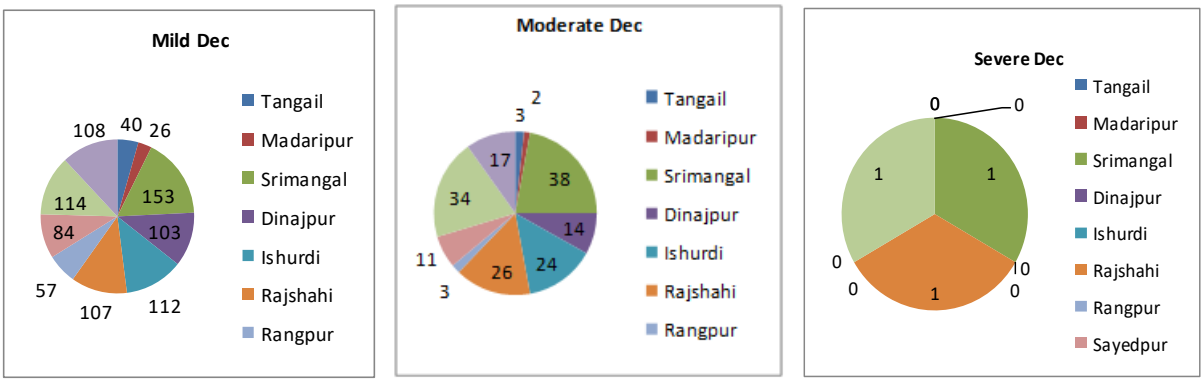

Fig.11 (a-c): Comparison of cold wave events a) MCW b) MoCW c) SCW for December during 1991-2021 over ten different stations.

3.11 Variation of Cold Wave Events during January for 1991-2021

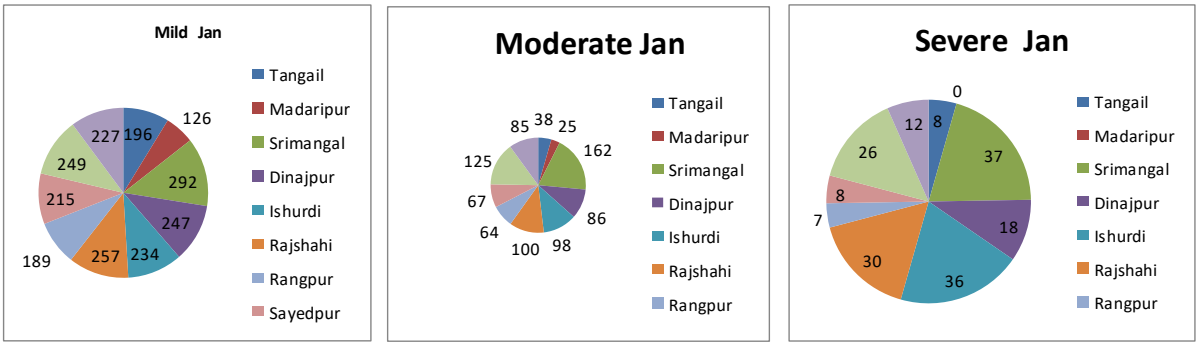

Fig.12 (a-c): Comparison of cold wave events a) MCW b) MoCW c) SCW for January during 1991-2021 over ten different stations.

3.12 Variation of Cold wave events during February for 1991-2021

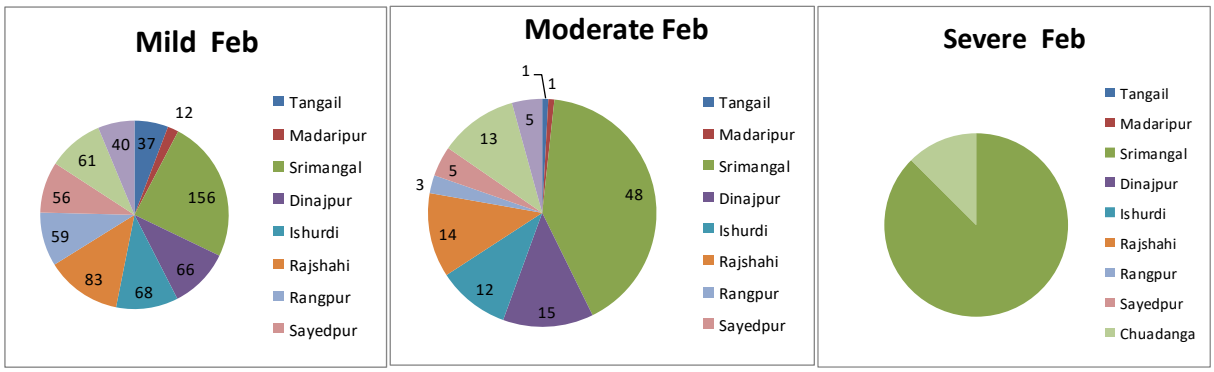

Fig. 13 (a-c): Comparison of cold wave events a) MCW b) MoCW c) SCW for February during 1991-2021 over ten different stations.

4. CONCLUSION

The variations of the frequency of cold waves situation may be due to the variation in extreme temperature over the regions. Srimangal is the station that faces all the three conditions of cold wave namely mild cold wave, moderate cold wave, and severe cold wave during the period took in consideration. Moderate and severe cold wave situation has an increasing trend in the last decade comparing with other two decades shown in the figure. During the period 2001-2010, all the station faced less mild cold wave conditions except in the Jessore station. Jessore, Chuadanga, and Rangpur were hit by more moderate cold wave situation during 2011-2021 than the other two decades. The highest numbers of cold wave days are found in Srimangal during 1st decade i.e. during

1991-2000 in the month of January. The frequency and duration of cold waves is useful for the climate prediction and better forecasting. The occurrence of cold wave/ severe cold wave over the hilly regions and the adjoining plains is mainly due to the mid-latitude westerlies which often have weak frontal characteristics [20]. Form the study it is seen that mild cold wave situation shows that maximum frequency of days is 605 found at Srimangol station. The following conclusions may be drawn from the study: No significant cold wave events observed over Chattogram, Cox's Bazar, Kutubdia and Teknaf during winter season. In Srimangal, a maximum number of cold wave days are found over all decades. The western, northwestern and the southeastern part are mostly affected by the cold wave situation. It is noticed that the maximum days of cold waves are found in the month of December, January, and February.

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