TREND ANALYSIS OF VERY HEAVY RAINFALL EVENTS OVER BANGLADESH

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Abstract

Bangladesh is recognized by low lying delta topography. Due to its unique location, it is in the list of countries which are highly prone to climate change. Thus, it is a prerequisite to understand the long term changes in the frequency and spatial distribution of very heavy rainfall (>88 mm/day) (VHR) events over the country. The present study formalized this objective and analyzed the trend of VHR using in-situ and satellite measurements of Bangladesh during 2000-2023. For this purpose, study utilizes in-situ rain gauges observations from Bangladesh Meteorological Department and satellite products from INSAT-3DR and Integrated Multi- Satellite Retrievals for Global Precipitation Measurement (IMERG). Majority of stations exhibit a decline trend in VHR events. Frequency of VHR events show a significant drop over the Northern region than Southern part of the country. In addition, Dhaka, which is located over the central part of the country, also shows substantial decline. The high frequency of VHR events are observed over Cox's Bazar, which is located in the southernmost part of the country. The station also displays a decreasing trend but less significant. Further, the decreasing trend observed in in-situ rain gauges observation is supported by the satellite measurements. The outcomes of the study would be useful to distinguish the varying trends of VHR events on annual and seasonal scales over the four different sectors of Bangladesh. Additionally, results are also important to understand the changing patterns of VHR over the country in Bangladesh.

Keywords: *Trend Analysis, VHR, IMERG and Bangladesh.*

1. INTRODUCTION

Bangladesh is characterized by the two distinct geographical features (i) broad low laying delta plain which is on high risk of flooding and (ii) small hilly region. It is one of the largest and most densely populated delta (Ganga-Bramaputra-Meghna) (Rawlani & Sovacool, 2011). Because of the varying geographical conditions and unique location, Bangladesh is highly prone to climate change scenario. Recent report published on the climate change impacts in Bangladesh details the several environmental factors and their disastrous impact on the country (Change, 2024). These vulnerability includes increase in sea level, fresh water scarcity, loss of bio diversity and frequent floods. Sea level over Bangladesh is rising by 3.8 to 5.8 mm/year, faster than the global average (Environment & Change, n.d.).

Rainfall over Bangladesh varies significantly from east to west. The north eastern part of the country is one of the wettest places of the world (Studies et al., 2017). Pre-monsoon (March-April-May) and monsoon (June-July-August-September) season rainfall often brings floods and landslides disasters over the low laying areas. Based on the past studies carried out to understand the annual and seasonal trend of rainfall, it is observed large variations in rainfall pattern and decline rainfall trend (Rakib, 2019). Studies also show decreasing trend in the consecutive wet days and increasing trend in the consecutive dry days (Basher et al., 2017). On contrary, some studies projected increase in rainfall activity and extreme rain events during wet seasons (Article, 2012) under the global warming scenario. Recent study of (Rimi et al., 2022), explained the influences of anthropogenic aerosols in declining trend of extreme rainfall events over Bangladesh. The majority of past studies relied primarily on the in-situ observations and model outputs to understand the rainfall patterns, distribution and frequency. The present study is intended to utilizes both in-situ rainfall observations from rain gauges and satellite measurement to understand the trend of very heavy rainfall (VHR) (rain>88mm/day) events and their distribution over Bangladesh.

Research Objective:

Present study aims to understand the frequency trend and spatial distribution of VHR events on annual and seasonal time scales over Bangladesh during 2000-2023.

2. STUDY AREA

Bangladesh is Located in the north-eastern part of South Asia. The majestic Himalayas stand some distance to the north, while in the south lays the Bay of Bengal. West Bengal borders on the west and in the east lies the hilly and forested regions of Tripura, Mizoram (India) and Myanmar.
The study area extends between 20°34' to 26°38' north latitude and 88°01' to 92°41' east longitude. Maximum extension is about 440 km in E-W direction and 760 km in NNW-SSE direction.
The region of interest is Bangladesh (Figure.1). The four sub-regions, NE (90.5-92.5 E, 24-25.5 N), NW (88-90E, 24-26 N), SE (91-93E, 20.5-24 N) and SW (89-91 E, 21.5-23.5 N) considered for the study are also displays in the figure. The sub-regions are selected using the criteria reported by (Rimi et al., 2022).

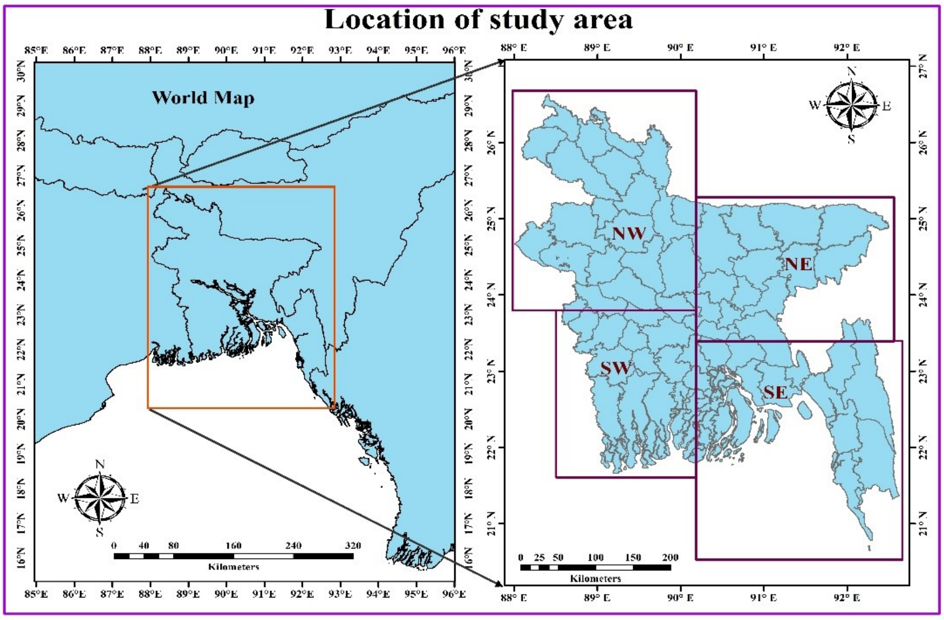


Figure 1: Location of the study area

3. DATA USED:

Study utilizes two types of rainfall products (i) in-situ and (ii) satellite. The details of the products are as follows:

3.1 In-situ:

Rain gauges rainfall observations from Bangladesh Meteorological Department (BMD) on daily scale during 2000-2023 over 8 stations.
North-West (NW): Dinajpur & Ishwardi
North-East (NE): Sreemangal & Dhaka
South-West (SW): Faridpur & Satkhira
South-East (SE): Chandpur & Cox's Bazar

3.2 Satellite data:

Hydro-Estimator (H-E) technique based rainfall products (Kumar et al., 2022) from INSAT-3DR are obtained from Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) web portal of SAC (www.mosdac.gov.in). H-E rainfall data is available at 4 km spatial and 30 min temporal resolutions. Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (IMERG) products (www.gpm1.gesdisc.eosdis.nasa.gov). IMERG uses rainfall estimates from the GPM constellation and partner satellite constitutes, both microwave and IR, based on rainfall estimates from polar as well as geostationary satellites. IMERG rainfall products are available at 10 km spatial and 30 min temporal resolutions.

4. METHODILOGY:

Step by step procedure adopted to perform the present study is as follows:

In-situ observations:

1. Gathered in-situ rain gauges station data from BMD during 2000-2023.
2. Checked the availability of continuous rainfall data for different BMD stations and selected 8 stations (2 each over NE, NW, SE and SW) over Bangladesh.
3. Computed the frequency of VHR on annual and seasonal scales separately for 8 stations.
4. Analyzed the trend of VHR events on annual and seasonal scales over 8 stations from 2000 to 2023.

Satellite measurements:

INSAT-3DR: Selected dates correspond to VHR event over Bangladesh and downloaded Hydro-Estimator (H-E) technique based rainfall products corresponds to event date. Analyzed the spatial distribution of rainfall.

IMERG: Extracted the rainfall measurements on daily scale from IMERG product and computed frequency of VHR event over Bangladesh on annual time scale. Analyzed spatial distribution of VHR on annual time scale.

5. RESULTS AND DISCUSSION:

In-situ

Annual trends:

Trend of VHR events over 8 stations of Bangladesh using in-situ rain gauges observations from 2000 to 2023 is shown in Figure 2. Where Figure 2(a), 2(b), 2(c) and 2(d) display trend over NW, NE, SW and SE stations respectively. Significant variations in the frequency of VHR events are observed in all the 8 stations. Broadly, frequency is high before 2010 and decreases up to 2015/2016 and increase in the later part of the study period overall the stations. Maximum frequency (13) of very heavy rainfall events are observed over Cox's Bazar (SE station). This is because of its geographical location, where thunderstorm activities are more prominent. The minimum change is observed over Faridpur, which is an inland station of Bangladesh. In total, all stations show decreasing trend in very heavy rainfall events except Chandpur (SE). However, rate of decrease is different for each station. Stations located over western regions (NW: Dinajpur and Ishwardi and SW: Faridpur and Satkhira) decreasing trend is low. Whereas, stations situated North-East region (Srimangal and Dhaka) have exhibit significant decline. Further, negligible change is observed over the Cox's Bazar in VHR events. Whereas, incremental trend is observed in Chandpur, which is located interior region of SE.

Seasonal trend:

Frequency trend in VHR events over 8 stations during summer monsoon season (June-July- August-September) is display in Figure.3. Here, trends over NW, NE, SW and SE are shown in Figure 3(a), 3(b), 3(c) and 3(d) respectively. Figures show the decline trend in VHR events over 4 sectors of Bangladesh during monsoon season. The NE region (Srimangal and Dhaka), the wettest part of the country is showing significant decremental trend in the very heavy rainfall events. Further, decreasing trend is also observed in Cos'x Bazar, located near to the SE coast of the country.

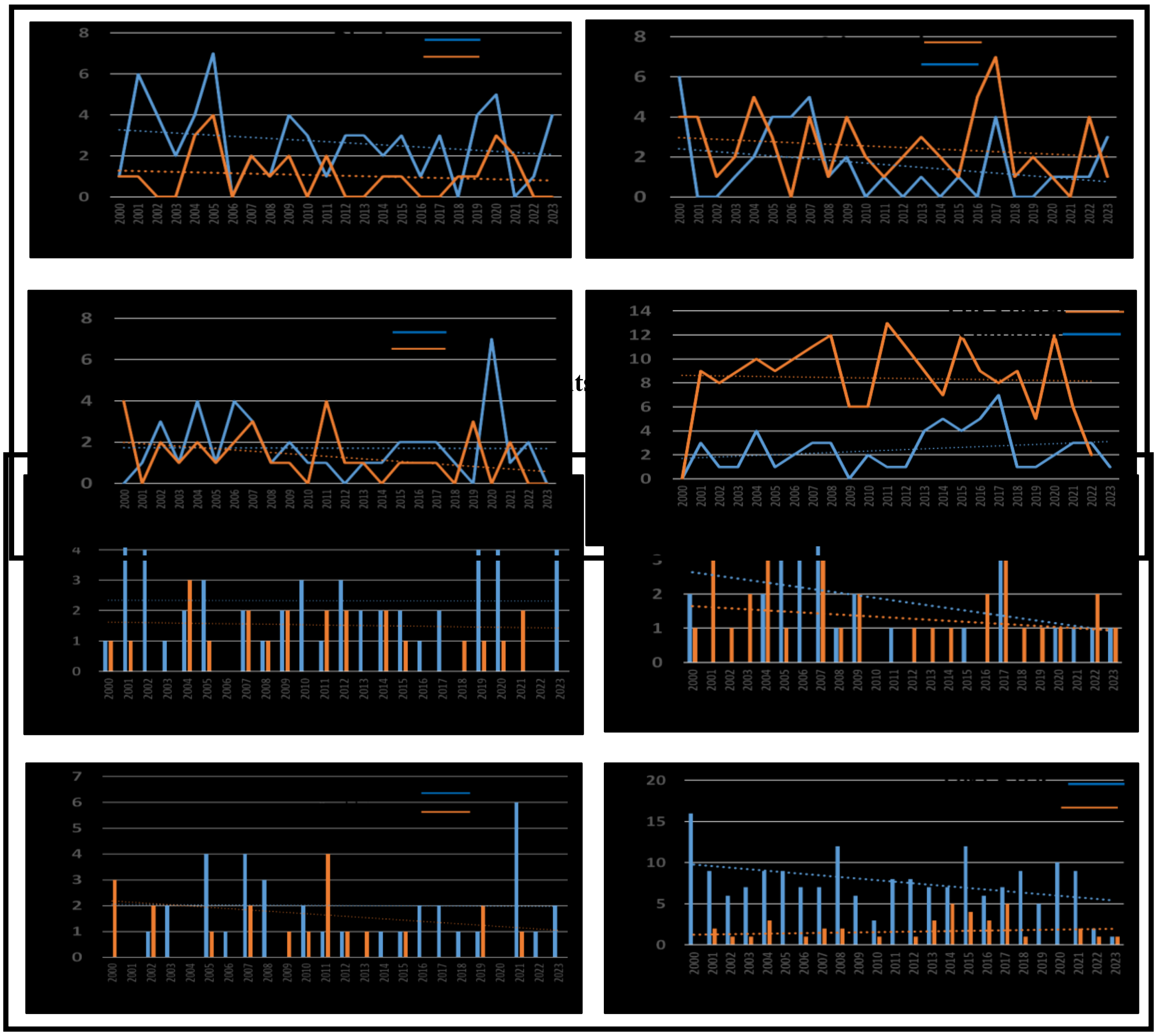
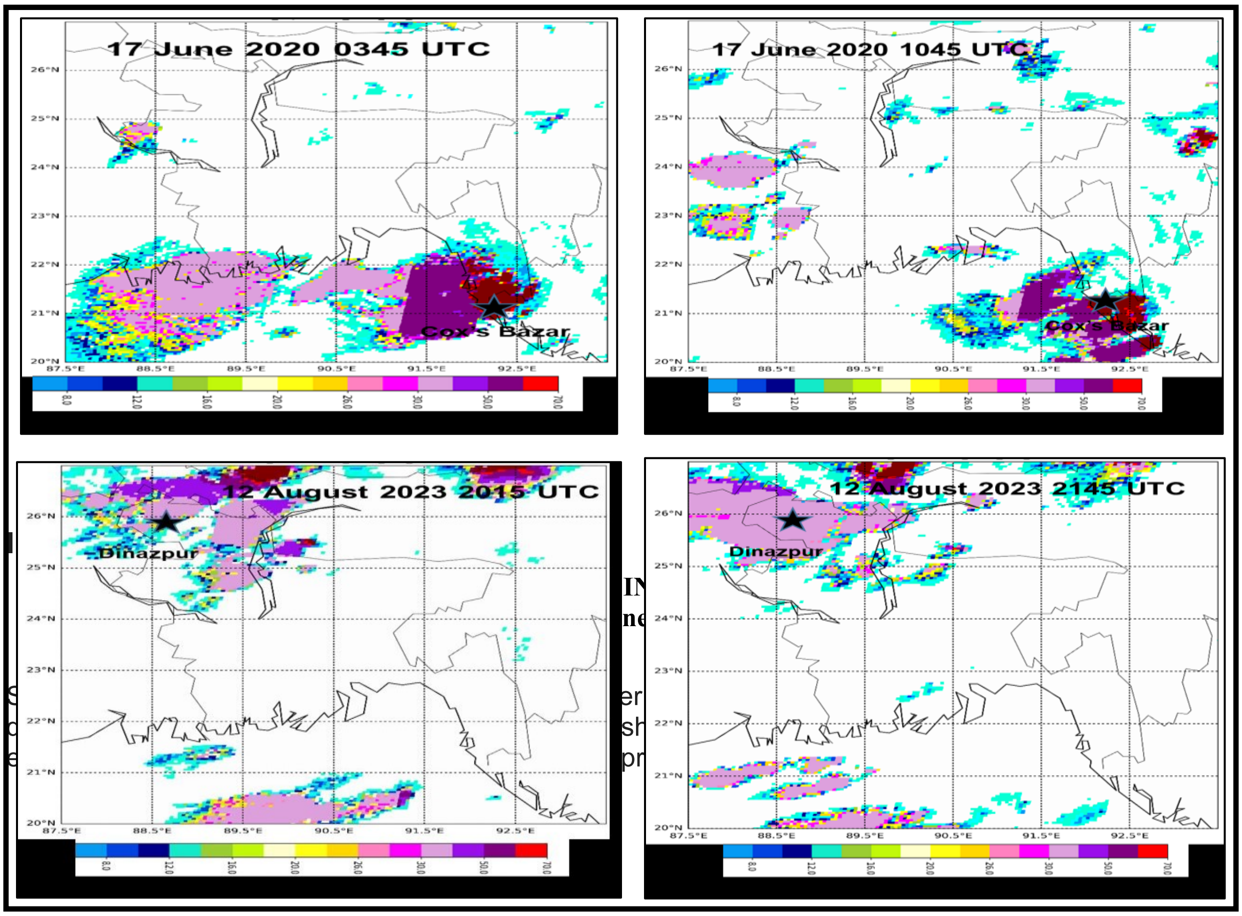
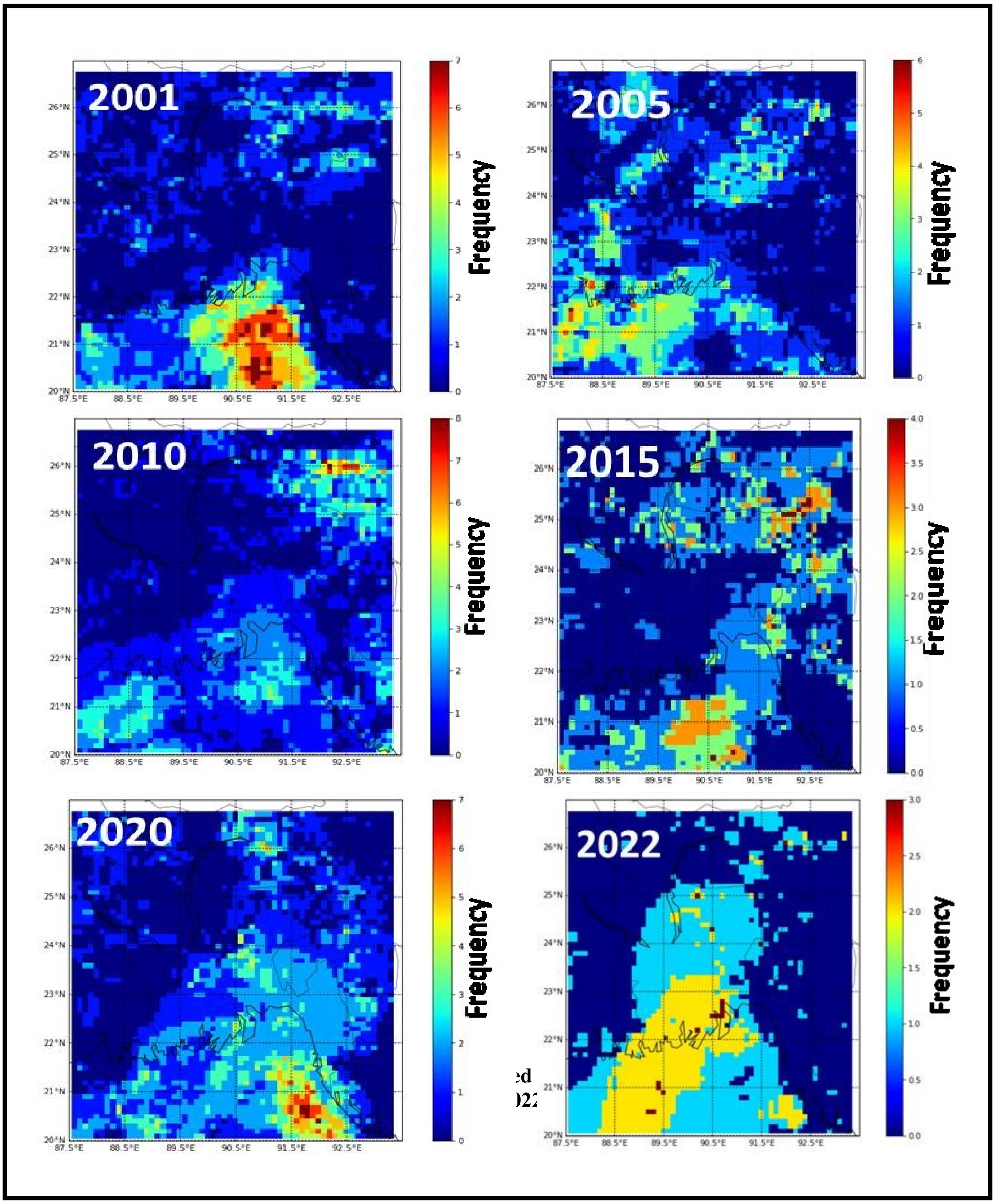


Figure 3 : Seasonal trend in VHR events over four regions of Bangladesh

Satellite
INSAT-3DR:

Figure:4 shows spatial distribution of H-E rainfall from INSAT-3DR during VHR events recorded by BMD on 17 June 2020 (top panel) and 12 August 2023 (bottom panel). Heavy rain during these events brought massive disaster over the country. These disasters are allied with floods, freshwater scarcity, agricultural harm, soil erosion, economic loss and living conditions of several people. H-E rainfall products from INSAT-3DRnot only captured these VHR events, but also allowed to monitor the growth, horizontal expansion over the ground, distribution and intensity at high temporal scale of 30 min. For example on 17 June 2020 VHR event recorded by BMD over South-Eastern region (Cox'Bazar marked by *). The development of the rainfall activity and dissipation can be well identified by H-E rainfall product. Similarly, on 12th August, VHR event was observed over the North western region of the Bangladesh (Dinazpur marked by *). In this case also H-E rainfall promisingly identified the VHR regions and well discriminated with the non-rainy areas.




2001
Frequency
2005
Frequency
2010
Frequency
2015
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2020
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2022
Frequency

6. CONCLUSIONS:

This project work is carried out under the Post Graduate Course in Satellite Meteorology and Global Climate of SAC, ISRO. Study aims to understand the trend of very heavy rainfall events over Bangladesh using in-situ and satellite observation during 2000-2023. Majority of stations of Bangladesh show decline trend of very heavy rainfall events. Four sectors of Bangladesh (NE, NW, SE and SW) are experiencing decreasing trend in VHR events, particularly eastern region of the country. Further the decline trend is consistent over the monsoon season. The significant decreasing trend is observed over the Dhaka, which is the country capital and densely populated. H-E rainfall products from INSAT-3DR display a great potential in capturing VHR events and their spatial distribution. Frequency of VHR events observed from the satellite measurement also infer the decline trend over the country. The outcomes of the study are important to understand the trend of VHR events and their changing spatial distribution over the Bangladesh. In addition, results also provoke to explore the reasons responsible for decline trend.

7. FUTURE SCOPE:

1. To analyze the frequency trends of rainfall falling under different categories for enhancing the complete understanding.
2. To explore the reasons behind the decline trend of VHR events over Bangladesh.

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