The Characteristics of Monsoon Rainfall over Bangladesh for the Period of 1992 to 2021

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Abstract

In this paper authors took the initiative to find out the rainfall pattern over Bangladesh. Where considered the rainfall information of 35 observatories of Bangladesh Meteorological Department, for the period of 1992-2021. Bangladesh receives an amount of rainfall all around the year. Multifarious reasons act behind these rainfall activities. Though it is considered that June to October is the monsoon period, it was observed from the historical record of rainfall that Bangladesh received huge amounts of rainfall in February to May and also November to December. Rainfall is one of the most important and influential parameters for the agriculture as well as for forestry. Long-term Increasing or decreasing trend of rainfall activities may push the climatic condition from one phase to another phase. In this paper authors tried to reveal the actual decadal rainfall condition of different categories and duration which has the interaction with temperature and some other weather parameters. Decadal analysis of different categories rainfall has done to find out the trend of different locations of the country. Authors also studied some rainfall spells of different duration for the individual month of the monsoon phase. Also analyzed for the individual station of the selected 35 observatories of Bangladesh Meteorological Department. Mann Kendall test is also done to find out to determine the increasing or decreasing trends of different significant levels.

Keywords: Rainfall, Monsoon, Duration Spell, Frequency, GIS, Bangladesh

Introduction

Bangladesh is a small country having an area of about 147570 square kilometers, extends from $20°34'$ N to $26°38'$ N and from $88°01'$ E to $92°41'$ E. Most of the time monsoon rainfall activities start from the first week of June and continue up to the second week of October. On the other hand, it is observed that the dry spell starts from the second half of October. According to the Bangladesh Meteorological Department, rainfall or precipitation is classified into five categories on the basis of amount or intensity of rainfall/day. The classified categories are light rain (1-10) mm/day, moderate rain (11-22) mm/day, moderately heavy (23-43) mm/day, heavy (44-88) mm/day and very heavy (>88) mm/day. Bangladesh receives the lowest amount of rainfall in January. The highest amount of rainfall for January recorded was the 95mm received on 11th January 2005 at Khepupara during the last 30 years. The summer monsoon arrives first in the extreme south-eastern part of the country, and initially moves towards the north. After being diverted by the Meghalaya Plateau, the flow turns towards the west. The mean arrival dates of the summer monsoon in the extreme south-eastern coastal part and in the extreme north-western part are 2 June and 15 June, respectively. Withdrawal of the summer monsoon proceeds in the opposite direction to the arrival [7]. The El Nino-Southern Oscillation (ENSO) is one of the global factors that influences and drives our climate and the weather that we feel. It is also very much important for prediction purposes because of its global nature, Dynamic movement, signal and the time scale and inherent lag relationship. The latent heat release and the convection pattern of topics have significant influence of (ENSO). Through the effects of teleconnections and mechanisms of ENSO, not only the tropics but also mid-latitude atmospheric circulations are going through the changes [1]. Climate change is also the reflection of all types of life style on the surface. Increasing or decreasing the rainfall is the vital cause of climate change which has an influence on ground water availability. It is important to understand the spatial and temporal distribution and the changing patterns in rainfall which is a basic and important requirement for the planning and management of water resources [2]. Report of IPCC mentioned that due to warm climate monsoon climate will have to face the drastic change in monsoon rainfall pattern. Bangladesh may experience a 5-6% increase of rainfall by 2030, which may create frequent big and prolonged floods. Monsoon circulation may strengthen and simultaneously surface temperature and magnitude and frequency of extreme rainfall events may increase reported by regional projections. Would strengthen monsoon circulation, increase surface temperature, and increase the magnitude and frequency of extreme rainfall events [3]. Research report published in Science Advances, described that considered the that periodic changes in the intensity of monsoon rainfall over the past 900,000 years and also associated with fluctuations in atmospheric carbon dioxide (CO_2), continental ice volume and moisture import from the southern hemisphere Indian Ocean. The finding emphases on that rising CO_2 and

higher global temperatures which were predicted by the model will lead to stronger monsoon seasons [4]. Long term changes in precipitation in global hemisphere scale are difficult to detect due to large spatio-temporal discontinuities and lack of observations over the oceanic regions. However, recent analysis over the northern hemisphere land areas since the mid nineteenth century has indicated significant increase of rainfall in mid latitudes and concurrent decrease in low latitudes over the last 30-40 years. Regional manifestations of global scale climate change processes are very important because of their link with the social economic prosperity of the affected human population [5]. Study of historic changes and its underlying forcing are very crucial to understand but essential to predict the future projections about potential changes in the monsoon rainfall .For this examination it should be distinguished between internal and external divers. External drivers can be of natural changes due to changes in orbital parameters; on the other hand internal divers may go through variations based on the interaction within the climate system [6].

Data and study area: In this study, data of the rainfall of all 35 weather stations in Bangladesh were collected from the Bangladesh Meteorological Department (BMD). Rainfall data included daily, monthly average and annual   for the period 1992-2021.

Methodology: Rainfall is one of the most dominating weather parameters that influence the weather and climate. In this paper authors tried to find out the real scenario of rainfall especially for the monsoon period of different zones of Bangladesh. For better understanding authors considered 30 years daily rainfall data (1992-2021) of 35 observatories of BMD. For analysis and for making easy explanations this data set was classified into different classes and categories on the basis of months and continuation period. Initially data processed by using FORTRAN programming language. For basic calculation and for graphical presentation MS-Excel spreadsheet was used as a supporting tool. GIS tool was also used to find out the decadal variation and locate the specific regions which are significant for receiving a noticeable number of rainfall spells. Mann Kendall test has been done to identify the significant trends

Results and Discussion: Fig.-1 is indicating the location of 35 considerable observatories and some other newly established observatories with brief information.

Here included in Fig.-2, how frequent the precipitation spells in the 35 observatories of BMD for the individual months of June, July, August, September and October. From the following graphical presentation it has been assumed that the highest number of rainfall spells occurred in Teknaf then Sylhet, Cox'Bazar, Sandwip, M.Court and Khepupara accordingly. On the other hand rainfall spells is less frequent in Ishurdi, Rajshahi and Chuadanga.
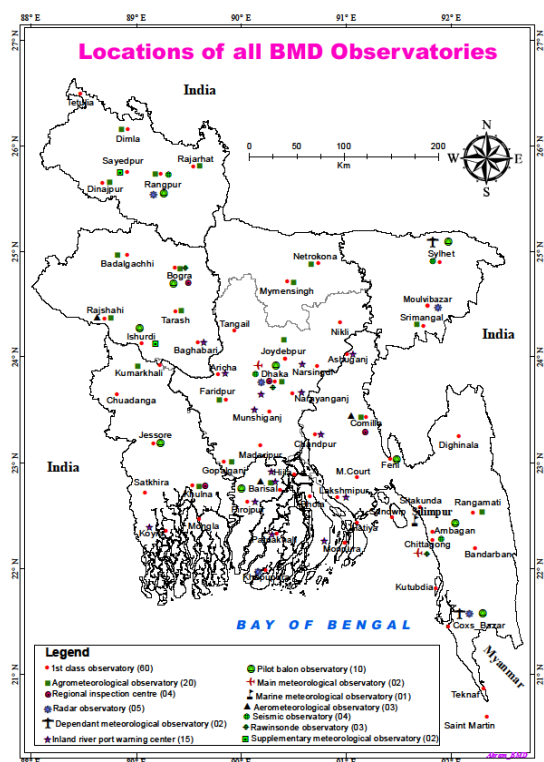

Fig.1: Location of BMD observatories

In this step authors tried to find out the monsoon rainfall characteristics categorically, on the basis of its intensity and duration.

The fig.-3(a) represents the category of Light rainfall when it occurred three consecutive days for the period of 1992-2021 all over the country. Analytical results of this graph indicate that, this categorical rainfall spell is most frequent in August after that in July then September. In October the number of occurrences of this categorical rainfall is very low. In consideration of the year for this category the country received the highest number of spells in 2016, 1999, and 2003.

Similar examinations are also done for Light rainfall and the duration of consecutive four days which reflect in
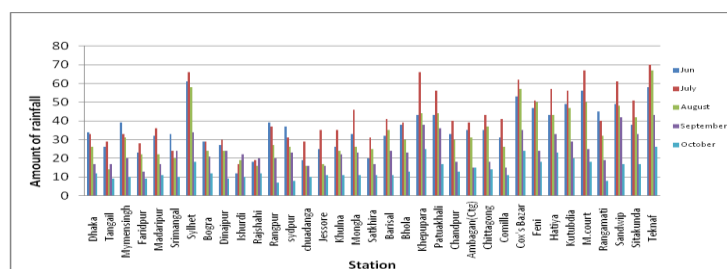

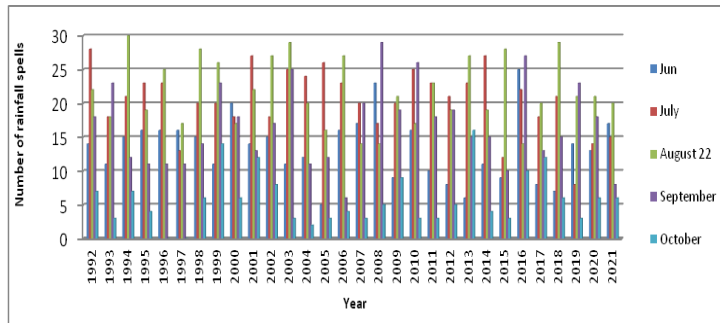Fig.2: Number of precipitation spells in the 35 observatories.

Fig.3(a): Light rainfall when it occurred three consecutive days for the period of 1992-2021

fig.-3(b). By analyzing this category, it is found that the characteristics are about similar with just previously presented categories. Country received the highest number of rainfall spells in August secondly in July, June and September and the number is very low in October. Number of rainfall spells is the highest at 1994 and very low at 2019 and 2015 compared to the other years.

Fig.-3(c) is the graphical reflection of the category, Light rainfall when it occurs consecutive five days for the time

period 1992 to 2021. Examining this category, it is revealed that July is the most significant month when the country experienced a higher number of rainfall spells compared to the other months. In October a very few rainfall spells swiped over the country. 2008 and 2011 are the notable years when a higher number of rainfall spells was counted.

Light rainfall for the duration of six consecutive days, for this category counted the number of spells and graphically presented in fig.-3(d). In June

Fig.3(b): Light rainfall when it occurred four consecutive days for the period of 1992-2021

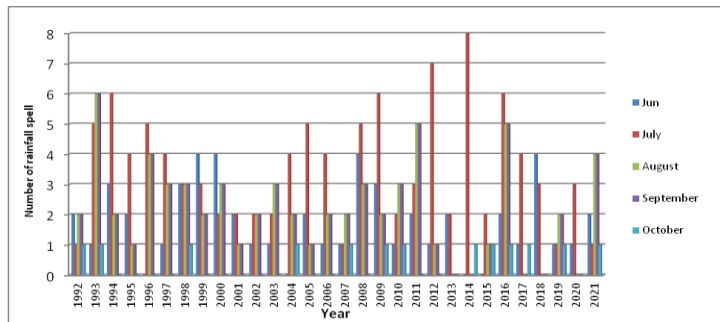the rainfall activities were a little bit more prominent for the period of 1992-2021 than the other considerable months. It is noticeable that the country did not receive this category of rainfall spell in October during this period. 2000, 2004 and 2008 these years can be noted for higher number of rainfall spells.

Fig.3(c): Light rainfall when it occurred 5 consecutive days for the period of 1992-2021

but in others month's country received a very little number of spells. 2001 is the year when country received 8 times rainfall which is the highest number of occurrences for a single year of this category during monsoon period for the mentioned period.

When the measured rainfall/day is a little bit higher than light rain, (11-21) mm/day is considered as moderate rainfall. Authors also categorized this category into five categories according to its continuations. First explain the duration

This stage authors intend to calculate the nature of long duration (seven days or more) rainfall spells for the Light rainfall and considered the period 1992 to 2021 which is analyzed and visualized in fig.-3(e). Country received 47 times rainfall spells only in July during monsoon period
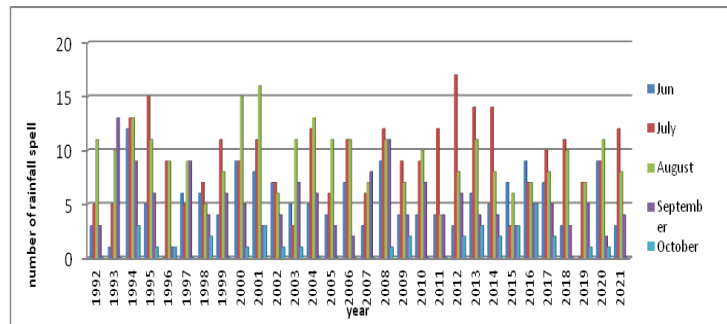

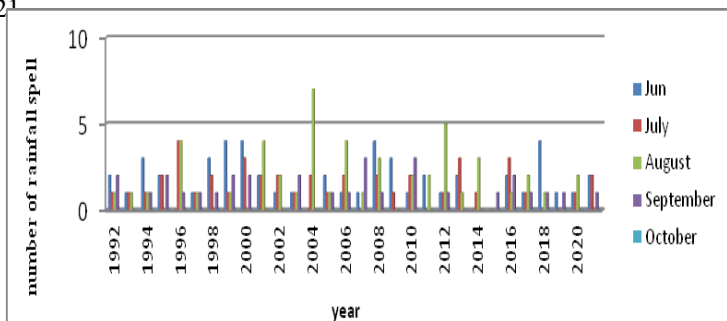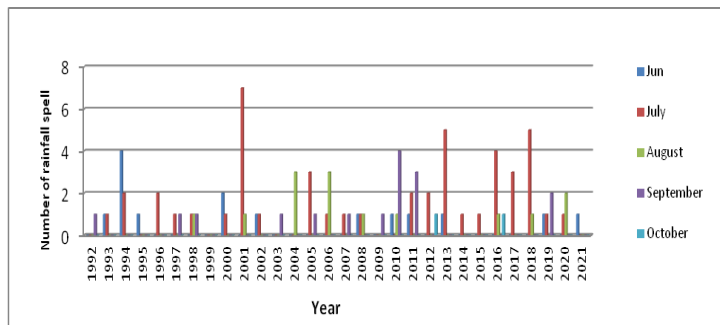Fig.3(d): Light rainfall when it occurred six consecutive days for the period of 1992-2021

three when monsoon rainfall showed its moderate activity consecutive three days which showed in fig.-4(a). Number of spells of the mentioned category were more prominent in June and it was much less in October.

Fig.3(e): Light rainfall when it occurred 7 consecutive days for the period of 1992-2021

Second variety of this category has considered when moderate rainfall continued its activity at a stretch for four days and also graphically presented in fig.-4(b). This time monsoon wind showed its activity more strongly in August then in June and compare to the others months. In October the moderate monsoon rainfall continued for four days only once at 2009.

When authors considered five days duration for moderate rainfall, they found

that in July the country received 7 times, August 5 times, September and October 2 times but in June only once the country received the rainfall spell during the mentioned period. The description represented in fig. - 4(c).

When authors paid attention to find out the scenario for the six consecutive days for moderate rainfall spells, it was revealed that moderate rainfall swiped the country for six days at a stretch only once at 1994 in July. It is notable that the country never experienced moderate

Fig.4(a): Moderate rainfall when it occurred 3 consecutive days for the period of 1992-2021

rainfall continuing more than six days at a stretch for the mentioned period. In this step authors calculated the number of moderately heavy rainfall spells in different duration for the monsoon phase and considered the mentioned period.

When studying the duration three category, the measurement result revealed that rainfall spells occurred the highest 70 times in July, 64 times in June, 46 times in August, 23 times in September and the lowest 16 times in October. The mentioned statistics graphically presented

Fig.4(b): Moderate rainfall when it occurred 4 consecutive days for the period of 1992-2021

in fig.-5(a).

Then authors calculate the number of occurrences when country received moderately heavy rainfall for consecutive four days and also represents graphically in fig.-5(b), which indicates that the country received rainfall spells a little bit more times in August than other months of monsoon phase. The number of spells was lowest in September and October during the considerate time period.

Most of the years during the mentioned period the country never experienced

Fig.4(c): Moderate rainfall when it occurred 5 consecutive days for the period of 1992-2021

moderately heavy rainfall spells except few mentionable years. In June 2011 and 2021 and in August 1996, 2014, 2017, 2011 are the years when this scenario was observed in a few places of the country. Graphical fig.-5© is the presentation of the observed scenarios. It is mentionable that the country did not receive this categorical rainfall spell for the duration of more than five days. When measured rainfall in between (44-88) mm/day is considered as heavy rainfall. Authors also classified this category into five classes on the basis of its continuation.
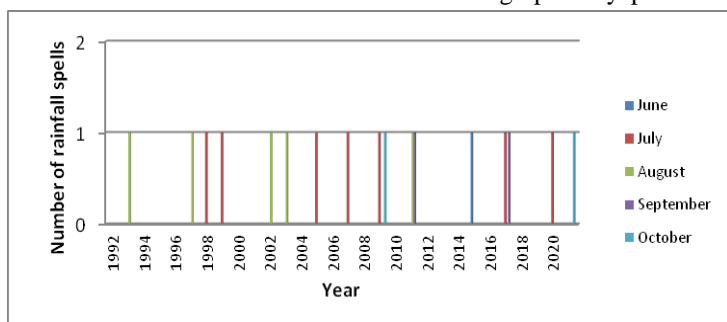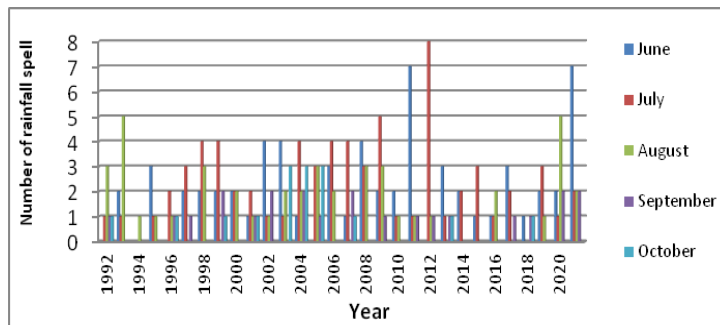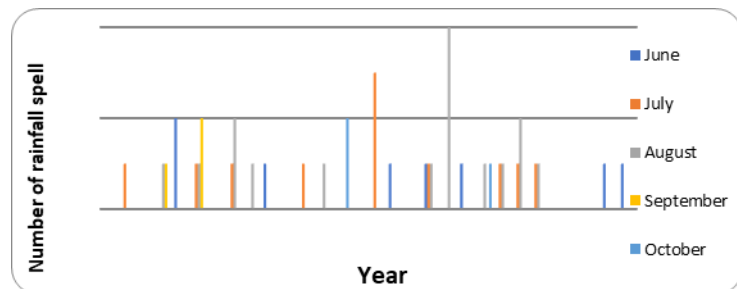
Fig.5(a): Moderately heavy rainfall when it occurred 3 consecutive days for the period of 1992-2021

At first explained the consecutive 3 days and showed in the following graphical Fig_6 (a). Authors make a short brief of the situation that in July monsoon wind was so active, so that the highest number (59) of rainfall spells swept over the country. Observations indicate that the number of spells was 38 in June, 36 in August, 22 in September and the lowest number was calculated 12 for October.

Analyzing the result of heavy rainfall duration 4 days spells from the historical data of Bangladesh Meteorological

Department represented in Fig.-6(b). Calculated value indicates that the number of spells is very few, the highest number of spells counted in July 13, in June 10, in August 7 in September 2 and lowest number of spells only once occurred in October during the considerable period.

Same analysis has been done for the duration of 5 days. Number of spell duration 5 days, observed from the

Fig.5(b): Moderately heavy rainfall when it occurred 4 consecutive days for the period of 1992-2021
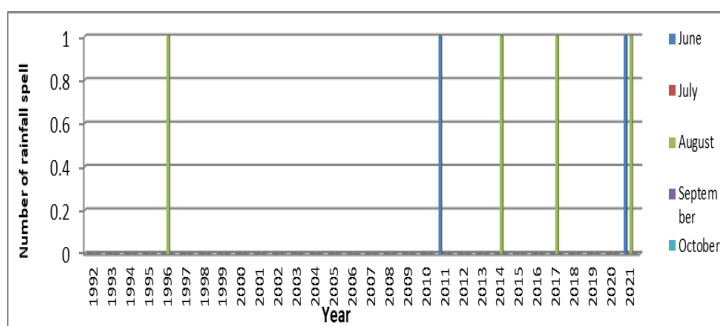
Fig.5(c): Moderately heavy rainfall when it occurred 5 consecutive days for the period of 1992-2021

historical data in July 6 times and in June 4 times but other three months of monsoon period did not experience heavy rainfall at a stretch 5days the described scenario reflected in fig.-6(c).

It is mentionable that country received heavy rainfall for duration six days at 2019 in July, at 1996 and 2011 in August. On the other hand, heavy rainfall started on 23th August and continued for eight days then ended on 30th August in 1998.
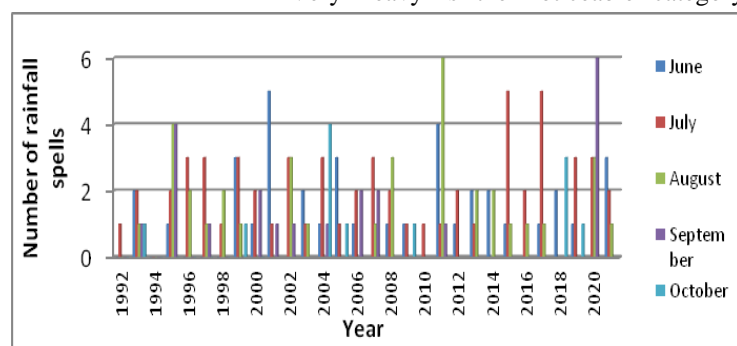
Very heavy is the noticeable category

when rainfall amounts are measured more than 88mm/day.

This category is also examined by the authors and classified according to its continuation. The classified categories are three days, four days, five days, six days, and seven or more days.

This category is also examined by the authors and classified according to its continuation. The classified categories are three days, four days, five days, six days, and seven or more days.

When describing the three days

Fig.6(a): Heavy rainfall when it occurred 3 consecutive days for the period of 1992-2021

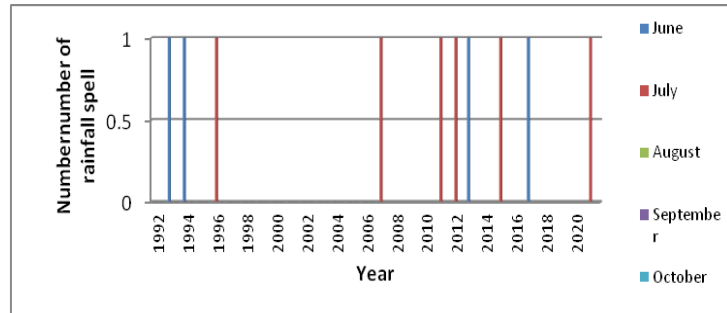category, it has to mention that the number of spells counted highest in July 29 times, in June 21 times, in August 13 times, in September 11 times and the lowest number of rainfall spells 4 times was received in October. Descriptions graphically presented in fig.-7(a).

The 4days category has been explained and presented in fig.-7(b). Counted from the historical data for the mentioned period and found that presence of this category was maximum in July secondly in June, other months experienced only once but except in October where there is no indication for the presence of spells of this

Fig.6(b): Heavy rainfall when it occurred 4 consecutive days
for the period of 1992-2021

category. Then authors took the initiative to explain the very heavy rainfall when it continued for five days at a stretch, it was noticed that in 2011 the country received twice this category of spell in August. July 2009 and 2015 are the significant years for receiving the similar type of spells once for each year. Other months of the monsoon period also received this category of spell only one time during the mentioned period. But in October the very heavy rainfall never continued for five consecutive days for a considerable

period. All the descriptions have been graphically presented in fig.-7 (c).

Among the 35 observatories of Bangladesh Meteorological department, very heavy rainfall continued for six days only in July at 2002 in Sandwip. But it occurred for consecutive seven days at June 2015 in Teknaf, July 2019 at Sitakunda. It is also noticeable that there is no record that very heavy rainfall continued for more than 7 days in any month of monsoon during mentioned

Fig.6(c): Heavy rainfall when it occurred 5 consecutive days
for the period of 1992-2021.

period. To reveal the characteristics of rainfall activities over Bangladesh for the monsoon period authors decided to calculate the rainfall spells for the individual months of monsoon period and considered the rainfall amount equal to or more than 10mm/day which also presented in fig.-8.

Counted values of rainfall spells were highest in July in all categories. It was also revealed from the observed data, that the number of spells were secondly

Fig.7(a): Very Heavy rainfall when it occurred 3 consecutive
days. for the period of 1992-2021

highest in the categories of duration 3, 4 and 5 in August but for duration (7-10) days category, was in June and for the category 10 days or more than 10 days, it was in September. Lowest number of spells swept over the country in October. It is also notable that the country never experienced any spells that lasted more than 10 days in October for the period of 1992 to 2021. In this step authors intend to find out the significant levels of the trends on the basis of its intensity and duration. Mann Kendall test has been done and only few significant levels were found which are shown on the Table: 1
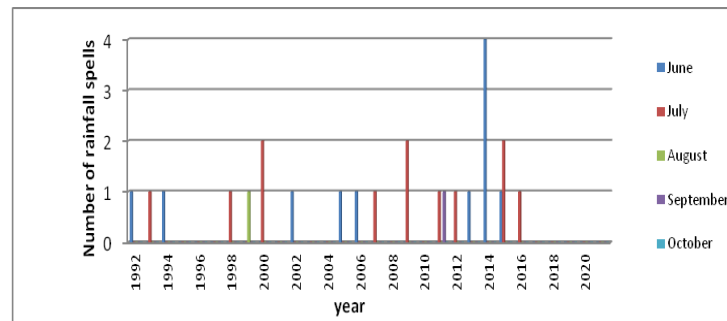

Fig.7(b): Very Heavy rainfall when it occurred 4 consecutive
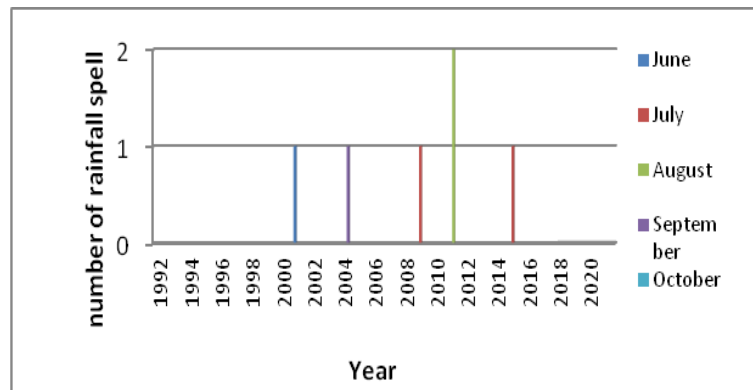days for the period of 1992-2021

Fig.7(c): Very Heavy rainfall when it occurred 5 consecutive days
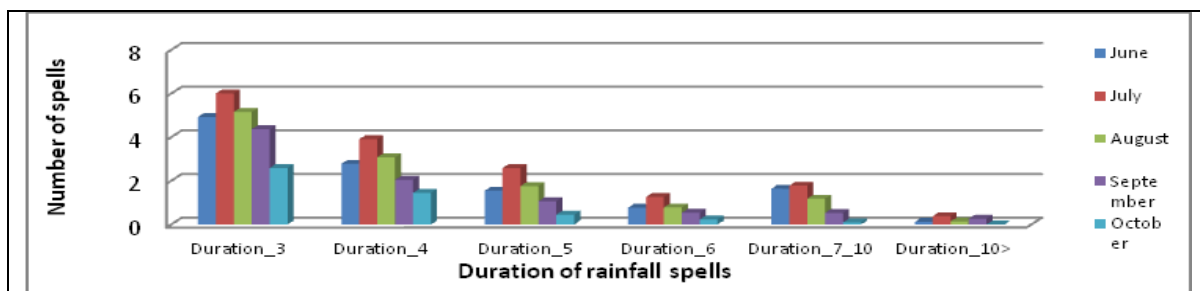for the period of 1992-2021

Fig.8: Number of rainfall spells of individual month of monsoon

Table: 1. The significant levels of the trends of rainfall spells on the basis of its intensity and duration by Mann Kendall test.

Category on the basis of intensity and duration	Tau	1 sided P-value	Significant Level
July_light_Duration3	-0.199	0.06808	On the edge of significance
August_light_Duration4	-0.242	0.037854	Highly Significant
August_light_Duration5	-0.252	0.035015	Highly Significant
September_light_Duration4	-0.202	0.069135	On the edge of significance
September_light_Duration5	-0.252	0.035015	Highly Significant
July_Moderate_Duration6	-0.223	0.08281	Highly suggestive significant
August_Moderate_Duration5	-0.227	0.073965	Highly suggestive significant
October_Moderate_Duration5	0.218	0.08506	Significant
June_ModeratelyHeavy_Duration5	0.243	0.06201	On the edge of significance
August_ModeratelyHeavy_Duration5	0.207	0.09481	Highly suggestive significant
September_ModeratelyHeavy_Duration4	-0.26	0.048318	Significant
July_VeryHeavy_Duration7	0.223	0.08281	Highly suggestive significant

Let (X_1, Y_1) ,..., (X_n, Y_n) be a bivariate random sample of size n. The Pearson correlation coefficient provides an optimal measure of the degree of association between the X's and the Y 's when the sample is drawn from abivariate normal distribution. The Pearson correlation coefficient is reasonably robust for many other

distributions as well. The Kendall correlation coefficient, denoted by τ, provides a more general non-parametric measure of monotonic association. It is said to be monotonic since making a monotonic transformation on either the X's or the Y 's does not change the numerical value of τ. Kendall's rank correlation coefficient (Kendall, 1970, equation 1.5) may be written,

$$\tau = \frac{S}{D} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(2)$$

where S, is the Kendall score given by

$$S = \sum_{i>j} sign(Xj - Xi)sign(Yj - Yi), \dots\dots\dots\dots\dots\dots\dots..(1)$$

where sign($\cdot$) denotes the sign function and D is the maximum possible value of S. In the case where there are no ties among either the X's or the Y 's,

$$D = \binom{n}{2}.$$

*More generally, if there are n_x distinct ties of extent t_i, $i = 1,....,n_x$ among the X's and n_y distinct ties of extent u_i, $i = 1,\dots,n_y$ among the Y 's then

$$D = \sqrt{\left(\binom{n}{2} - T\right)\left(\binom{n}{2} - U\right)}.$$

Where

$$T = \frac{1}{2\sum_{i-1}^{nx} ti(ti-1)},$$

and

$$U = \frac{1}{2}\sum_{i=1}^{ny} ui(ui-1).$$

In the case where there are no ties in either ranking, it is known (Kendall, 1975, p.51) that under the null hypothesis, the distribution of S may be well approximated by a normal distribution with mean zero and variance,

$$Var(S) = \frac{1}{18} n(n-1)(2n+5),$$

provided that $n \geq 10$. Valz and McLeod (1990) have given a simplified derivation of this formula for Var (S). In the case of ties, the variance of S is more complicated,

$$Var(S) = \left\{ \frac{1}{18} n(n-1)(2n+5) - \sum ti(ti-1)(2ti+5) - \sum ui(ui-1)(2ui+5) \right\}$$
$$+ \frac{1}{9n(n-1)(n-2)} \left\{ \sum ti(ti-1)(ti-2) \right\} \left\{ \sum ui(ui-1)(ui-2) \right\}$$
$$+ \frac{1}{2n(n-1)} \left\{ \sum ti(ti-1) \right\} \left\{ \sum ui(ui-1) \right\}.$$

Mann Kendall test has done and Table-1 indicates the significant level of different categories of Rainfall spells.

It is also analyzed to compare the duration and frequency of rainfall spells over the country for the monsoon period.

In this step authors decided to find out the rainfall intensified regions of the country. To achieve the expectation spatial distribution has been done for the individual month of monsoon phase and for the total monsoon period on the basis of frequency and duration of rainfall spells. The fig.-9(a) and fig.-9(b) are the representative scenario of rainfall intensified regions of Bangladesh, accordingly frequency and duration of rainfall spells for the month of June. Interpreting the both analysis, it can be summarized that the southern and the extreme northeastern part of the country experienced the longest duration and the maximum number of frequency but on
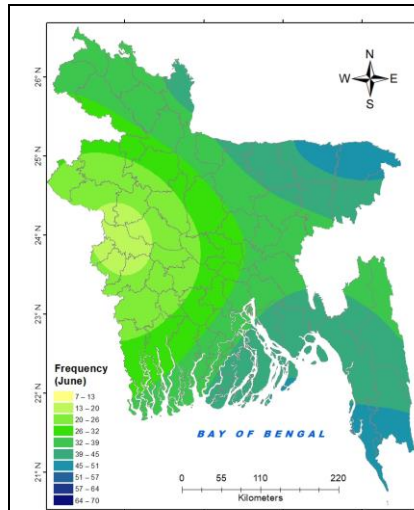
Fig.9(a): Spatial distribution of rainfall spells frequency for the month of June
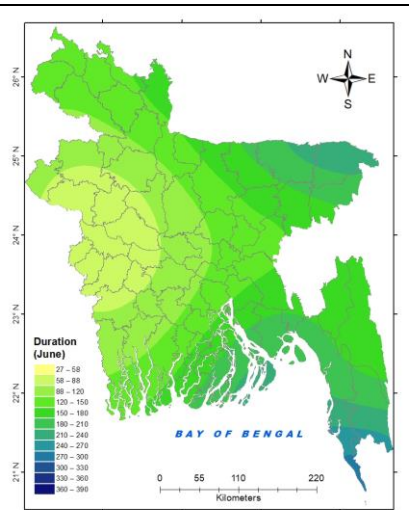

Fig.9(b): Spatial distribution of rainfall spells duration for the month of June

the other hand northwestern part of the country specially Ishurdi, Chuadanga, Shatkhira and surrounded regions received the less number and shorter duration of rainfall spells for the period (1992-2021) in June. It has to mention that the highest number of rainfall spells of different Categories 61 was counted in Sylhet but for the longest duration of total rainfall spell 336 days observed in Teknaf. Considered the month July, where analyzed fig.-10(a) for frequency and fig-10(b)

for duration by spatial distribution has been presented below and also explained as rainfall activity was most intensified in the southern and the northeastern part of country, it was moderately intensified in the central part and lightly intensified in the northwestern part of the country. It is also noticeable that rainfall spells were the most frequent and continued for the longest duration in Teknaf. The opposite scenario can be explained for Ishurdi where the number of rainfall spells was most infrequent and also the total duration was the shortest for the considered period among the 35 observatories of the
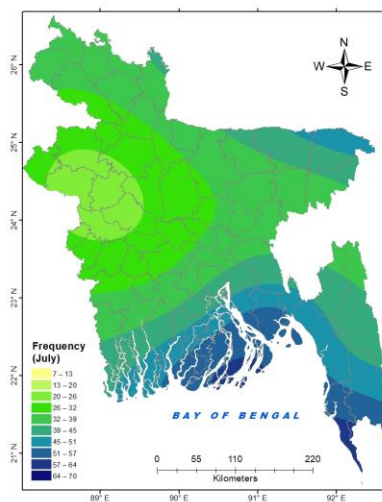

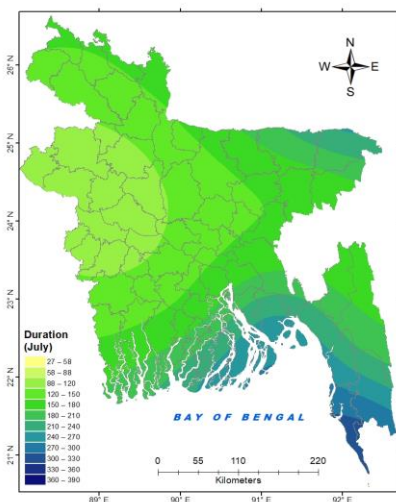Fig_10(a): Spatial distribution of rainfall spells frequency for the month of July

Fig.10(b): Spatial distribution of rainfall spells duration for the month of July

country. By using similar method, it was also examined for the month of August. The analyzed scenario for the frequency and duration of rainfall spells which represented in the fig.-11(a) and fig.-11(b). Interpreting the mentioned figures, it can be explained that the monsoon axis swept the Southern part of the country especially Teknaf, Sandwip and Cox's Bazar most actively and also sylhet region received remarkable number of rainfall spells for
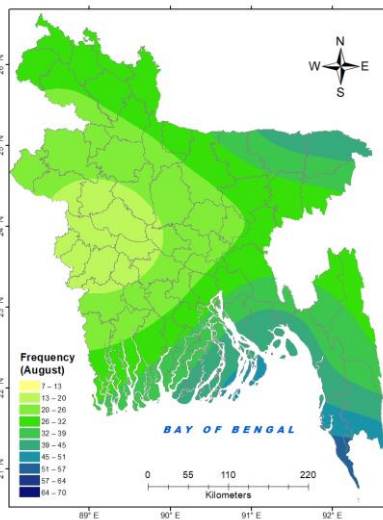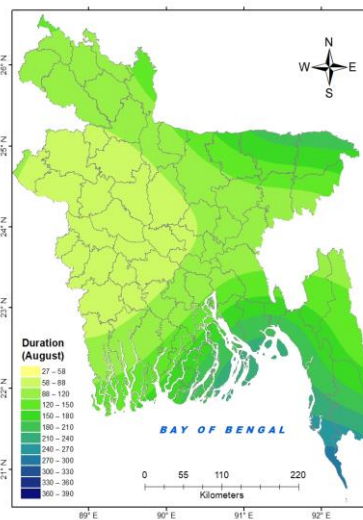

Fig.11(a): Spatial distribution of rainfall spells frequency for the month of August.

Fig.11(b): Spatial distribution of rainfall spells duration for the month of August.

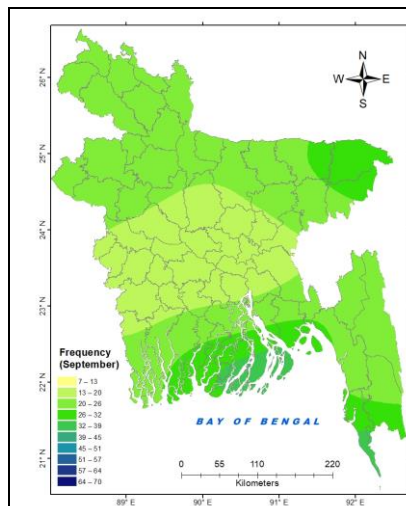longer duration in August compare to the Northern,

Fig.12(a): Spatial distribution of rainfall spells frequency for the month of September.
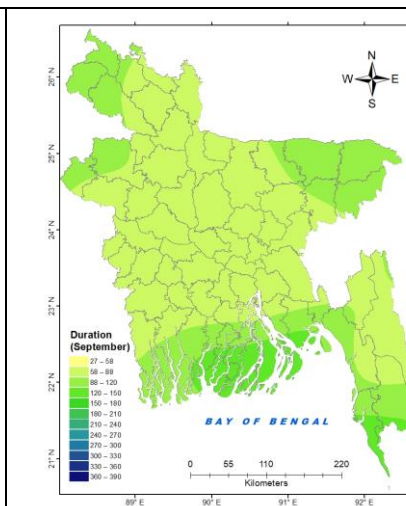

Fig.12(b): Spatial distribution of rainfall spells duration for the month of September

Northwestern and its extended part also. Jessore, Rajshahi and Chuadanga and surrounded regions experienced the lowest number and the shortest duration of rainfall spells.

Another mentionable month is September which received much amount of rainfall due to monsoon wind. Fig.-12(a) and fig.-12(b) are the reflection of the rainfall spells and duration for the September month and for the considered period. When explained the rainfall activity scenario, it found little bit different from the above-described scenario months of June, July and August. The monsoon axis swept most of the part less actively. Only the extreme southern part mainly notable Teknaf, Sandwip, Sitakunda, Hatiya and Cox'bazar and extreme Northeastern part received the number of rainfall spells due to monsoon wind. Central part experienced the lowest number of rainfall spells. The lowest number of spells counted 13 at Faridpur during this period.
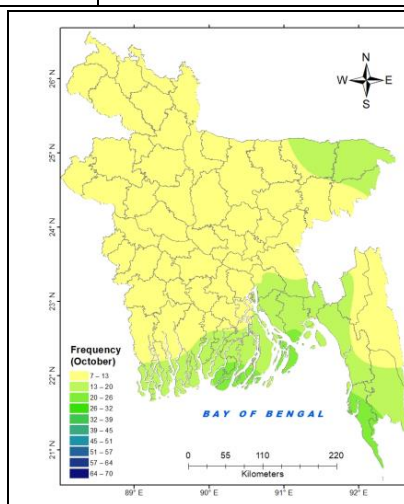

Fig.13(a): Spatial distribution of rainfall spells frequency for the month of October.
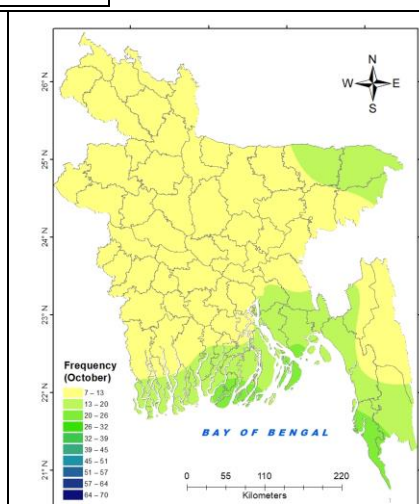

Fig.13(b): Spatial distribution of rainfall spells duration for the month of October.
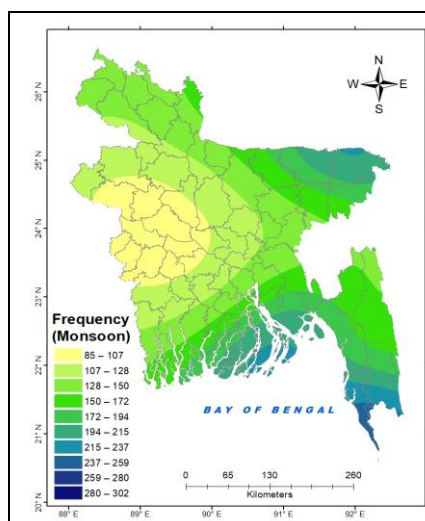

Fig.14(a): Spatial distribution of rainfall spells frequency for the monsoon period.
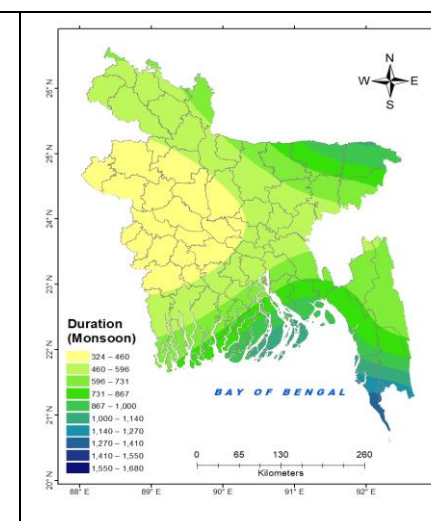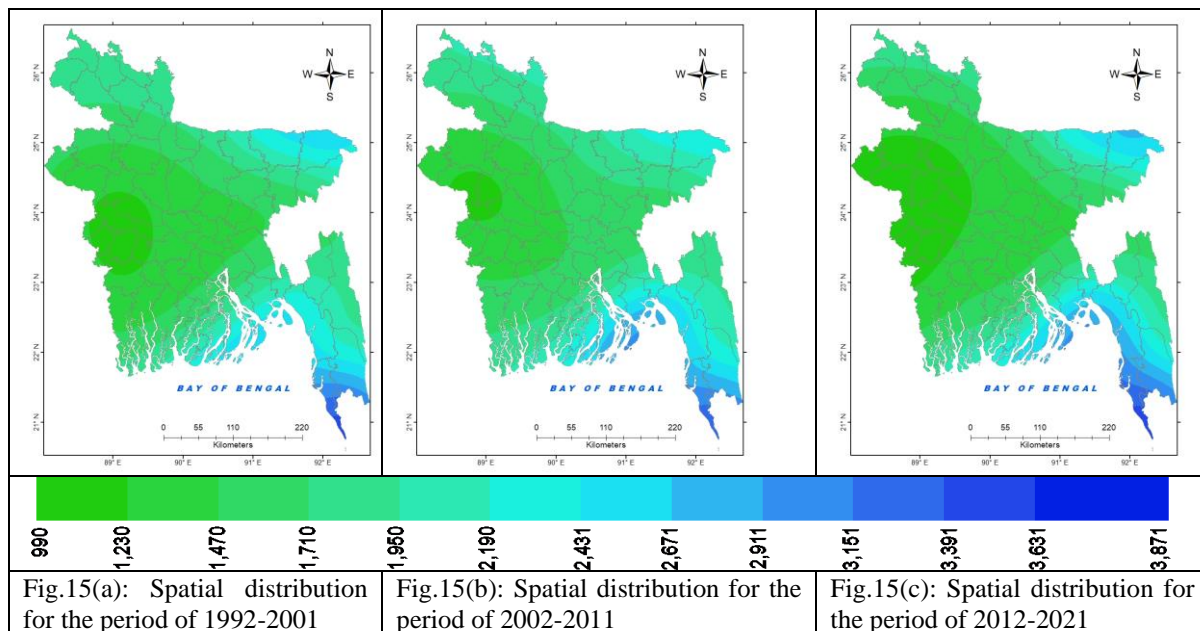

Fig.14(b): Spatial distribution of rainfall spells duration for the monsoon period.

October month is last month of monsoon period. Mean withdrawal dates of the summer monsoon from the extreme north-western part and extreme south-eastern part of the country are 30 September and 17 October [7]. Fig_13 (a) and Fig_13(b) indicates the spatial distribution of frequency and the duration of rainfall spells for the October month accordingly. In October country received the lowest amount of rainfall due to monsoon wind. When describing the mentioned figures, it was

observed that most part of the country received a very little number of rainfall spells except the southern part where Teknaf, Cox's Bazar, Khepupara and Hatiya received quite better number of rainfall spells. Among other parts of the country sylhet experienced some better number of rainfall spells and for longer duration. The rainfall condition considering the spells and Duration For monsoon period where considered the months June, July, August, September, October.

Spatial distribution has done for the frequency and for the duration which presented in Fig_14 (a) and 14(b). When go through the interpretation of the figures, it was observed that the sceneries are more or less similar with the descriptions of the above-mentioned individual months. Rainfall spells and duration are more noticeable in the extreme Southern and northeastern part but it was less prominent in Northwestern part compare to the other part of the country.

Fig.15(a): Spatial distribution for the period of 1992-2001	Fig.15(b): Spatial distribution for the period of 2002-2011	Fig.15(c): Spatial distribution for the period of 2012-2021

Finally authors completed the decadal analysis on the basis of (rainfall amount /day). Analyzed the output results of special distribution, it can be explained that in second decade (2002-2011) country received the highest amount of rainfall among the divided three decades. First decade (1992-2001) received amount of rainfall a bit better compare to the latest decade (2012-2021) but it received less amount of rainfall compare to the second decade except some parts of the southern regions, most notables are Kutubdia, Chittagong ,Sitakunda, cox'bazar, Feni, Rangamati and the Northeasten part mainly Sylhet region where country received the highest amount of rainfall in the latest decade compare to the other two decades. Above explanation also visualized in the Fig.15 (a), Fig.-15(b), Fig.-15(c) accordingly.

Conclusion:

1. Country received the highest number of rainfall spells most of the times in August and lowest number in October when categorized on the basis of intensity during monsoon period for the period of 1992-2021.

2. When categorized only on the basis of duration it was observed that in July the country received the highest number of rainfall spells and lowest in October during monsoon for the period of 1992-2021.

3. According to Mann Kendall test it can be concluded that light rainfall in July for duration three days, in August and September for duration four and five days indicate decreasing trend in different significant levels.

4. According to Mann Kendall test it can be also concluded that moderate rainfall in July duration six days, in August duration Five days indicate the decreasing trend and the levels determined Highly suggestive significant.

5. In September moderately heavy rainfall duration four days category determined a decreasing trend significantly on the basis of Mann Kendall test.

6. Analyzed the trends of moderate rainfall in October and moderately heavy rainfall in July, August for duration five days and very heavy rainfall in July for duration seven or more than seven days by using the Mann Kendall test which indicates the increasing trend of different significant levels.

7. Spatial distribution has been done for every individual month of monsoon period for the considerable time period 1992-2021 which indicates that the rainfall activity was the most prominent in the extreme South and Southeastern part especially Teknaf and the surrounding regions received the highest number of rainfall spells. On the other hand Northwestern part specially Ishurdi and the neighboring regions experienced lowest number of rainfall spells.

8. Decadal analyzed also done on the basis of (rainfall amount/day) mm that come to the result that in the second decade (2002-2011) rainfall activity was the most noticeable in the first decade (1992-2001) it was moderately prominent and in the latest decade (2012-2021) country received the lowest amount in the most of the regions all over the country compare to the other two decades during monsoon period.

9. According to the decadal analysis Southern part and the Sylhet regions of the country are gradually receiving the higher amount of rainfall.

Acknowledgement:

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