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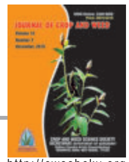

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# Rainfall probability and trend analysis for strategic crop planning with their impact on the existing cropping system in the new alluvial plains of West Bengal

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## ABSTRACT

*Daily rainfall data for the period of 36 years (1985-2020) of new alluvial zone of West Bengal has been analysed to understand weekly, monthly, seasonal and annual distribution pattern along with expected rainfall amount at 90%, 75% and 50% probability levels.The Mann-Kendall test for monotonic trend analysis together with the nonparametric Sen's slope estimator was applied to estimate the magnitude of the seasonal rainfall trend. The results revealed a long term declining trend of winter and post monsoon rainfall, whereas increasing trend was observed in summer and south west monsoon rainfall. Annual rainfall of the region ranged from 1523.4-1786.4 mm out of which 198.4-264.6 mm was received in summer/pre-kharif, 1138.5-1334.4 mm during monsoon/ kharif, 157.4-185.7 mm during post monsoon and 29.1-34.6 mm during the winter season. Weekly rainfall during the monsoon (23$^{rd}$ -39$^{th}$ SMW) at 90% probability ranged from 7.9-36.5 mm, 18.9-55.5 mm at 75% probability and 37.6-84.1 mm at 50% probability level.The ideal combination of crops for this regions may be kharif rice in medium and lowland, vegetables, ground nut etc in the upland in the kharif; mustard field pea, potato in upland during the rabi season.*

***Keywords***: Crop planning, Mann-Kendall test, rainfall probability, trend analysis, West Bengal

One of the most important natural resources for crop production is rainfall which can vary in amount or distribution or both spatially and temporally. Assessing the trend of climate parameter is important because the hydrological cycle is getting changed (Feng *et al*., 2016) due to climate change in terms of occurrence of precipitation, distribution, time, intensity, quality and quantity. Any changes in the rainfall pattern will directly affect the runoff and stream flow as these are important parameters for the demand-supply chain of water in the industrial, household and power generating sectors also. The onset and withdrawal timing of the rainy season is now directly linked with the crop-weather calendar preparation for the better understanding of the crop growing period, date of sowing and harvesting of specific crops at any particular region, the critical growth stage of the crop that will face rainfall or dry days etc., rainfall frequency analysis have so far been attempted in different regions of India (Muniyappa and Aruchamy, 2010; Ravindrababu *et al.,* 2010) and it was summarized that rainfall occurrence is certain or can be assured rainfall at probability greater than or equal to 80 %, while 50% chances of occurrence is the medium limit of rainfall probability and may involve dry spell risk in between the cropping season (Bhakar *et al.,* 2008). Therefore rainfall probability analysis can be used to predict the cause of the crop failure, or any yield loss due to excess or deficit distribution of rainfall. The weekly rainfall distribution at different probability levels is very much helpful and suggested by many researchers for the purpose of crop planning, identifying the drought period etc. During recent periods, use of probability distribution function for weekly, monthly, seasonal rainfall analysis has been receiving much attention to the programmers, researchers and other stake holders for their future planning related to agriculture. Similar kind of research work was also undertaken by other researchers in various parts of India like Pusa, Bihar (Singh *et al.,* 2008), Odisha (Ray, 2016; Kumar *et al.,* 2018; Dugal *et al.,* 2018), Ludhiana, Punjab (Kumar and Bharadwaj, 2015), Bundelkhand, Madhya Pradesh (Alam *et al.,* 2016) and Raghunathpur, West Bengal (Ghosh *et al.,* 2014) and outside India also (Gadedjisso-Tossou *et al.,* 2021; Fujibe *et al.,* 2005).Till date the districts under New Alluvial Zone has not been explored that much. In view of the above points, our present study has been done to find out annual, seasonal, monthly and weekly rainfall distribution, chances of getting a particular amount of rainfall at different probability levels and the seasonal trend of rainfall for better understanding of the rainfall variability in the new alluvial zone of West Bengal using 36 years of time series data (1985-2020). The impact of seasonal rainfall

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on the existing cropping pattern has also been carried out in this study.

## MATERIALS AND METHODS

36 years of daily rainfall data (1985-2020) was collected from Google Climate Engine (https://app.climateengine.org/climateEngine) for the new alluvial zone of West Bengal which comprises districts like Nadia (23.47$^0$ N, 88.55$^0$E), North 24 Parganas (22.61$^0$ N, 88.40$^0$E), Howrah (22.56$^0$ N, 88.05$^0$ E), Hooghly (22.89$^0$ N, 88.24$^0$ E) and Purba Bardhaman (23.23$^0$ N, 87.87$^0$ E). The location of the research area has been depicted in Fig.1. We have ignored the district Kolkata as agriculture is not a significant matter of concern in Kolkata. The daily rainfall data was then converted into weekly totals in the Standard Meteorological Week (SMW) basis. Weekly rainfall (mm) at probability 90%, 75% and 50% was derived using the Weibull's plotting position method (Murthy, 1998). In this process, the weekly rainfall was organized in descending order of magnitude. We have calculated the probability 'P' of the week having rainfall exceeding or equaling normal value by using following formula :

$$P = \frac{m}{n+1}$$

Where $p$ = probability of occurrence, m = rank number; and $n$ = number of years of data used.

For seasonal/annual rainfall probability analysis at 90%, 75% and 50% levels, the whole year was divided into four distinct seasons like the monsoon (23$^{rd}$ SMW-39$^{th}$ SMW), post monsoon (40$^{th}$ SMW- 52$^{nd}$ SMW), winter (1-8$^{th}$ SMW ) and summer (9$^{th}$ SMW-22$^{nd}$ SMW) as India Meteorological Department (IMD) designates these four main seasons of India. The monthly minimum expected rainfall (mm) was also estimated at 10%, 25%, 50% and 75% probability levels (Rai and Singh, 2009). The yield data for the main crops grown in the new alluvial zone was collected from the Department of Planning and Statistics, Govt. of WB (http://wbpspm.gov.in/publications/District% 20 Statistical% 20 Handbook).

### *Trend analysis*

Trend is any significant change over time which can be detected by parametric and non-parametric procedures. In this study statistical significance of trend analysis was done by using Mann-Kendall test while nonparametric Sen's slope estimator method ( Sen,1968) determined the magnitude of the trend.

## RESULTS AND DISCUSSION

### *Distribution of annual and seasonal rainfall*

The compilation of 36 years (1985-2020) of rainfall data on daily basis of five districts of the new alluvial zone of West Bengal revealed that average annual rainfall was 1575.1 mm, 1661.7 mm, 1786.4 mm, 1669.8 mm and 1523.4 mm for Nadia, North 24 Parganas, Howrah, Hooghly and Purba Bardhaman, respectively with coefficient of variation ranging from 12.4-13.8% that means very less variation in the amount of rainfall over the years (Table 1). In Nadia, 20 years recorded below normal rainfall, rest 16 years recorded above normal rainfall. Maximum rainfall (2135.4 mm) was recorded in 2017 and minimum rainfall (1212 mm) was recorded in 2014. North 24 Parganas recorded 17 years with below normal rainfall and 19 years with above normal rainfall. Maximum rainfall (2093.4 mm) was recorded in 2017 and minimum rainfall (1263 mm) was recorded in 2014. 19 years recorded below normal rainfall and 17 years recorded rainfall above the normal in Howrah with maximum rainfall (2264.6 mm) in 1999 and minimum rainfall (1446.5 mm) in 2014. In Hooghly, there was also 19 years with rainfall below normal and 17 years having rainfall above normal. Maximum rainfall (2177.5 mm) was recorded in 2017 and minimum rainfall (1326.6 mm) was recorded in 2014. In Purba Bardhaman, there were 23 years with below normal rainfall and 13 years with above normal rainfall. Maximum rainfall (2062 mm) was recorded in 2017 and minimum rainfall (1164.9 mm) was recorded in 2010 (Fig. 2). The seasonal rainfall distribution in terms of summer/*pre-kharif*, monsoon/*kharif*, post monsoon and winter rainfall in five districts revealed that maximum rainfall received in monsoon season followed by summer, post monsoon and winter. Monsoon rainfall ranged from 1138.5 mm to 1334.4 mm; summer rainfall ranged from 198.4 mm to 264.6 mm; post monsoon rainfall ranged from 157.4 mm to 185.7 mm and winter rainfall ranged from 29.1 to 34.6 mm. Among all the seasons, the maximum variation of rainfall was observed in winter (42.7-52.6%) and minimum variation was observed in monsoon season (15.2-17%). Variation in summer and post monsoon rainfall was very close to each other (Table 1). The contribution of the seasons to total annual rainfall was 73.6% from monsoon rainfall, 14.1% from summer rainfall, 10.3% from post monsoon rainfall and 1.9% from winter rainfall.

### *Monthly rainfall distribution*

The monthly rainfall distribution and their contribution to total annual rainfall was described in Table 1 for all the five districts in the new alluvial zone of West Bengal. For all the five districts in the study, July came up as the highest rainfall month with monthly total rainfall ranging from 349.6-400.0 mm contributing for 21.1-23.6% of the annual rainfall whereas December was recognized as the month with lowest rainfall. The monthly total rainfall for December ranged from 1.5-

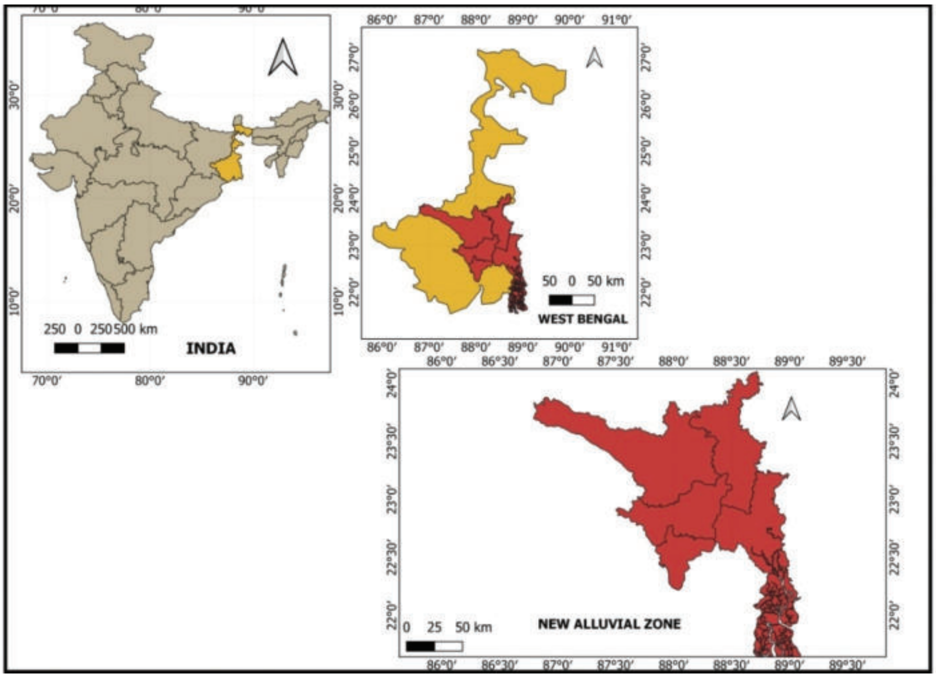


**Fig. 1: Study area map of new alluvial zone of West Bengal**

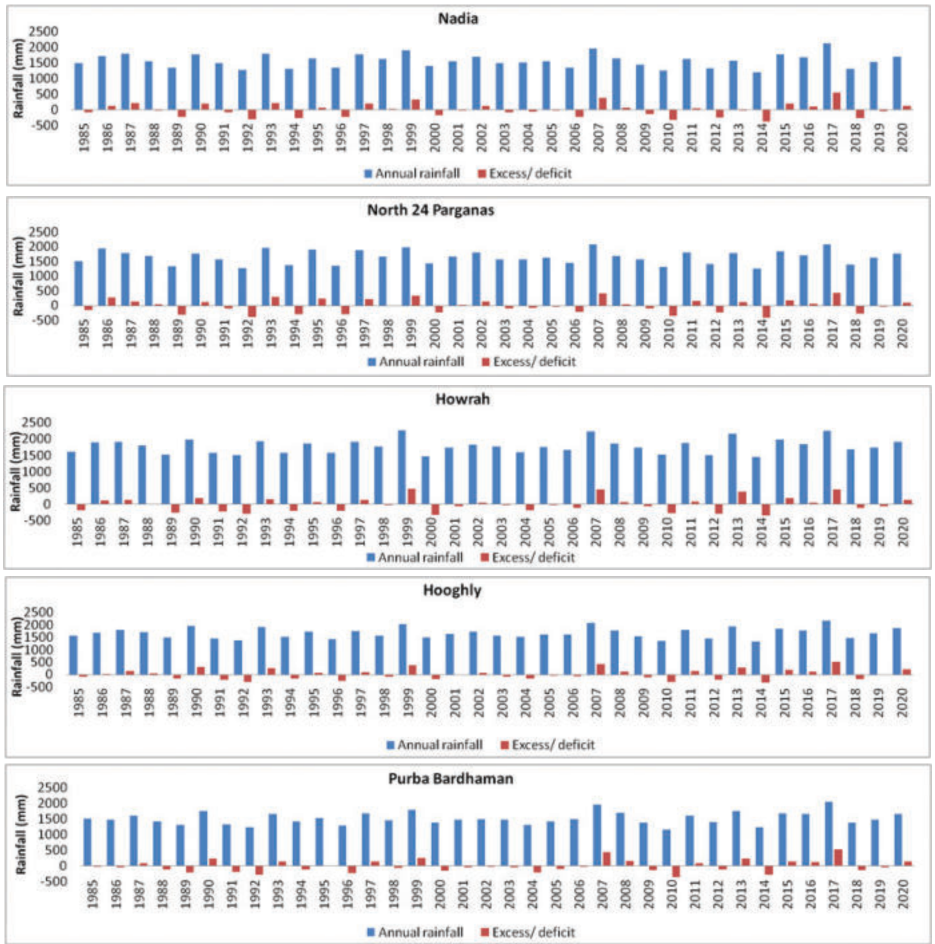


**Fig. 2: Total annual rainfall with excess/deficit annual rainfall for five districts**

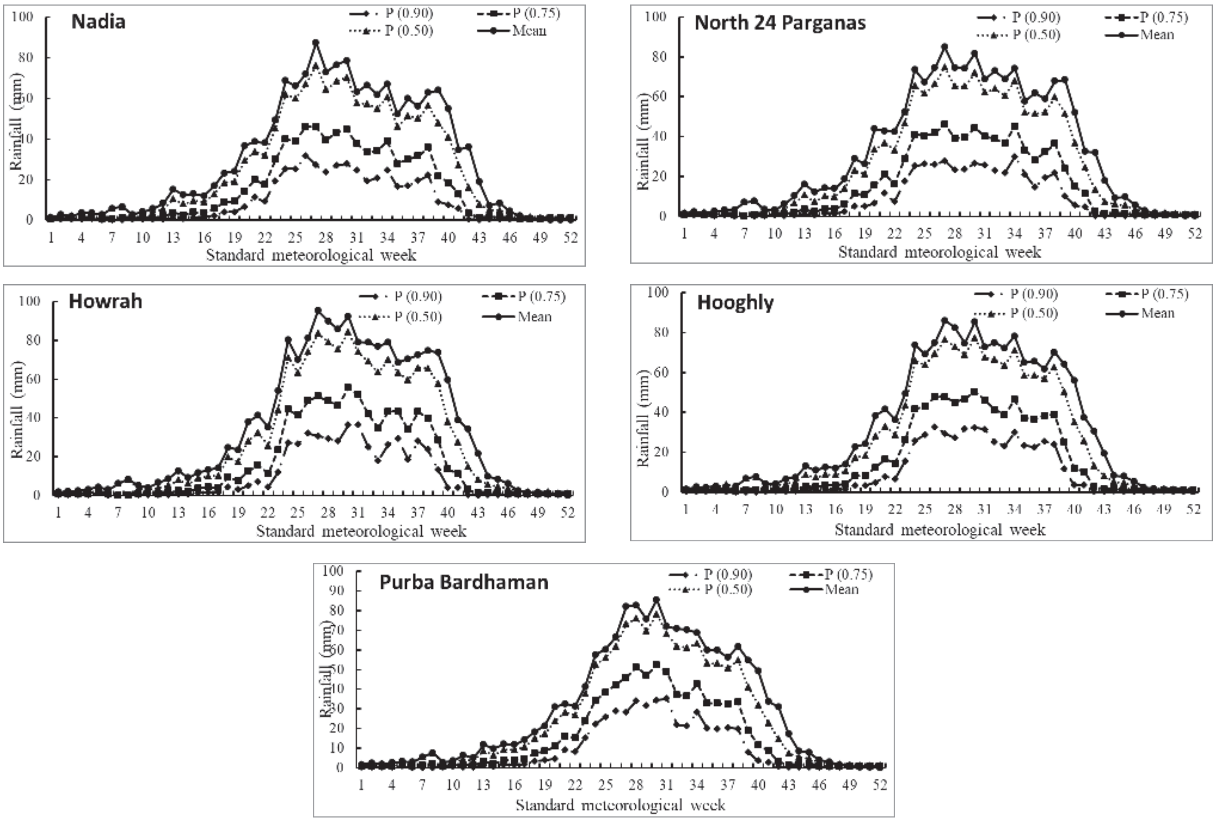


**Fig. 3: Weekly mean rainfall and rainfall at 90%, 75% and 50% probability level for five districts**

4.1 mm which contributed to only 0.1-0.2% of the total annual rainfall. The monthly rainfall variation was minimum (24.6-36.7%) for June to September and maximum (83.1-171.5%) for November and December which signifies that south west monsoon rainfall was certain and at the same time winter rainfall is very much uncertain in the new alluvial zone of West Bengal.

***Distribution and probability analysis of the weekly rainfall***

Mean weekly rainfall distribution at different districts has been presented in Fig.3. The weekly average rainfall ranged from 0.1 mm (52nd SMW) to 87.5 mm (27th SMW) in Nadia, 0.2 mm (52nd SMW) to 84.9 mm (27th SMW) in North 24 Parganas, 0.1 mm (52nd SMW) to 95.2 (27th SMW) mm in Howrah, 0.1 mm (52nd SMW) to 86 mm (27th SMW) in Hooghly and 0.1 mm (52nd SMW) to 85.6 mm (30th SMW) in Purba Bardhaman district. The amount of weekly rainfall was higher at 50% probability level followed by 75% and 90% probabilities. Higher the probability levels means lower will be the associated risk factor. Weekly rainfall at 90%, 75% and 50% probability levels ranged from 0 (6-8 SMW)-31.7 (26 SMW) mm, 0.5 (7 SMW)-46.2 (26 SMW) mm and 1.1(51-52 SMW)-76.3 (27 SMW) mm in Nadia, 0 (6-8 SMW)-30 (34 SMW) mm, 0.3 (7 SMW)-46.2 (27 SMW) mm and 1.1(52 SMW)-74.9 (27 SMW) mm in North 24 Parganas; 0 (6-8 SMW)-36.5 (31 SMW) mm, 0 (8 SMW)-55.5 (30 SMW) mm and 1.1(52 SMW)-84.1(30 SMW) mm in Howrah; 0 (6-8 SMW)-32.7 (26 SMW) mm, 0.6 (6 SMW) -50.3 (30 SMW) mm and 1.1(52 SMW) -77.3 (30 SMW) mm in Hooghly; and 0 (6-8 SMW) -35.2 (31SMW) mm, 0.7(48 SMW) -52.2 (30 SMW) mm and 1.1(51-52 SMW) - 78.3 (30 SMW) mm, respectively in Purba Bardhaman district. Analysis revealed that 20 mm assured rainfall could be expected from 24-34 SMW at 90% probability level, 23-39 SMW at 75% probability and 20-41 SMW at 50% probability, but 50 mm weekly rainfall can be expected at 50% probability from 24-38 SMW in Nadia. North 24 Parganas could expect 20 mm weekly rainfall from 24-35 SMW, 23-39 SMW and 18-41 SMW with 90%, 75% and 50% probability and there is a chance of having least ways of 50 mm of weekly rainfall from 24-39 SMW at 50% probability. Chances of occurrence of 20 mm weekly rainfall at 90%, 75% and 50% probability levels could be expected from 24-38 SMW, 23-39 SMW and 20-41 SMW, respectively and weekly 50 mm rainfall could be expected from 24-39 SMW for Howrah. Hooghly could expect 20 mm weekly rainfall from 24-38 SMW, 23-39 SMW and 22-41 SMW at 90, 75 and 50% probability levels, whereas weekly 50 mm rainfall

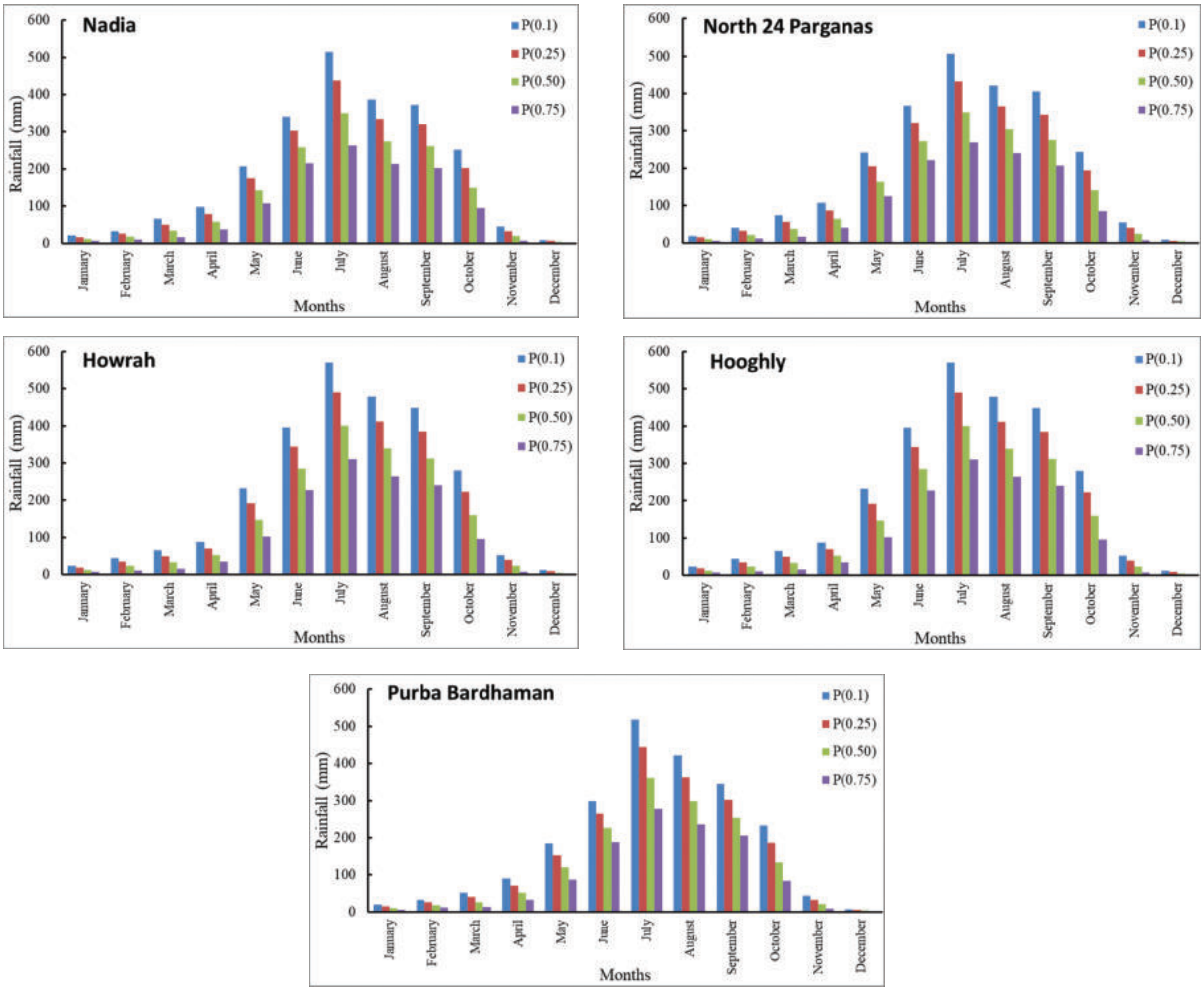


**Fig. 4: Monthly expected rainfall at different probability levels for five districts**

could be expected from 24-39 SMW at 50% probability. 20 mm weekly rainfall at 90%, 75% and 50% probabilities could be expected from 24-37 SMW, 23-38 SMW and 20-39 SMW respectively and weekly 50 mm rainfall could be expected from 24-38 SMW at 50% probability for Purba Bardhaman district.

***Monthly rainfall probability analysis***

The minimum expected monthly rainfall (mm) at 10%, 25%, 50% and 75% probability levels was depicted in Fig.4. For agricultural crop planning purpose, more importance is given to rainfall probability at 75%. From the figures it is clear that the months of June to September received the highest amount of rainfall and December received the lowest amount of rainfall at all the probability levels in all the districts. Rainfall received with 75% probability in June-July-August-September ranged from 187.3 mm to 310.2 mm and rainfall in December ranged from 0.7 mm to 2.8 mm for all the districts. July was the highest rainfall month with 263.1 mm to 310.2 mm total monthly rainfall followed by August (213.9 mm to 264.0 mm), September (202.3 mm to 240.3 mm) and June (187.3 mm to 226.7 mm). From November to March rainfall received at 75% probability was less than 20 mm.

***Agricultural crop planning from the weekly rainfall probability analysis***

Figure 2 covers the weekly average rainfall and the expected rainfall at 90% and 75% (assured rainfall) and 50% probabilities (medium risk limit), covering the whole year. At 75% probability, monsoon season received weekly 21.7-46.2 mm, 23.8-46.2 mm, 23.5-55.5 mm, 25-50.3mm and 18.9-52.2 mm rainfall distributed from 23$^{rd}$ to 39$^{th}$ SMW (112 days) in Nadia, North 24 Parganas, Howrah, Hooghly and Purba Bardhaman, respectively.The analysis revealed that during this period, minimum 20 mm weekly rainfall or more has been recorded. Weekly rainfall of 50 mm or more can be expected at 50 % probability from 24-38 SMW (Nadia), 24-39 SMW(N 24 Parganas), 24-39 SMW (Howrah and Hooghly) and 24-38 SMW (Purba

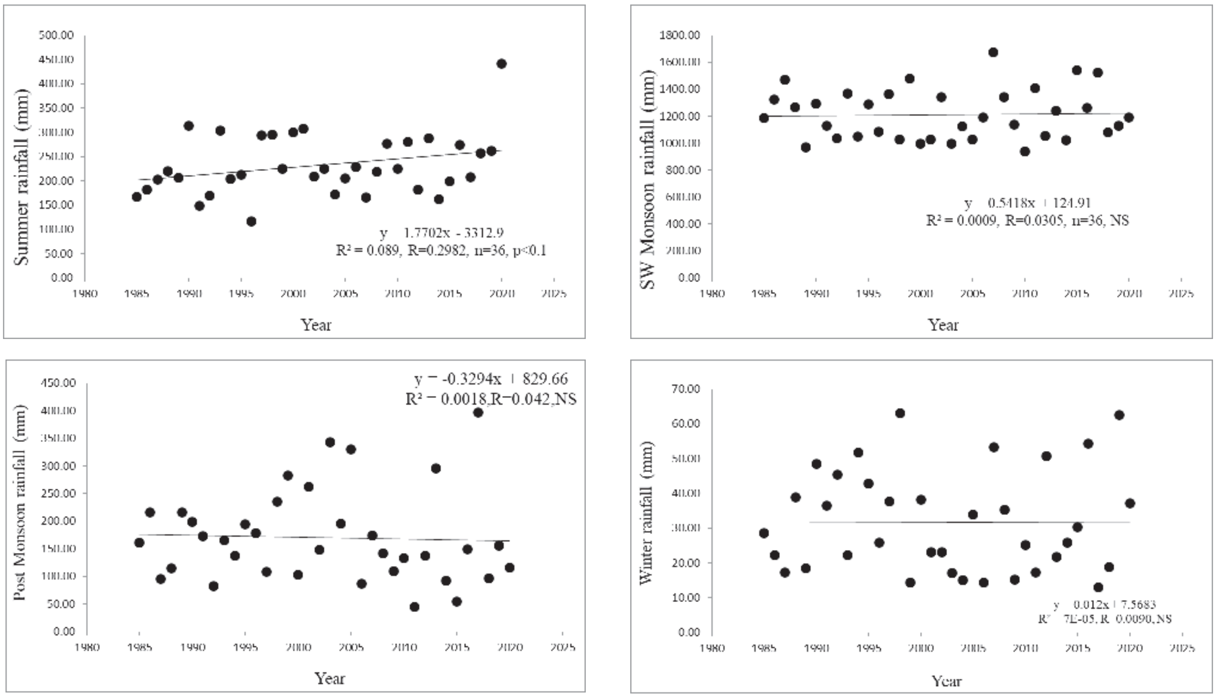


**Fig. 5: Seasonal rainfall trend analysis**

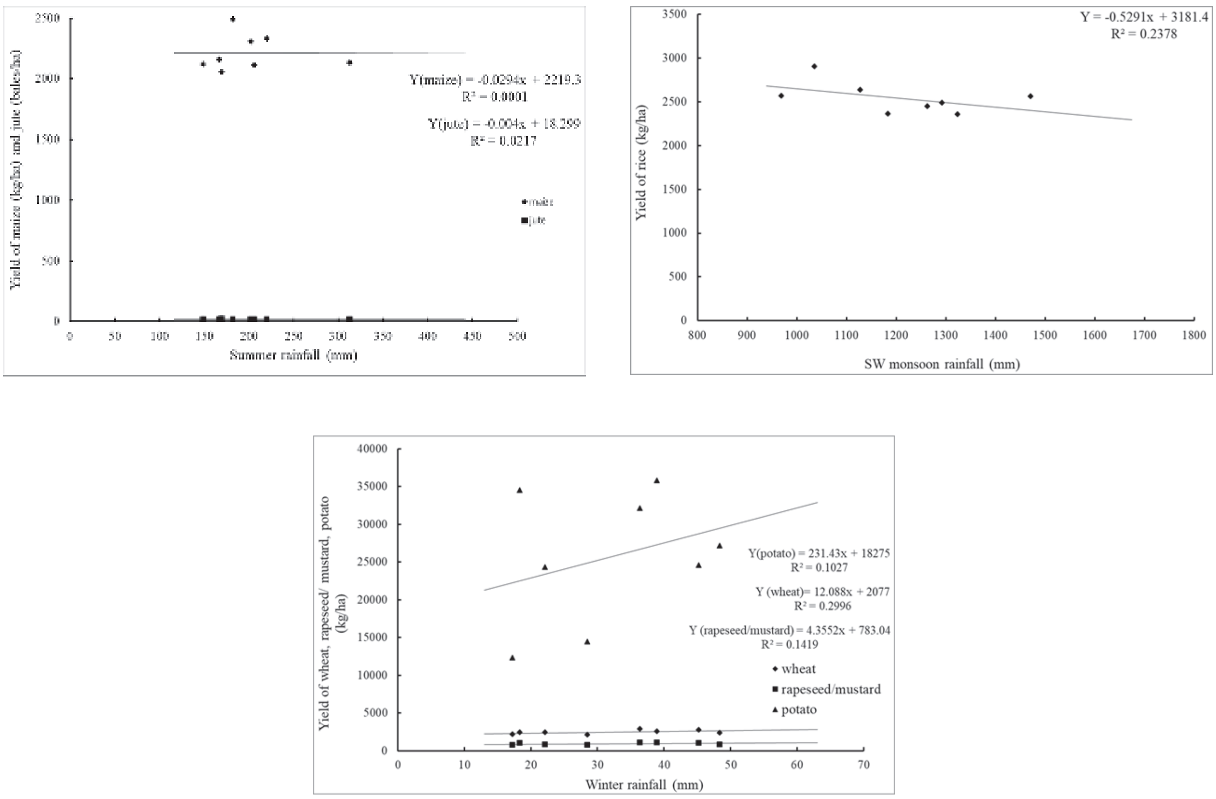


**Fig. 6: Relationship of crop yield and seasonal rainfall**

**Table 1: Mean monthly, seasonal and annual rainfall statistics (1985-2020)**

| Months and seasons | Nadia | | | | North 24 Parganas | | | | Howrah | | | | Hooghly | | | | Purba Bardhaman | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rainfall (mm) | SD | CV % | % of total | Rainfall (mm) | SD | CV % | % of total | Rainfall (mm) | SD | CV % | % of total | Rainfall (mm) | SD | CV % | % of total | Rainfall (mm) | SD | CV % | % of total |
| March | 33.4 | 24.8 | 74.3 | 2.1 | 36.4 | 29.3 | 80.7 | 2.2 | 32.3 | 25.9 | 80.4 | 1.8 | 31.3 | 22.6 | 72.2 | 1.9 | 26.7 | 19.3 | 72.3 | 1.7 |
| April | 58.6 | 30.5 | 52.0 | 3.7 | 63.5 | 33.8 | 53.2 | 3.8 | 52.7 | 27.7 | 52.5 | 2.9 | 53.3 | 27.8 | 52.2 | 3.2 | 51.6 | 29.2 | 56.7 | 3.4 |
| May | 141.6 | 50.8 | 35.9 | 9.0 | 164.7 | 59.8 | 36.3 | 9.9 | 146.8 | 66.7 | 45.4 | 8.2 | 146.2 | 65.5 | 44.8 | 8.8 | 120.2 | 49.7 | 41.4 | 7.9 |
| Summer/*Pre kharif* | **233.6** | **59.5** | **25.5** | **14.8** | **264.6** | **68.4** | **25.9** | **15.9** | **231.7** | **67.9** | **29.3** | **13.0** | **230.8** | **69.0** | **29.9** | **13.8** | **198.4** | **57.0** | **28.8** | **13.0** |
| June | 258.4 | 63.6 | 24.6 | 16.4 | 271.3 | 74.0 | 27.3 | 16.3 | 284.7 | 85.9 | 30.2 | 15.9 | 268.9 | 75.1 | 27.9 | 16.1 | 225.9 | 57.1 | 25.3 | 14.8 |
| July | 349.6 | 128.3 | 36.7 | 22.2 | 350.1 | 121.8 | 34.8 | 21.1 | 400.0 | 133.1 | 33.3 | 22.4 | 361.5 | 122.4 | 33.9 | 21.6 | 360.1 | 123.4 | 34.3 | 23.6 |
| August | 273.5 | 88.3 | 32.3 | 17.4 | 302.7 | 92.7 | 30.6 | 18.2 | 337.7 | 109.3 | 32.4 | 18.9 | 322.3 | 107.5 | 33.3 | 19.3 | 299.1 | 94.6 | 31.6 | 19.6 |
| September | 260.5 | 86.3 | 33.1 | 16.5 | 275.4 | 101.1 | 36.7 | 16.6 | 312.1 | 106.3 | 34.1 | 17.5 | 282.1 | 86.1 | 30.5 | 16.9 | 253.5 | 71.4 | 28.1 | 16.6 |
| Monsoon/*Kharif* | **1141.9** | **192.8** | **16.9** | **72.5** | **1199.4** | **203.3** | **17.0** | **72.2** | **1334.4** | **202.2** | **15.2** | **74.7** | **1234.7** | **193.3** | **15.7** | **73.9** | **1138.5** | **176.8** | **15.5** | **74.7** |
| October | 148.1 | 80.6 | 54.4 | 9.4 | 139.9 | 80.9 | 57.8 | 8.4 | 158.8 | 93.8 | 59.1 | 8.9 | 147.3 | 85.1 | 57.8 | 8.8 | 134.7 | 75.8 | 56.3 | 8.8 |
| November | 19.8 | 19.3 | 97.2 | 1.3 | 24.1 | 24.3 | 100.8 | 1.5 | 22.8 | 23.9 | 104.9 | 1.3 | 21.1 | 20.4 | 96.3 | 1.3 | 21.2 | 17.6 | 83.1 | 1.4 |
| Post Monsoon | **169.5** | **80.4** | **47.4** | **10.8** | **166.3** | **82.3** | **49.5** | **10.0** | **185.7** | **95.4** | **51.4** | **10.4** | **171.2** | **85.7** | **50.1** | **10.3** | **157.4** | **77.7** | **49.4** | **10.3** |
| December | 1.6 | 2.7 | 168.6 | 0.1 | 2.3 | 3.8 | 170.0 | 0.1 | 4.1 | 6.1 | 149.9 | 0.2 | 2.8 | 4.3 | 155.0 | 0.2 | 1.5 | 2.6 | 171.5 | 0.1 |
| January | 11.7 | 7.7 | 66.1 | 0.7 | 9.6 | 7.2 | 74.7 | 0.6 | 12.3 | 8.4 | 68.2 | 0.7 | 11.4 | 7.4 | 65.1 | 0.7 | 10.6 | 6.9 | 65.0 | 0.7 |
| February | 18.3 | 11.6 | 63.3 | 1.2 | 21.8 | 15.0 | 69.1 | 1.3 | 22.3 | 17.0 | 75.9 | 1.3 | 21.7 | 14.1 | 65.2 | 1.3 | 18.5 | 10.7 | 57.9 | 1.2 |
| Winter | **30.0** | **13.3** | **44.3** | **1.9** | **31.4** | **15.7** | **50.1** | **1.9** | **34.6** | **18.2** | **52.6** | **1.9** | **33.0** | **15.0** | **45.4** | **2.0** | **29.1** | **12.4** | **42.7** | **1.9** |
| Annual | **1575.1** | **214.4** | **13.6** | | **1661.7** | **230.0** | **13.8** | | **1786.4** | **222.0** | **12.4** | | **1669.8** | **216.5** | **13.0** | | **1523.4** | **200.1** | **13.1** | |

**Table 2: Mann Kendal test and Sen's slope estimate**

| Seasons | Sen's slope (Q) | Mann Kendall trend statistics(Z) |
|---|---|---|
| Winter | -0.048 | -0.20 |
| Summer | 1.538 | 1.35 |
| SW Monsoon | 0.167 | 0.07 |
| Post Monsoon | -1.122 | -0.83 |

Bardhaman) where the risk factor is 50%. Farmers can initiate field preparation operations from 23$^{th}$ to 25$^{th}$ SMW. 27$^{th}$ to 28$^{th}$ SMW is the ideal period of sowing/ transplanting of *kharif* rice.Up to 30-31$^{st}$ SMW, the rice crop will be in tillering stage, 34$^{th}$ SMW in the panicle initiation stage, and 40$^{th}$ to 41$^{st}$ SMW in maturity stage. Groundnut, sunflower, cucumber, short duration pulse like arhar of 120 days can be taken up as upland during *kharif/* monsoon season. Harvesting of rice will be completed within 42$^{nd}$-43$^{rd}$ SMW. Immediate after harvesting of *kharif* rice, mustard, field pea and any other short duration pulses are sown in the existing soil moisture of that field. Thus successful rain fed cropping of rice-pulse can be taken up. A major portion of the monsoon rainfall is generally lost every time through runoff which can be stored through the construction of suitable water harvesting structures such as on-farm reservoirs. As the monsoon may be withdrawn by 40$^{th}$ week or may be extended up to 41$^{st}$ week, medium duration rice in medium land and non-paddy crops in the upland can be harvested by 41$^{st}$ week without any moisture stress. Sowing of irrigated *rabi* crops in nurseries could be undertaken between 40-42 SMW. 47$^{th}$ SMW onwards weekly rainfall received at 50%, 75% and 90% probability was very less (<3 mm per week), so no rain fed crop will be recommended to the farmers unless there will be provision of supplemental irrigation. For the rainfed highland areas, it is better to save some water from monsoon to post monsoon season which could be used for land preparation and the good establishment of winter crops. Bhadoria *et al.* (2013) analysed the rainfall and recommended that rain water harvesting from July to September could be used as pre-sowing irrigation for succeeding *rabi* crops which will generally be sown on residual soil moisture. Generally wheat is sown between 41-43 SMW but under unexpectedly late sown condition (may be due to the late harvest of *kharif* rice) wheat sowing may be delayed up to 48$^{th}$ SMW.

***Seasonal rainfall trend analysis***

Variation of rainfall on the seasonal basis for the new alluvial zone of West Bengal has been calculated by using Mann-Kendall statistics and the magnitude of the slope by Sen's slope estimator (Fig.5 and Table 2). The summer and monsoon seasons showed significant upward (increasing) trend as both Z and Q statistics were positive, while post monsoon and winter rainfall revealed decreasing trend with negative Z and Q statistics.The significant positive trend which was observed for summer and monsoon seasons have a trend magnitude of 1.538 mm year$^{-1}$ and 0.167 mm year$^{-1}$ respectively, whereas post monsoon and winter seasons which showed a negative or decreasing trend having the trend magnitudes of 1.122 mm year$^{-1}$ and 0.048 mm year$^{-1}$ respectively.

***Impactof seasonal rainfall on existing cropping system***

New alluvial zone is the largest sub zone of the lower Gangetic plains occupying 40% of the total land area of this zone. Cropping intensity of this region is sufficiently high (139%) (Sirohi, 1989) with rice as the main *kharif* crop. The State is the leading producer of paddy and second largest producer of potato with 30% of total potato production of the country. Also, more than 60% of the country's raw jute fibres are produced here. Main cropping systems are jute-rice-wheat/potato, maize-rice-rapeseed/mustard (Samui *et al.* 2004).The relationship of seasonal rainfall and crop yield has been explained in Fig. 6. There is a weak linear relationship between summer rainfall and yield of jute and maize.There was a non-significant linear negative correlation between SW monsoon rainfall and yield of the *kharif* rice where SW monsoon explained about 23.78% variation in rice production. The main reason is the rice cultivars generally sown in the new alluvial zone of WB are Shatabdi (IET-4786), Khitish, Muktoshri (IET-21845) and aromatic rice cultivars like Gobindabhog, Radhatilak, Tulaipanji etc., for which above normal rainfall (flood situation) may reduce the total production (Rokonuzzaman *et al.,* 2018).Winter rainfall showed a positive relationship with yield of *rabi* crops like wheat, potato and rapeseed/mustard, explaining about 29.96%, 10.27% and14.19% variation in yield respectively. Rainfall at CRI, tillering, 50% flowering, milk and dough stages of wheat will help to meet crop water demand and maintain soil moisture status (Thakur e*t al,*.2018).Similar results on the effect of rainfall on potato yield were also documented by Kumar *et al.* (2019).

## CONCLUSION

Decreasing trend of seasonal rainfall will directly impact moisture availability in the soil and in long run soil moisture storage. In this condition we have to choose the crops and its variety very wisely. Drought resistant or moisture stress resistant cultivars are preferred.After the onset of monsoon there should not be any delay in seed bed preparation or nursery making of the *kharif* rice, otherwise sowing of *rabi* crops will also be delayed. We have to irrigate the crops judicially maintaining proper irrigation scheduling. Mulching, spraying of anti-transpirants or early maturing, short duration cultivars may prove beneficial in the present context of decreasing rainfall trends.Asignificant positive trend is observed at summer and monsoon rainfall which could be utilized for the rain water harvesting or application of live saving irrigation or pre sowing irrigation of *rabi* crops. Also there will be a major problem of flood due to excessive monsoon rainfall, so flood mitigation strategies have to be prepared.

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