Journal of Agrometeorology

(A publication of Association of Agrometeorologists)

ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 27 (3) : 360-364 (September - 2025)
https://doi.org/10.54386/jam.v27i3.3066
https://journal.agrimetassociation.org/index.php/jam

Research Paper

Rainfall analysis for crop planning for paddy grown in North Bank Plain Zone of Assam

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ABSTRACT

This study was undertaken to analyse the rainfall data for crop planning in three districts (Lakhimpur, Biswanath, and Sonitpur) of the North Bank Plain Zone (NBPZ) of Assam using long-term rainfall data (1991-2020). During the study period, the mean annual rainfall of 3209, 1811, and 1828 mm was observed in Lakhimpur, Biswanath, and Sonitpur, respectively. A non-significant decreasing trend of annual rainfall was observed in Lakhimpur (2.75 mm year^{-1}) and Sonitpur (8.62 mm year^{-1}), while an increasing trend was observed in Biswanath (8.98 mm year^{-1}). In all districts, regardless of probability levels, the maximum and minimum expected rainfall was found between the 26th to 30th and 49th to 2nd SMW, respectively. The expected weekly rainfall during the monsoon season was lower in Biswanath and Sonitpur at all probability levels compared to the Lakhimpur district. Based on the understanding of existing patterns, variability of rainfall, probability of occurrence of rainfall in a period, observed rainfall trends, etc. the contingency crop planning for *Sali*, *Ahu* and *Boro* rice grown in the zone were suggested for the concern districts.

Key words: Crop planning, NBPZ, Rainfall trend analysis, Rainfall probability

The rainfall is considered to be one of the most important weather parameters that plays a crucial role in the agricultural production system. In Assam, despite having an irrigation potential of 40% of the net cropped area, the state's agriculture is predominantly rainfed, with only 26% of the area under irrigation. However, analysis of long-term rainfall data indicated decreasing trends in annual and monsoon rainfall with an increasing number of rainfall-deficient years from 2001 onwards in both the Brahmaputra and Barak basins of the state (Deka *et al.,* 2013).

Probability and frequency analysis of rainfall data enables to determine the expected rainfall at various chances (Bhakar *et al.,* 2008). Such strategic information can be used to prevent widespread negative impact of floods and droughts; and effectively can be used for designing water reservoirs, flood control structures, soil and water conservation planning, agricultural crop planning etc. (Dabral *et al.,* 2009; Ahmed *et al.,* 2009).

Amongst the six different Agro-Climatic Zones of Assam, the North Bank Plain Zone (NBPZ) is one of the climatologically vulnerable zone in the state and the North-East India (Neog *et al.,* 2016), with the major weather constraints of flash flood and seasonal drought. The increased frequency of intermittent dry spells and flash floods during the growing season is becoming a major weather risk, leading to extensive damage to *Sali* rice in NBP zone (Neog *et al*., 2020). Understanding existing patterns and variability of rainfall, observed rainfall trends, and the likelihood of rainfall occurring within specific periods is essential for identifying appropriate adaptation strategies to mitigate the impact of increasing rainfall variability on agriculture in NBPZ of Assam.

MATERIALS AND METHODS

The investigation was carried out in the North Bank Plain Zone (NBPZ), which is one of the six Agro-Climatic Zones of Assam comprised of six districts *viz*., Darrang, Sonitpur, Lakhimpur, Udalguri, Biswanath and Dhemaji. The daily rainfall data from 1991-2020 of three districts *viz.*, Lakhimpur (Lat. 27.24°

Article info - DOI: *https://doi.org/10.54386/jam.v27i3.3066*
Received:31 May 2025; Accepted: 27 July 2025; Published online : 1 September 2025

N, long. 94.11° E, elevation 88 m AMSL) Biswanath (Lat. 26.67°N, long. 93.15° E, elevation 91 m AMSL) and Sonitpur (Lat. 26.63° N, long. 92.8° E, elevation 48 m AMSL) were collected from the Indian Meteorological Department, New Delhi.

For seasonal analysis, each year had been divided into four seasons *viz*. winter (December-February), pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October- November). To identify long-term rainfall trends, Sen's slope method (Sen, 1968) had been used and the significance of these trends was assessed using the non-parametric Mann-Kendall rank test (Mann, 1945 and Kendall, 2015). Rainfall probability was calculated using the incomplete gamma distribution module of the "Weather Cock" software, which was developed by CRIDA-ICAR (Rao *et al.,* 2011**)**. The daily rainfall data were arranged in weekly format according to the standard meteorological week (SMW) of the year before entering into the Weather Cock software. The amount of rainfall at different probability levels (50%, 75% and 90%) called assured rainfall had been computed for each standard week by fitting the Incomplete Gamma Distribution model. Based on the observed characteristics of rainfall, the identified trends, and the expected rainfall for a specific period, contingency plans for major cereal crops like *Sali* paddy, *Ahu* paddy and *Boro* paddy were suggested in the three districts of NBPZ of Assam that were considered in the study.

RESULTS AND DISCUSSION

Descriptive statistics of rainfall

The basic statistical parameters of monthly, seasonal, and annual rainfall of the study area were studied by computing mean, standard deviation, and coefficient of variation using the standard methods. The mean annual rainfall was highest during the period 1991-2020 in Lakhimpur district (3209 mm) followed by Sonitpur (1828 mm) and Biswanath (1811 mm) respectively (Table 1). The CV of annual rainfall was highest in Sonitpur district (27%), followed by Biswanath (18%) and Lakhimpur (12%). In all the districts, the highest rainfall was received during the Monsoon season, followed by pre-monsoon, post-monsoon, and winter season. Among the districts, Lakhimpur received the highest monsoon rainfall (2244 mm), followed by Biswanath (1149 mm) and Sonitpur (1148 mm). Among all the seasons, CV was the highest in the winter season for Biswanath (100%) and Sonitpur (104%), while for Lakhimpur the highest CV (67%) was observed in pre-monsoon season (Table 1). The annual standard deviation (SD) was highest for Sonitpur district (492 mm), followed by Lakhimpur district (389 mm) and Biswanath district (317 mm).

Long term trends of rainfall

The annual rainfall showed a non-significant decreasing trend in Lakhimpur (-2.75 mm year^{-1}) and Sonitpur (-8.62 mm year^{-1}), while it showed an increasing trend in Biswanath (8.98 mm year^{-1}) (Table 2). A significant decreasing trend of rainfall was observed during the winter season in Lakhimpur (-3.23 mm year^{-1}), however, no significant increasing trends of rainfall were observed in any seasons of any district. The monthly rainfall decreased significantly in the month of January (- 0.77 mm year^{-1}) and February (-1.51 mm year^{-1}) in Lakhimpur, while increasing significantly in July (4.77 mm year^{-1}) in Biswanath district (Table 2). Likewise, Deka and Nath (2008) reported a decrease in rainfall by 1.8% and 3.3% in pre-monsoon and monsoon season in Jorhat district of Assam, respectively. Furthermore, annual as well as monsoon rainfall showed a long-term decreasing trends in both Brahmaputra and Barak River basins of Assam; although, the trend was statistically significant for the Barak Basin Deka *et al.,* (2013).

Rainfall probability analysis

The assured weekly rainfall at 90%, 75%, and 50% probability levels was calculated using the incomplete gamma distribution module of "Weather Cock" software for Lakhimpur, Biswanth and Sonitpur districts of NBPZ of Assam. In all districts, regardless of probability levels, the maximum expected rainfall was observed between the 26th and 30th SMW, coinciding with the active phase of the monsoon in the region. On the other hand, the lowest assured rainfall irrespective of probability levels was observed in the 49th to 2nd SMW in all the districts. The likelihood of more than 20 mm of rainfall per week at 90% probability was considerably higher for shorter periods in Biswanath and Sonitpur (from 24th **to 28**th SMW) as compared to Lakhimpur district (20th to 34th SMW) (Fig. 1).

Likewise, the duration of rainfall with more than 20 mm per week at a 75% probability level was longer in Lakhimpur (16th SMW to 39th SMW) as compared to the other two districts (18th SMW to 34th SMW). The expected weekly rainfall during the monsoon season was lower in Biswanath and Sonitpur at all probability levels compared to the Lakhimpur district. In earlier study also, North Bank Zone was found with experiencing highly indeterminate winter rainfall and recurrent mid-season drought like condition (Sarmah *et al.,* 2013). Similar type of capricious behaviour in weekly rainfall at different probability levels have been reported for the different parts of Assam (Saikia *et al.,* 2017; Gharphalia *et al.,* 2018).

Table 1: Variations in seasonal and annual rainfall of three districts of NBPZ (1991-2020)

Seasons	Lakhimpur		Biswanath		Sonitpur	
	Mean (mm)	CV (%)	Mean (mm)	CV (%)	Mean (mm)	CV (%)
Pre- Monsoon	682	67	479	32	488	21
Monsoon	2244	16	1149	23	1148	38
Post- Monsoon	185	56	128	63	125	58
Winter	97	59	54	100	42	104
Annual	3209	12	1811	18	1828	27

Table 2: Monthly, seasonal and annual trends of rainfall in three districts of Assam during the time period 1991-2020

	Lakhimpur		Biswanath		Sonitpur	
	Trend	Z Value	Trend	Z Value	Trend	Z Value
January	-0.77*	-2.14	0.00	-0.33	-0.15	-0.75
February	-1.51*	-2.55	0.00	-0.04	-0.31	-0.87
March	-0.9	-0.75	0.00	-0.04	0.57	0.73
April	0.56	0.25	2.35	0.82	1.30	0.75
May	-1.30	-0.30	0.97	0.36	-2.26	-1.18
June	0.20	0.04	1.40	0.64	-0.65	-0.29
July	5.88	1.39	4.77 *	2.43	2.23	1.61
August	-3.28	-0.79	-1.11	-0.39	-1.43	-3.45
September	5.09	1.53	3.89	1.75	-0.60	-0.32
October	-0.11	-0.04	-0.19	-0.07	-1.57	-0.86
November	0.02	0.12	0.07	0.58	0.00	0.00
December	0.23	0.88	0.14	1.59	0.00	-0.02
Pre-monsoon	-1.59	-0.50	2.40	0.89	0.32	0.11
Monsoon)	8.37	0.79	7.43	1.32	-2.23	-0.29
Post-monsoon	0.27	0.00	0.58	0.39	-1.33	-0.71
Winter	-3.23*	-2.78	-0.23	-0.29	-0.51	-0.82
Annual	-2.75	-0.36	8.98	1.32	-8.62	-1.28

*Indicates statistical significance at 95% confidence level as per Mann- Kendall rank test

Contingency crop planning based on rainfall analysis

The cropping system of NBPZ of Assam is the rice-based cropping system and rice dominates the agriculture in the zone. Diverse varieties of rice have been traditionally growing in the zone since the unknown past to match diverse land situations with varying weather conditions. In this zone, the rice is grown in three seasons, namely *Sali* (winter), *Ahu* (autumn), and *Boro* (summer). Based on the analysis of current rainfall patterns, variability, historical trends, and prediction of rainfall in a specified period, contingency crop plans for *Sali* rice, *Ahu* rice and *Boro* rice are suggested and discussed below.

Crop planning for sali paddy

In NBPZ of Assam, *Sali* paddy is grown as a *Kharif* crop from June to November. The nursery bed preparation for *Sali* paddy should be started from the 21st SMW in the Lakhimpur district and the 22nd SMW in Sonitpur and Biswanath districts when the probability of occurrence of more than 30 mm of rainfall at 75% probability levels is assured. The average weekly water requirement for transplanting rice is 40 mm (Aryal, 2012). Therefore, it is suggested to start the transplanting of rice in the Lakhimpur district from the 25th SMW and continuing up to the 38th SMW, when the probability of occurrence of weekly rainfall remains above 40 mm. However, in the case of Sonitpur and Biswanath districts, the transplanting of *Sali* rice could be started from the 25th SMW and continued up to the 28th SMW.

It was noted that in the Lakhimpur district, the assured rainfall at 75% probability level exceeded 50 mm from the first week of June (23rd SMW) to the last week of August (34th SMW), and even rainfall exceeded 100 mm in several weeks in this period. Moreover, observed coherent increase in rainfall during monsoon (8.37 mm/year) as a whole, and June (0.2 mm/year), July (5.8 mm/year), and September (5.1 mm/year) in particular, in the districts resulted in increasing frequency of flash flood in recent years, which is likely to increase in future due to climate change in the district. That is why, the *Sali* rice grown in the low land situations in the district was often affected by intermittent flash floods during June to mid-September. For management of flash floods in *Sali* rice in the district, it is suggested to complete the sowing of long duration varieties (150 days) like Ranjit, Bahadur, etc. in June, however, if sowing is not possible within this month due to stagnant water or recurrent flood, sowing of medium duration varieties (135 days) like Satyaranjan, Shraboni, etc. may be suggested. If recurrent floods do not permit the sowing of sali rice before 15th July, the sowing of short-duration (120 days) varieties like Lachit, Chilarai, etc. may be initiated. On the other hand, if sowing is not possible before 30th July, the sowing of very short-duration (100 days) varieties, such as Luit, Kapili, Kolong, Disang, etc. was suggested. Similar contingency planning for coping with the recurrent floods in the case of *Sali* rice in NBPZ of Assam was also suggested by Neog *et al.,* (2020).

It was found that in the Biswanath and Sonitpur districts, the weekly rainfall (at 75% probability level) declined rapidly from 40 mm and became even less than 20 mm from the 31st SMW onwards. Moreover, the present study showed a decreasing trend of rainfall during the monsoon (-2.23 mm year^{-1}) and pre-monsoon (-1.33 mm year^{-1}) seasons in Sonitpur district, along with a decreasing trend of rainfall in August and September in all three districts. The changes in rainfall trend and observed decrease in weekly assured rainfall at all probability levels from the first week of August (31st SMW) could be linked to the reported increased number of intermittent dry spells in recent years during the *Sali* rice growing season in this zone. Hence, there is every possibilities for suffering of *Sali* rice from intermittent dry spells occurring at different growth stages when the crop is grown in upland and medium land situations in this zone. To minimize the negative impact of intermittent dry periods

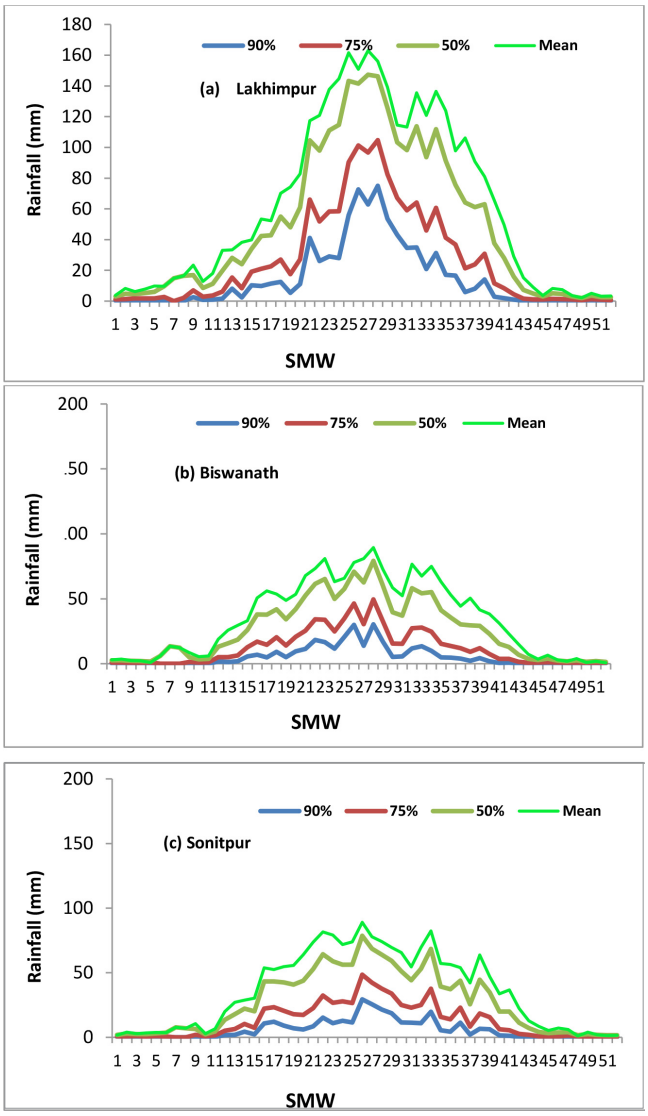

Fig. 1: Weekly mean rainfall and assured rainfall at 50%, 75% and 90% probability levels for (a) Lakhimpur (b) Biswanath, and (c) Sonitpur districts of NBPZ of Assam

on *Sali* rice in the region, it was suggested to replace long-duration, high-yielding cultivars (e.g. Ranjit, Bahadur, etc.) or traditional rice cultivars with high-yielding short-duration varieties (Numali, Dishang, Kolong, etc.) for the upland situation and medium-duration varieties (Satyaranjan, Basundhara, Mulagagharu, etc.) for medium land situations. Even though occasional droughts did not affect long-duration rice varieties grown in lowland situations, the grain yield of these cultivars reduced substantially when sowing was delayed beyond the third week of June, as suggested by Neog *et al.,* (2020), so farmers are suggested to either complete sowing by the third week of June or switch to different rice varieties.

Crop planning for Ahu paddy

In the Lakhimpur district, at 50% probability, the assured rainfall exceeded 15 mm after the 7th SMW. It is, therefore, suggested to begin the dry seeding of Ahu rice from the 8th SMW in this district. For Biswanath and Sonitpur districts, the rainfall at 50% probability, exceeded 15 mm after the 11th SMW. Therefore, it is recommended to start the sowing of Ahu rice from the 12th SMW onwards in these districts. It is important to note that during Ahu rice growing season, the Lakhimpur district generally experienced higher assured rainfall as compared to the Biswanath and Sonitpur districts. Therefore, it is suggested to grow medium-duration Ahu rice cultivars like Kanaklata (130-135 days) and Rasi (130-135 days) in the Lakhimpur district, while short-duration Ahu cultivars like Dishang, Kolong, and Luit in other districts.

Crop planning for Boro paddy

In Beel (low-lying) areas of NBPZ where growing *Sali* rice is impossible due to water stagnation during kharif season, *Boro* rice can be grown using available in-situ surface water. Transplanting of the *Boro* rice in such areas should be completed when the expected weekly assured rainfall (75% probability) level is the lowest (0.7 to 2.5 mm week^{-1}), and the harvesting of the crop should be completed before the 17th SMW, beyond which the assured rainfall (at 75% probability level) will exceed 20 mm per week.

CONCLUSION

The significant decreasing trends of January and February rainfall in Lakhimpur district, while significant increasing trend of July and September month rainfall in Biswanath district and coherent decreasing trend of annual rainfall of Lakhimpur and Sonitpur district have indicated the change in rainfall pattern as a consequence of climate change. However, impact of such adverse situation can be minimized by manipulating agronomic practices, such as manipulating sowing times, selecting appropriate varieties suitable to prevailing land situations etc. To minimize the negative impact of intermittent dry spells on *Sali* rice in the area, it is suggested to replace long-duration, high-yielding cultivars or traditional rice cultivars with high-yielding short-duration varieties for the upland situation and medium-duration varieties for medium land situations. For management of flash floods in *Sali* rice, it is suggested to complete the sowing of long duration varieties (150 days) in June. If recurrent floods do not permit sowing the sali rice before 15th July, the sowing of short-duration (120 days) varieties is suggested. On the other hand, if sowing is not possible before 30th July, the sowing of very short-duration (100 days) varieties is suggested.

ACKNOWLEDGMENT

The authors wholeheartedly acknowledge the Director of Post Graduate Studies (DPGS), Assam Agricultural University, Jorhat and the Department of Agricultural Meteorology, Assam Agricultural University, Jorhat for providing the necessary infrastructure and financial support for performing the field research under Master Degree Programme.

Funding: No funding was received for this work.

***Conflict of Interest*:** The authors declare that there is no conflict of interest related to this article.

Data availability: Data can be provided by corresponding author on reasonable request.

Authors contribution: **N. Sarma, P. Neog** and **A. N. Patowary:** Investigation, Experiment data recording, Formal analysis, Visualization, Conceptualization, Editing, Supervision Methodology, Writing- original draft of the manuscript etc.; **R. L. Deka** and **K. Medhi:** Involved in periodic assessment of analysed results and extends scientific justification of different findings.

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