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Short communication

Shift in monsoon rainfall pattern in the North Eastern region of India post 1991*

U.S. SAIKIA, B. GOSWAMI, D. J. RAJKHOWA, A. VENKATESH, KAUSALYA RAMACHANDRAN[1], V.U.M RAO[1], B. VENKATESWARLU[1] and S.V. NGACHAN

ICAR Research Complex for NEH Region, Umiam, Meghalaya, 793 103

[1]Central Research Institute for Dryland Agriculture, Santosh Nagar, Hyderabad 500 059

Email : ussaikia73@gmail.com

The indication of climate change, in a given place, is manifested through abnormal changes in climatic behaviour. Rainfall and temperature are the two major factors, which govern the ultimate climatic vulnerability profile of any given location. During the recent times, researchers have reported abnormal changes in the climatic pattern over different parts of world (IPCC, 2007). Increasing occurrences of drought and floods destroying on-field crops have become common news in otherwise climatically stable regions. Being a very high rainfall region, rainfall received during monsoon season could fulfill the water demands of the major crops. However, like the rest of the world, this region has also experiencing fast change in climatic behaviours as a result of irrational human interventions on natural resources (MoEF, 2010), leading to very existence of sustainable livelihood in this ecologically sensitive region. Further, due to rain dependence and resource poorness, the farmers of this region are least flexible to go for any comprehensive adaptive measure to tackle the menace of extreme climatic events. Accurate analysis and interpretation of climatic data often helps to formulate plans as well as to prioritize the intended interventions, so that the limited available resources can be utilized very rationally to tackle the menace of climatic exigencies. Hence, to strengthen and supplement the existing base of information, this study was taken up to identify the regions, which needs preferential attention in terms of the degree of climatic adversities faced during the recent times.

$1^0 \times 1^0$ gridded rainfall data, generated by IMD (Rajeevan *et al*., 2006), for the four monsoon months (June-September) was analyzed to detect change in rainfall behaviour in terms of changes in amount of rainfall and nos. of rainy days. The Standardized Precipitation Index (SPI) (McKee *et al*., 1993), which is acclaimed worldwide as the most suitable index to monitor and determine the extent of drought or flood, was used to identify the regions, which are exhibiting significant rise or fall in seasonal wetness/dryness pattern. A positive SPI value indicates wet condition and opposite value stands for a dry condition. The SPI value ranged between -0.99 to +0.99 represents a normal condition. The behaviour of monsoon rainfall during the recent period (1991-2007) was compared with the base period (1951-1990) and statistical significance in change was determined through standard Mann-Kendall test.

Change in amount of monsoon rainfall and rainy days Spatio-temporal changes in amount of rainfall and nos. of rainy days have been presented in Table 1 and Fig. 1. In both pre- and post- 1990, amount of average monsoon rainfall receipt is highest in Sikkim and lowest in Manipur. During 1991-2007, Arunachal Pradesh, Nagaland and Assam have lost highest amount of seasonal rainfall, which ranged between 10-15% of their respective baseline values. The Mann-Kendall test indicates significant ($P<0.01$) decrease of amount of rainfall in Ukhrul and Senapati districts of Manipur and Phek, Zunheboto and Wokha districts of Nagaland. All other North Eastern districts have also recorded reduction in rainfall but still the trends are not significant statistically.

Similarly, the distribution of rainfall is also equally important as it determines the length of dry or wet spells that may impact the standing crop adversely. The number of rainy days is the indicator to study the distribution pattern of rainfall in any given location. In the North Eastern region the range of rainy days was 76-85 days during 1951-90. But, this has reduced to 65-81 days in the recent period indicating an average reduction of 9% rainy days over the region. The reduction is significant ($P<0.01$) for all the districts of Mizoram and Nagaland; upper Assam districts of Tinsukia, Dibrugarh; and Tirap, Changlang, Lower Dibang valley districts of Arunachal Pradesh. No significant difference in nos. of rainy days has been observed in Sikkim and Tripura during 1991-2007 compared to 1951-1990.

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Table 1: Change in average monsoon rainfall and rainy days in North Eastern states in recent time (1991-2007) compared to baseline period (1951-1990)

State	Rainfall (mm)			Rainy days		
	1951-1990	1991-2007	% Change	1951-1990	1991-2007	% Change
Arunachal Pradesh	2022	1723	-14.8	77	74	-3.9
Assam	1788	1613	-9.8	78	72	-7.7
Manipur	1044	1030	-1.3	76	68	-10.5
Meghalaya	1552	1530	-1.4	79	72	-8.9
Mizoram	1345	1242	-7.7	85	65	-23.5
Nagaland	1410	1202	-14.7	82	77	-6.1
Sikkim	2147	2126	-1.0	85	81	-4.7
Tripura	1432	1373	-4.2	76	75	-1.3

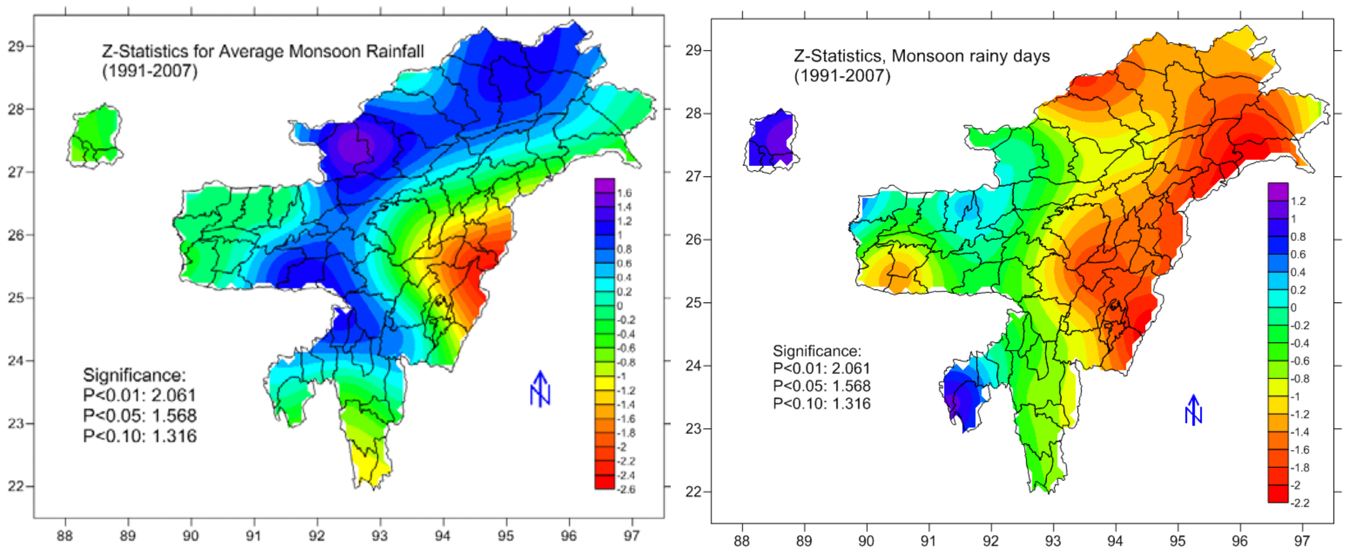

Fig. 1: Significance of spatio-temporal change in amount of monsoon rainfall and rainy days in North Eastern region in recent time (1991-2007) compared to baseline period (1951-1990) as depicted by Mann-Kedall Z- statistics

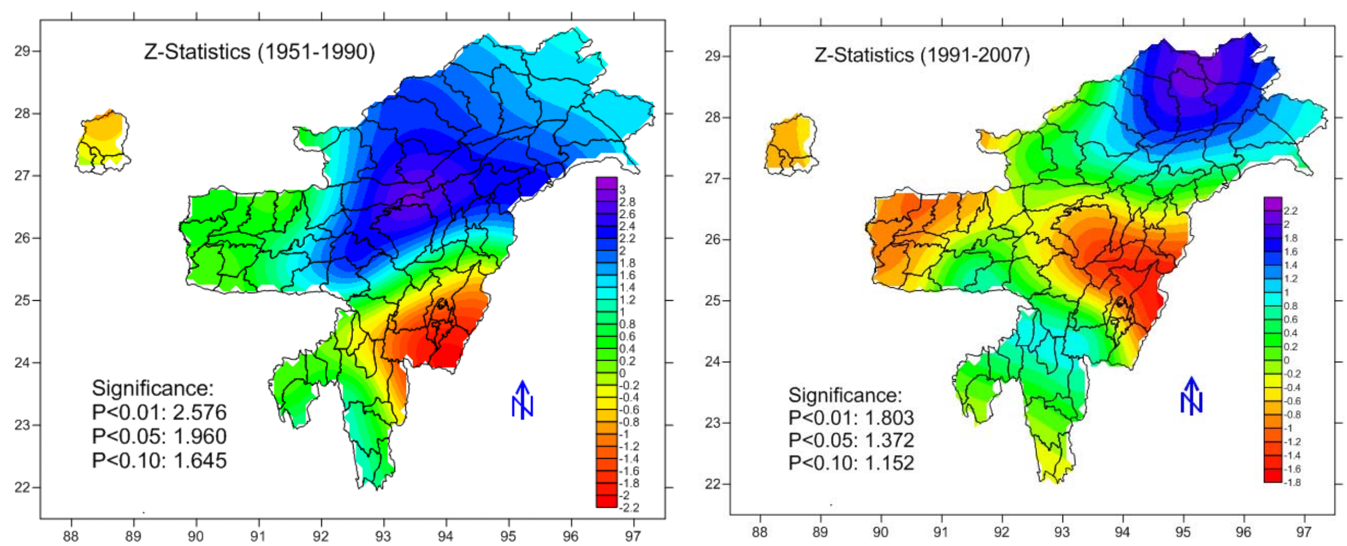

Fig. 2: Significance of spatio-temporal change in average monsoon SPI in North Eastern region in recent time (1991-2007) compared to baseline period (1951-1990) as depicted by Mann-Kedall Z- statistics

Change in pattern of wetness/dryness as indicated by seasonal SPI

There is indication of increase in magnitude of wetness in several locations including a few districts of Arunachal Pradesh. Upper Siang, Dibang Valley, Lower Dibang Valley (for both P<0.01), West Siang and East Siang districts (For both P<0.05) of Arunachal Pradesh have indicated significant (P<0.01 & 0.05) increase of positive SPI during the monsoon period of 1991-2007 (Fig. 2). In contrast, the Manipur districts - Ukhrul and Senapati and Nagaland districts - Phek, Kohima, Zunheboto and Wokha have recorded significant increase of negative SPI post 1990. The traditionally wet Meghalaya hills districts, viz., Ri-Bhoi, East Khasi Hills, West Khasi Hills and Jaintia Hills; Assam districts Karbi Along and Sonitpur; and Arunachal Pradesh districts West Kameng, Lower Subansiri and Tawang have lost their degree of wetness during 1991-2007.

This study has revealed that though there is general trend of reduction in amount of monsoon rainfall as well as nos. of rainy days, but that is not uniformly applicable through out the north eastern region. SPI analysis revealed that some regions are getting excessively wetter whereas some others are drying up during the main crop season. As a result intermittent drought and floods are becoming regular phenomena in most part of the North Eastern region during the monsoon season, which was not seen earlier.

The north eastern region has total water resources of 42.5 million hectare metre. But due to lack of proper storage and recycling facilities most of the rain water goes as waste every year. Roughly 20.74% net sown area is irrigated leaving most of the 4.13 million hectare net sown area to the mercy of seasonal rainfall. The land use pattern the hills of the region are mostly faulty and nearly 0.88 million hectare area is under shifting cultivation in NE region. As a result roughly 1.3 million hectare suffers from serious soil erosion problem. Top soil is much higher (46 t ha^{-1}) in this region compared to the all India average of 11 t ha^{-1}. Besides, low cropping intensity (131.4%), mono-cropping and subsistence nature of farming are the main drawbacks here. The above mentioned bottlenecks are combined with inaccessibility to remote places in reaching to the farmers hampering introduction of improved technologies and making the agriculture of the region more prone to any extreme climatic aberrations.

Hence, our interventions should be more location specific, preferential and comprehensive to bring resilience in to the agricultural system in the north eastern region. Some of such interventions may be *viz*. In low to mid altitude (800-1400 m above msl) regions with increasing possibility of long dry spells farmers may adopt short duration crops such as maize, finger millet, green gram, black gram, chick pea, rice bean, soybean, sunflower, sesame etc. Besides, *in situ* conservation of moisture with locally available mulching materials and conservation agricultural practices should be encouraged to conserve and proper use of available soil moisture.

In mid altitude as well as lowland flood plains (0-800 m above msl) short duration and high yielding rice varieties like *Prafulla, Gitesh, Vivek Dhan-82, VL Dhan-61, IET-19628* etc. may be encouraged. These varieties are equally good under mid-altitude conditions, where transplanting may be completed till mid August. Growing of *Boro* rice can also encouraged in low lying areas and supported by shallow tube wells where ever possible. In perennial flood prone areas submergence tolerant rice varieties *viz. Jalashree, Jalkunwari* and *Swarna Sub-1* are showing very promising results. The risks involved in farming practices arising out of aberrant weather can further be reduced with adoption of integrated farming systems and watershed development with animal, fishery and agro-forestry components that also ensure proper soil and moisture conservation and nutrient recycling.

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