Scholarly Research Journal for Humanity Science & English Language,
Online ISSN 2348-3083, SJ IMPACT FACTOR 2017: 5.068, www.srjis.com
PEER REVIEWED JOURNAL, AUG-SEPT 2018, VOL- 6/29

SPATIAL AND TEMPORAL VARIABILITY IN RAINFALL DISTRIBUTION ACROSS METEOROLOGICAL HOMOGENOUS REGIONS OF INDIA: A CASE STUDY OF SOUTHWEST MONSOON 2012

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Abstract

The monsoon, a vital meteorological phenomenon in the Indian subcontinent, holds profound significance for the livelihoods of its inhabitants. This research investigates the spatial and temporal variability in rainfall patterns during the 2012 monsoon season. The study extensively used data from the India Meteorological Department to conduct a detailed synoptic analysis, exploring the monsoon's impact on meteorological homogeneous regions, including Northwest India, South Peninsula, Central India, and Northeast India. Assessment of seasonal rainfall revealed a near-normal average for the country as a whole, concealing a marked spatial variability. However, weekly cumulative departures of rainfall, analyzed at both regional and national levels, exposed a significant deficiency during the mid-season, later mitigated by a surge in rainfall activity from August to September. Intriguingly, the Northeast region experienced heavy rains in the initial weeks of June, while receiving scanty rains during July and August, showcasing the monsoon's unpredictable nature. The study offers a thorough understanding of the monsoon's spatial and temporal variations, whereby the prevailing synoptic systems showcases a greater control on the regional variations.

Keywords: Meteorological Homogenous Regions, weekly cumulative departures, 2012 summer monsoon, spatio-temporal variability

1. Introduction

In context of the Indian subcontinent, monsoon means life-giving rains. To the inhabitants of this region, monsoons are said to be a matter of life and death. Most of the people inhabiting the tropical monsoon climate are cultivators. The agricultural calendar of India is governed by monsoon. In India, rice is the major crop which provides food for millions of people. Since over half of the farmlands are rain-fed, monsoon is critical in achieving food sufficiency of the country. Besides agriculture, monsoon rains affect many other facets of life. According to D. Subbarao (Governor of Reserve Bank of India), the performance of his financial policy was all a hostage to monsoon like it was for most Indians. In addition, failure of monsoon renders farmers jobless and forces them to migrate towards the cities. This situation crowds the city slums and further aggravates the job, infrastructure and sustainability of city life. Such is the magnitude of effects that monsoon casts on the lives of Indians. The economic significance of monsoon can be aptly summed up by Finance Minister Pranab Mukherjee's statement that monsoon is the real finance minister of India. A good monsoon resulting in improved agricultural production brings down prices of essential food commodities and reduces their imports, thus overall reducing the food inflation. All these factors initiate positive ripple effects throughout the economy of India.

Two remarkable features of the summer monsoon are its regular occurrence every year from June to September and the irregular variation in the amount of seasonal mean rainfall that it brings to India from one year to the other. There are many instances of years with flood (strong monsoon) or drought (weak monsoon) during which India as a whole receives excess or deficient seasonal rainfall, respectively. Even within a season, there is considerable variation, both in space and time, in the rainfall over India. This intraseasonal and interannual variability of summer monsoon has always remained a topic of research since many years. Over the past century, much scientific effort has been devoted to the study of monsoon systems, especially the South Asian monsoon system. During the late nineteenth and early twentieth century's, Sir Gilbert Walker observed a phase relationship between monsoon rainfall and the Southern Oscillation (Walker, 1925; Walker and Bliss, 1932). Later studies have supported the connection between weak monsoons and warm central Pacific sea surface temperatures (Angell, 1981; Rasmusson and Carpenter, 1983; Ropelewski and Halpert, 1987; Shukla, 1987). Other studies (Krishna Kumar et al., 1999; Gadgil S., 2006) showed that in addition to El Nino - Southern Oscillation (ENSO), there are other meteorological parameters present, which has a profound influence on the Indian monsoon system.

The Indian monsoon exhibits large variation on intraseasonal to interannual and interdecadal time scale. The Indian summer monsoon has vigorous intraseasonal oscillations in the form of active" and weak (or break") spells of monsoon rainfall within the summer monsoon season (Ramamurthy 1969). These active and break spells of the monsoon are associated with fluctuations of the tropical convergence zone (TCZ; (Yasunari 1979; Sikka and Gadgil 1980). Goswami, B. N. and Ajaya Mohan, R. S. (2001) have studied the intraseasonal variation associated with the active and break period of monsoon. They concluded that the strong (weak) monsoon years are associated with higher probability of occurrence of active (break) conditions. Krishnamurthy, V. and Shukla, J. (2007) have suggested a simple conceptual model to explain the interannual variability of the Indian monsoon rainfall, which consisted of a linear combination of a large-scale persistent seasonal mean component and a statistical average of intraseasonal variations.

With the above discussion in background, it can be concluded that any fluctuations in the distribution or quantity of the monsoon rains may lead to conditions of floods or droughts causing the agricultural sector to suffer adversely. If the monsoon rains fail or if their arrival is delayed by a few weeks, widespread starvation and economic disaster are the natural results. Besides its temporal variability, monsoon also exhibits large scale spatial variability. Sometimes, the behaviour of monsoon is so erratic that in some parts of a country heavy rains cause disastrous floods, while in other parts there is severe drought. The year 2012 turned out to be one such dramatic year, which exhibited large scale spatial and temporal variability in monsoon rains. With this view in mind, the main aim of this research is to study the spatial and variability in the rainfall distribution during monsoon 2012 season. The study also tries to understand the causes behind the uneven and erratic distribution of rains in various parts of the country.

2. Data and Methodology

The Indian Daily Weather report details and Climate Diagnostic Bulletins for the monsoon months of 2012 retrieved from India Meteorological Department (IMD) were extensively used for the synoptic study of the characteristics of 2012 summer monsoon. Daily rainfall data for All-India as well as for four meteorological homogeneous regions, namely Northwest India, South Peninsula, Central India and Northeast India, were collected for all the months of the southwest monsoon of 2012. These four meteorological homogenous regions have been defined by the India Meteorological Department based on the coherent rainfall over regional scales (Fig. 1).

From the daily values, different rainfall totals were computed on a weekly, monthly and seasonal scale for each homogenous region. The normal rainfall values for all the regions were retrieved from IMD and accordingly departures of 2012 rainfall from the long period average were calculated. These anomalies were calculated both on a weekly as well as seasonal scale. The Monsoon report 2012 published by IMD was used for the study of the semi-permanent systems and their effect on the spatial variability of the 2012 summer monsoon rainfall.

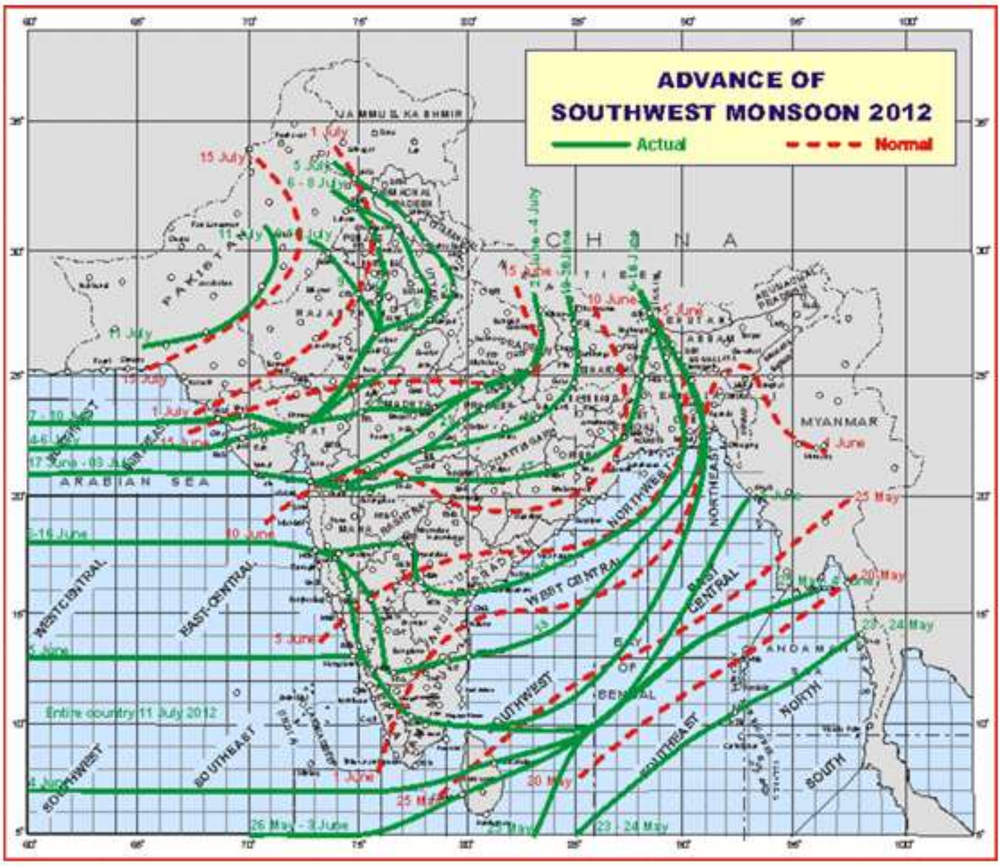
Fig. 1: Four Homogeneous Regions of India

3. Results and Discussion

3.1 Onset of southwest monsoon 2012

Southwest monsoon current advanced over the Andaman Sea on 23rd May with a delay of about 3 days and set in over Kerala on 5th June, 4 days later than its normal date of 1st June. With the formation of a vortex in the form of an embedded upper air cyclonic circulation off Karnataka, the advance of southwest monsoon along the west coast of India was very rapid. However, as the vortex became less marked and the off-shore trough also became feeble, a hiatus of 6 days was observed thereafter.

With the strengthening of the Arabian Sea of the monsoon current, the monsoon revived again and advanced further. The southwest monsoon advanced into most parts of peninsular India including interior Maharashtra by 17th June. Thereafter, a prolonged hiatus in the further advance of monsoon occurred during 22nd June – 2nd July, which was caused by the shifting of the monsoon trough near the foothills of Himalayas. With the formation of a low-pressure area over Madhya Pradesh, the southwest monsoon advanced steadily from 3rd July and covered the entire country on 11th July, 4 days earlier than its normal date of 15th July. The isochrones of advance of southwest monsoon 2012 are shown in Fig. 2.



Source: IMD

Fig. 2: Onset dates of Southwest Monsoon 2012

<u>3.2 Seasonal Rainfall</u>

The southwest monsoon season rainfall over the country as a whole was near normal (92% of its long period average). However, there was a marked spatial variability in the rainfall distribution observed throughout the country (Table 1).

Table 1: Distribution of 2012 summer monsoon rainfall

Seasonal Rainfall (June to September)			
Region	LPA (mm)	Actual Rainfall for 2015 SW Monsoon season	
		Rainfall (mm)	Rainfall (% of Long-Period Average)
All-India	887.5	816.5	92
Northwest India	615.0	572.0	93
Central India	975.5	936.5	96
Northeast India	1437.3	1280.0	89
South Peninsula	715.1	643.5	90

Source: www.tropmet.res.in

3.3 Weekly Rainfall

Area weighted cumulative weekly rainfall percentage departure for the country as a whole and the four homogeneous regions (NW India, NE India, Central India and South Peninsula) for the period 1 June to 30 September is shown in Fig. 3. Cumulative rainfall departure was negative throughout the season however, the large rainfall deficiency of about 20% till the mid of season was reduced to some extent due to good rainfall activity from first week of August to mid of September. Cumulative weekly rainfall departure for the all the four homogeneous regions were also below normal during the whole season except for eastern and Northeast region where it was positive during first and fourth week of June. Cumulative rainfall at the end of season was 93% of LPA for northwest, 89% of LPA for northeast India, 96% of LPA for central India and 90% of LPA for south peninsula.

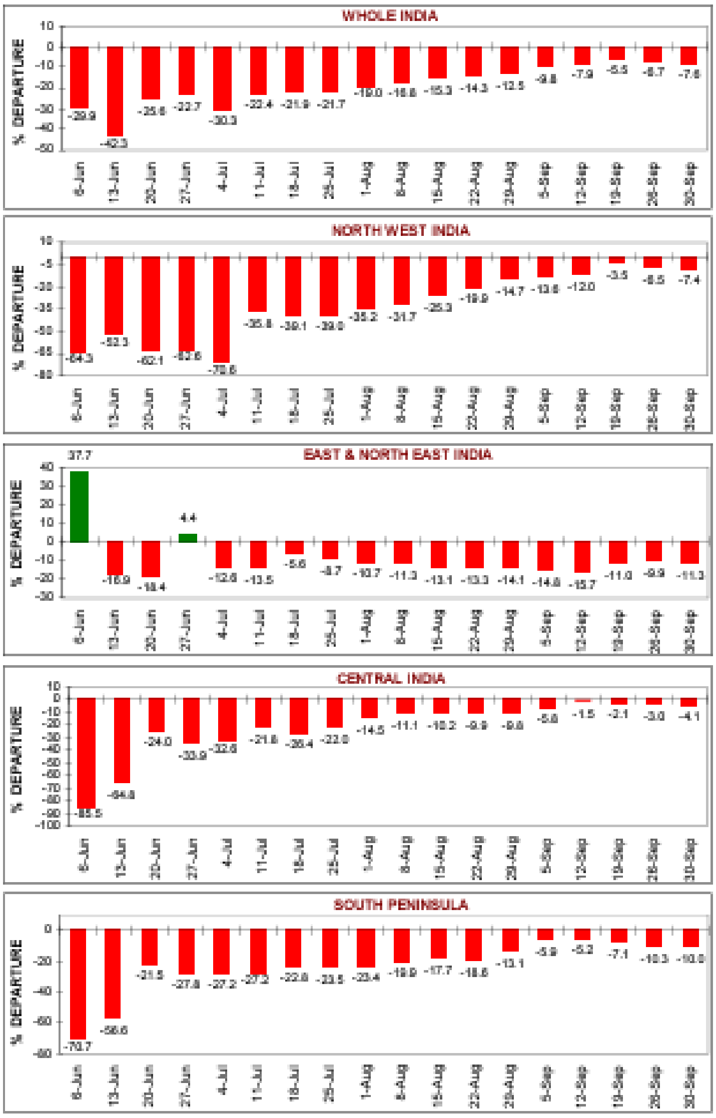


Fig. 3: Percentage departure of area weighted cumulative weekly rainfall for the country as a whole and the four homogeneous regions.

3.4 Synoptic Features

The features on the day-to-day synoptic charts depicted a rather unorganised monsoon circulation pattern during the onset of southwest monsoon 2012 in June. The major synoptic scale system had only been the offshore trough along the west coast. The seasonal heat-trough along the northern plains got established quite late, only towards the 3rd week of June and it shifted northwards subsequently. Mascarene High oscillated in its intensity and position frequently. Even though the upper level features including the Tibetan High and Tropical Easterly Jet were in place quite often, the low-level circulation features did not resemble any time the active monsoon situation. This was due to the prevalent dry phase of Madden Julian Oscillation over the Indian seas, along with a neutral weak positive mode of the Indian Ocean Dipole. No low-pressure area formed during the month in either basin, of the North Indian Ocean. All these factors contributed to below normal rainfall during June 2012. However, it can be observed from Fig.3 that there were heavy rains in the first week of June over the Northeast region.

As compared to June, most part of the country received near-normal rains in July. However, when weekly cumulative totals were computed, even the July rains could not compensate the scanty rainfall received in the month of June. During this month, an anomalous anticyclonic circulation was observed at 850 hPa over the central and south Arabian Sea and adjoining parts of the country. The Mascarene High displayed large oscillations in its position and intensity during this month. The Cross-Equatorial Flow over the Arabian Sea also varied accordingly. This feature, in combination with a suppressed convection over the Arabian Sea, caused the monsoon flow pattern to remain weak during this month. Two low pressure areas formed in July 2012, one over land (northeast Madhya Pradesh and adjoining south Uttar Pradesh) and the other over the Bay of Bengal. In the wake of such synoptic components, a marked spatial variability in rainfall was observed, with the western part of the country receiving much deficient rainfall.

The percentage negative departure of area weighted cumulative weekly rainfall for the country as a whole and the four homogeneous regions was quite low during August and September. Most of the central and eastern subdivisions received normal rainfall during mid-August because five low pressure areas formed in succession over the region. All these low-pressure areas were generally active for four to five days and had a predominantly westerly/north-westerly track. These low-pressure areas caused good rainfall over the concerned region. During the month of September, rainfall over the country as a whole was 112%. Western and North-western parts of the country received considerably good amount of rainfall, whereby the weekly cumulative departures were near zero by the end of the monsoon season.

4. Conclusion

The 2012 summer monsoon season reveals spatial and temporal disparities in rainfall patterns over different meteorological homogeneous regions of India. The delayed onset, marked by the rapid advance and subsequent hiatus, set the stage for a season characterized by variability. The present study revealed the spatial nuances of the monsoon's impact, with certain regions experiencing floods while others endured severe droughts. The temporal dynamics, captured through weekly cumulative departures, showcased the temporal variability of the monsoon, rebounding from a mid-season deficiency to culminate in an overall positive outcome.

The synoptic features and atmospheric anomalies influencing the 2012 monsoon helped in understanding this complex meteorological phenomenon. Anomalous anticyclonic circulation, oscillations in the Mascarene High, and the formation of low-pressure areas emerged as pivotal factors shaping regional rainfall patterns. The August turnaround, marked by the formation of multiple low-pressure areas, highlights the intricate interplay of synoptic systems in modulating the monsoon's behaviour.

As the monsoon continues to be a cornerstone of life in the Indian subcontinent, the research findings hold relevance for climate research, policy formulation, and the resilience of communities in the face of a climatically dynamic future.

References:

Angell, J. K. (1981). Comparison of variations in atmospheric quantities with sea surface temperature variations in the equatorial eastern Pacific. Monthly Weather Review, 109(2), 230-243.

Gadgil, S. (2006). The Indian monsoon. Resonance, 11(11), 8-21.

Goswami, B. N., & Mohan, R. A. (2001). Intraseasonal oscillations and interannual variability of the Indian summer monsoon. Journal of Climate, 14(6), 1180-1198.

Krishnamurthy, V., & Shukla, J. (2007). Intraseasonal and seasonally persisting patterns of Indian monsoon rainfall. Journal of climate, 20(1), 3-20.

Kumar, K. K., Rajagopalan, B., & Cane, M. A. (1999). On the weakening relationship between the Indian monsoon and ENSO. Science, 284(5423), 2156-2159.

Ramamurthy, K. (1969). Forecasting Manual. Part IV, India Meteorological.

Rasmusson, E. M., & Carpenter, T. H. (1983). The relationship between eastern equatorial Pacific sea surface temperatures and rainfall over India and Sri Lanka. Monthly Weather Review, 111(3), 517-528.

Ropelewski, C. F., & Halpert, M. S. (1987). Global and regional scale precipitation patterns associated with the El Niño/Southern Oscillation. Monthly weather review, 115(8), 1606-1626.

Shukla, J. (1987). Interannual variability of monsoons. Monsoons, 14, 399-464.

Sikka, D. R., & Gadgil, S. (1980). On the maximum cloud zone and the ITCZ over Indian longitudes during the southwest monsoon. Monthly Weather Review, 108(11), 1840-1853.

Walker, G. T. & Bliss. EW (1932): World Weather V. Memories of the Royal Meteorological Society, 4, 53-84.

Walker, G. T. (1925). The Meteorology of India. Journal of the Royal Society of Arts, 73(3793), 838-855.

www.imd.gov.in

www.tropmet.res.in

Yasunari, T. (1979). Cloudiness fluctuations associated with the Northern Hemisphere summer monsoon. Journal of the Meteorological Society of Japan. Ser. II, 57(3), 227-242.