

Pattern of Rainfall Distribution in Bihar During S.W. Monsoon Season

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Abstract

Climate plays a significant part in shaping the fate and future of any area. Rainfall, temperature, atmospheric moisture and other secondary elements are main constituents of it. Broadly Speaking, the climate of the Bihar is monsoonal. It experiences four seasons of its own peculiarities. Prevalence of 'Loo' during the summer season (April, May,) and 'Cold Waves', during, the winter season (January and February) restricts the working days of the people. Steady rise and fall in temperature from January to June and July to December, respectively is observable feature. Relative humidity fluctuates not only from month to month but during a day also. July and August months observe high percentage of relative humidity (80%) and December and January have low relative humidity percentage.

Introduction

It covers an area of 94,163 square kms. It extends between 24° 20' N to 27° 31' N latitude and 83° 20' E to 88° 18' E longitude. It is an entirely land-locked state, having an average elevation of about 150 meters above mean sea level. The state shares its boundary with Nepal to the north, the state of West Bengal to the east, Jharkhand to the south and Uttar Pradesh to the west.

Location of the districts of Bihar



Fig. 1.1

All these distinctive features of its climate are caused mainly by two factors, viz, its geographical location in sub-tropical latitude especially in the heart of the landmass and the very location of Himalayas in its close proximity. Off-shoots like the Someshwar range and Dun range of Siwalik systems lying in its northern margin exert local influence on the pattern of the spatial distribute of the incidence of rainfall.

Climate

Climate is considered as the most potent factors of the physical environment and vitally responsible for the dynamism of it. In a predominantly agricultural region like the north Bihar plain its impact on the socio-economic conditions of the residing people can easily be understood. It has only two all pervading precious physical resources such as soils and water potentialities and both are directly or indirectly controlled beyond doubt by climatological factors viz. temperature, rainfall and the amount of vapor in the air.

Although the study area has continental location within the sub-tropical climatic belt, yet the monsoon reigns supreme here and carries great weight in governing socio-economic development. Four seasons of its own peculiarities are experienced here. Prevalence of 'loo' during the summer season (April - May) 'cold waves' during the winter season (January-February) sultry conditions "with heavy downpour" during the rainy season (July to September), frequent manifestation of floods and droughts, perspiring high temperature and fluctuating in humidity percentage with the passing passage of time are some of the unique characteristic features of the climate experienced in the region. All these prevailing conditions have bearings on the availability of water resources as well as on the agricultural practices.

Factors influencing rainfall Distribution in Bihar

The area under reference is a part and parcel of the middle-Gangetic plain. Like other parts of India it experiences the impact of monsoon which is notorious for its fickle nature. The lofty Himalayan Mountain in its close proximity in north and the Indian Ocean along with its arms has great bearings on its climate. Hemmed in between the high Himalaya and peninsular upland and lack of physical undulations to control the sweeping winds and air currents from east and west conspire to make it a transitional in character between the relatively drier upper and per humid lower Ganga plains on its west and east respectively. As it is revealed from the fact that the Eastern U.P., the North Bihar plain and the Bengal Plain receive annual rain about 99.3 cm., 122.6 cm and 150 cm respectively.

Among factors of climate, rainfall and temperature have direct bearing on the overall situation of the water resources vis-a-vis agricultural practices. Hence, the detail study of rainfall conditions of the region assumes greater importance. Without the scientific knowledge of the intensity, duration, variations overtime, spatial pattern regional and seasonal distribution of rainfalls neither it is feasible to assess the total availability of water resources nor its proper management will be possible. Despite the development of irrigation, the agricultural practice are still a gamble in monsoon.

The rainfall is the main source of water supply to surface flow and of underground supply of water for irrigation. The rain that falls on the earth gets distributed into runoff, soil-moisture, ground water, surface storage evaporation and transpiration. The incident solar radiant energy takes back a good bit of the water as vapour by evaporation and evapo-transpiration and these vapors accumulating at high attitudes form closes and that, in turn, bear the rain, again repeating the same hydrological cycle.

Annual Rainfall Pattern

The State Bureau of Statistics made rainfall studies for 29 years 1989-2017 of 51 Rain Recording stations in Bihar and came to conclusion that the study area receives, on an average, about 1220 mms annual rainfall. But from past records it is evident that the said amount varies from year to year. And this fluctuation is not only confined to the annual receipt of rains, but variations take place on spatial dimension as well as over time. The Bureau has derived four distinct characteristics of the rainfall here:-

- (i) Unequal distribution of rains on annual basis,
- (ii) Spatial differentiation in the distribution of rainfall,
- (iii) Unequal distribution of the rainfall during the season, and
- (iv) Partial failure or sometimes complete failure of the rain.

These peculiarities of rains have direct bearing on the availability of water resources keeping these peculiarities of rains in view, it is essential to have detail knowledge of the occurrence of rainfall in the study area. It throws light on the annual patterns of rainfall as witnessed over the study area during the past years.

The tabular data reveal that the area under study receives, on an average, 122.6 cms of annual rainfall. This amount is more than the average computed for the state (118.6 cm). It also exceeds the national average (113.2 cm). But all the districts do not receive the same amount. The Purnea district in the eastern part and the West Champaran district in the extreme north-western part of the region receive the maximum amount of

rainfall. There are only seven districts such as Purnea, West Champaran, Kishanganj, Katihar, Madhepura, Saharsa, East Champaran, Madhubani and Darbhanga which receive more than the average computed for Bihar. The remaining districts receive rainfall less than the average computed for the area.

Table 1.1 shows the mean rainfall (mm) and coefficient of variation of the state for the monsoon months, southwest monsoon season and annual during the period 1989-2018. It can be seen that the state gets highest rainfall (33% of south west monsoon rainfall) in July month while the August month gets 28% of the south west monsoon rainfall. June and September receive 17% and 21% of south west monsoon rainfall, respectively. More than 85% of annual rainfall is received during the southwest monsoon season only. The variability of monsoon and annual rainfall are also less, 19% and 18% for monsoon and annual, respectively.

Mean rainfall (mm) and coefficient of variation of the state for the monsoon months, southwest monsoon season and annual.

TABLE 1.1

	June	July	August	September	JJAS	Annual
Mean	160.2	313.9	264.5	200.1	938.7	1098.9
Cv	40.3	33.4	26.6	40.5	19.3	18.2

Already there are many studies available on the observed trends and variability of rainfall and also extreme rainfall events, but all the studies are based on past 100 years or more data and also the recent years are not included (Warwade et al, 2018; Guhathakurta et al, 2015; Guhathakurta et al, 2011; Guhathakurta & Rajeevan, 2008 etc) in the study. In the present report all the analysis of observed rainfall patterns, trends and variability have been done based on recent past 30 years (1989-2018) that will help to have idea of the recent changes in climate adaptation and management by the concerned authorities.

Time series of rainfall in mm for the months of June, July, August, September and trends

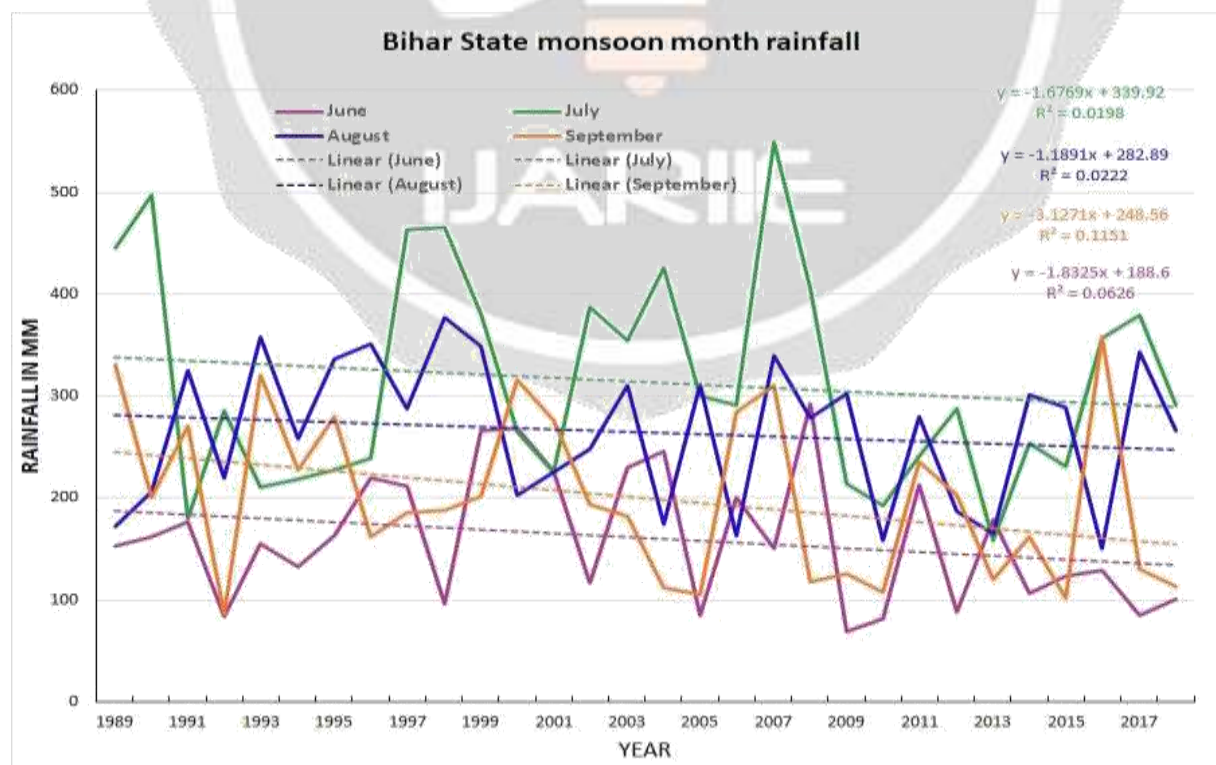


Fig. 1.2

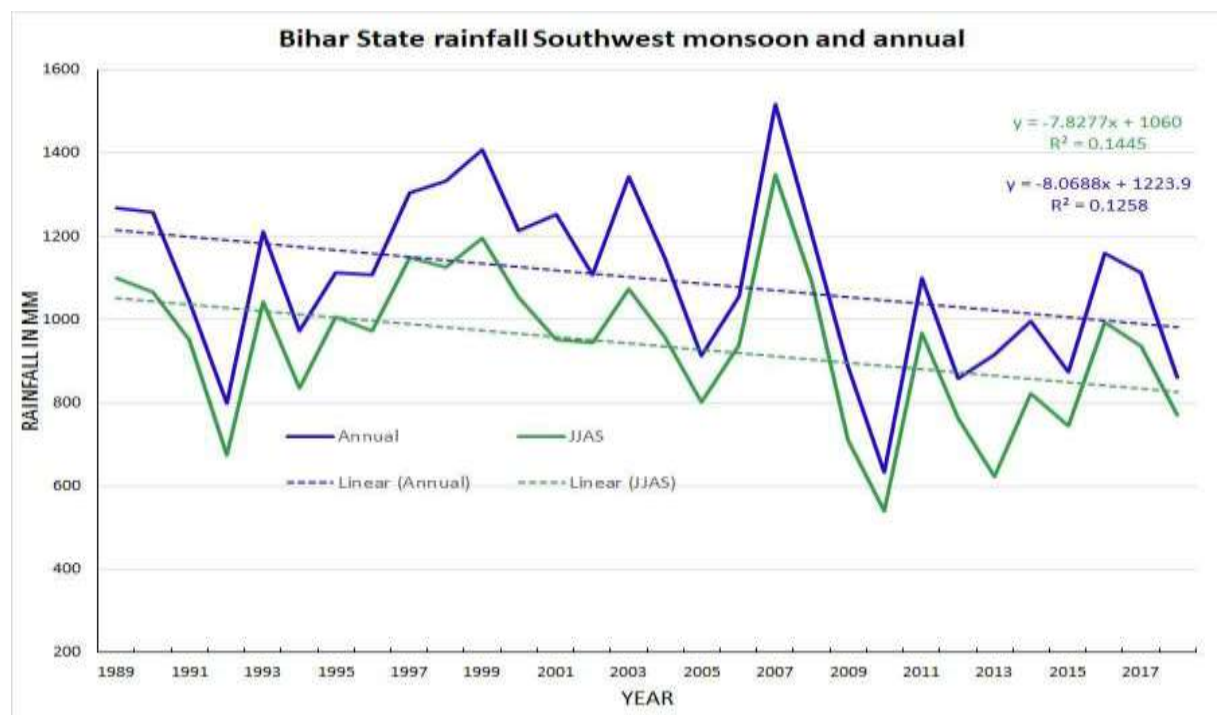
Time series of rainfall in mm for the southwest monsoon season and annual trend**Fig. 1.3**

Fig. 1.2 and 1.3 show the time series of rainfall in mm for the months of June, July, August, September and southwest monsoon season, annual respectively. The trend lines are also displayed for each of the series. The southwest monsoon season rainfall shows a significant decreasing trend, but neither monthly rainfall nor annual rainfall show any significant increasing/decreasing trend. Although, a decreasing trend is observed in all the southwest monsoon months as well as both the seasonal and annual mean. During the last 30 years, the highest rainfall of June, July, August and September received in the year 2008 (291.8 mm), 2007 (548.9 mm), 1998 (377.1 mm) and 2016 (357.9 mm), respectively and the lowest rainfall of June, July, August and September received in the year 2009 (69.4 mm), 2013 (158.7 mm), 2016 (150.9 mm) and 1992 (86 mm), respectively. Highest southwest monsoon rainfall of 1349.3 mm and annual rainfall of 1516.8 mm received in the year 2007 and the lowest southwest monsoon rainfall of 539.5 mm and annual rainfall of 632.5 mm received in 2010.

District rainfall mean, variability and trend Mean and coefficient of variation

Table 1.2 gives the rainfall statistics for the districts of Bihar for the four monsoon months, southwest monsoon season and annual. Show the spatial pattern of these statistics. Three districts in the northeast viz. Kishanganj, Arariya and Purnia and one in the northwest viz. West Champaran receive highest rainfall over other districts during all the southwest monsoon months and the season. Rainfall received over these districts are around 150-350 mm in June, 350-600 mm in July, 300-450 mm in August, 200-400 mm in September, 1100-1700 mm during the southwest monsoon and 1300-2100 mm in annual. In general, districts over the southwest of Bihar received less rainfall during the southwest monsoon season (698-897 mm) as well as annual (780-1029 mm). The highest mean southwest monsoon rainfall (1694.1 mm) and annual rainfall (2023.2 mm) is observed over Kishanganj district and the lowest mean southwest monsoon rainfall (697.9 mm) and annual rainfall (780.1 mm) is observed over Arwal district.

The districts exhibiting maximum and minimum variability of mean rainfall are Buxar (92.4%) and Kishanganj (38.6 %) for June, Vaishali (70.9 %) and Katihar (35%) for July, Sheohar(64.9%) and Banka (26.5%) for August and Vaishali (74.6%) and Aurangabad (47.5%) for September. Vaishali (52.2%) and Bhagalpur (21.4%) show the

maximum and minimum variability of rainfall during the southwest monsoon, respectively. While, Sheohar (55.3%) and Gopalganj (19.6%) show the maximum and minimum variability of annual rainfall, respectively.

Distribution of rainfall during S.W. Monsoon

Table 1.2

DISTRICT	JUNE		JULY		AUGUST		SEPTEMBER		MONSOON		ANNUAL	
	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV
Jamui	140.6	57.2	257.1	47.4	237.0	31.4	216.2	63.0	890.9	31.5	1033.8	29.9
Katihar	212.8	46.7	329.2	35.0	248.4	43.6	276.4	64.5	1066.9	30.9	1326.7	29.6
Khagaria	165.0	63.5	271.1	45.0	247.1	44.7	223.6	62.1	906.8	32.0	1085.1	31.5
Kishanganj	330.4	38.6	567.5	41.7	444.0	46.5	352.2	54.6	1694.1	26.4	2010.5	33.6
Lakhisarai	122.4	51.0	287.7	49.1	208.8	30.1	175.8	54.6	794.7	26.9	922.9	25.0
Madhepura	196.3	41.3	295.6	35.9	257.1	43.0	235.3	55.4	984.4	23.8	1203.8	22.3
Madhubani	166.5	48.8	325.4	46.1	251.8	52.9	168.8	55.5	912.4	29.9	1071.1	26.5
Munger	142.6	55.2	313.9	58.3	242.1	37.0	229.3	54.8	928.0	31.8	1079.6	30.0
Muzaffarpur	160.3	59.7	298.0	40.1	257.3	48.1	187.4	69.5	903.0	32.69	1062.2	29.9
Nalanda	114.2	61.6	275.8	50.0	223.5	35.1	182.4	48.9	795.9	27.4	903.3	26.2
Nawadah	117.9	68.9	269.7	49.3	229.7	35.3	173.5	50.9	790.8	24.9	921.8	22.5
Patna	128.3	67.2	273.1	52.1	222.2	26.6	169.7	49.3	793.3	27.6	911.4	26.5
Purnea	268.3	40.1	419.6	40.9	334.9	43.5	296.2	51.6	1319.0	27.7	1623.3	25.9
Rohtas	120.7	71.3	281.3	49.3	255.2	28.8	153.1	53.6	810.3	24.2	903.4	24.0
Saharsa	165.7	45.0	315.9	46.4	250.6	39.02	203.8	55.6	936.0	26.6	1122.4	26.1
Samastipur	155.4	54.3	303.4	45.4	254.2	46.8	199.2	55.8	912.3	28.4	1091.1	26.3
Saran	134.7	65.1	275.5	52.8	250.9	36.1	172.7	52.3	833.8	27.4	950.8	35.0
Sitamarhi	169.4	73.8	303.0	57.9	264.6	54.4	164.2	59.1	901.2	38.7	1042.5	36.4
Sheikhpura	126.8	60.7	286.7	52.7	203.4	40.6	170.5	58.8	787.4	42.1	908.3	40.9
Sheohar	173.1	77.3	308.3	66.3	260.9	64.9	183.4	68.3	925.7	47.3	1076.2	55.3
Siwan	130.1	64.7	273.9	45.4	233.8	44.1	176.2	58.6	814.0	25.1	957.9	24.0
Supaul	202.7	49.7	357.3	58.3	258.4	40.2	211.0	49.7	1029.3	29.6	1253.2	27.7
Vaishali	115.1	76.5	276.4	70.9	214.4	50.0	154.7	74.6	760.4	52.2	856.9	49.9
Arwal	97.9	70.1	246.0	69.4	231.0	61.4	158.3	65.9	733.3	38.3	816.9	35.5
Araria	258.4	39.8	447.2	41.8	324.8	46.2	281.1	53.7	1311.6	30.5	1569.4	28.1
Aurangabad	138.3	64.4	280.4	40.1	257.7	33.1	179.6	47.5	855.9	33.0	958.7	33.5
Banka	148.7	51.2	293.8	43.4	247.8	26.5	206.8	56.0	897.0	22.2	1070.2	20.9
Begusarai	148.5	62.0	295.3	47.7	259.9	44.1	218.9	61.2	922.6	37.8	1065.9	40.1
Bhabua	110.1	73.9	279.4	40.6	291.2	55.5	193.2	51.4	873.9	25.9	956.7	26.0
Bhagalpur	161.5	48.3	301.7	36.8	258.8	38.9	225.9	56.8	947.6	21.4	1167.3	22.6
Bhojpur	123.9	70.9	298.0	57.3	253.5	39.9	179.9	52.1	855.4	36.3	958.9	39.4
Buxar	114.4	92.4	288.7	56.2	251.1	40.3	159.8	50.7	813.6	30.4	900.1	35.6
Champan East	175.4	54.0	322.6	47.8	287.1	52.7	182.1	60.6	967.2	30.5	1144.8	26.1
Champan	197.3	62.4	399.1	37.4	358.9	47.2	212.4	59.4	1167.6	24.8	1374.8	22.6

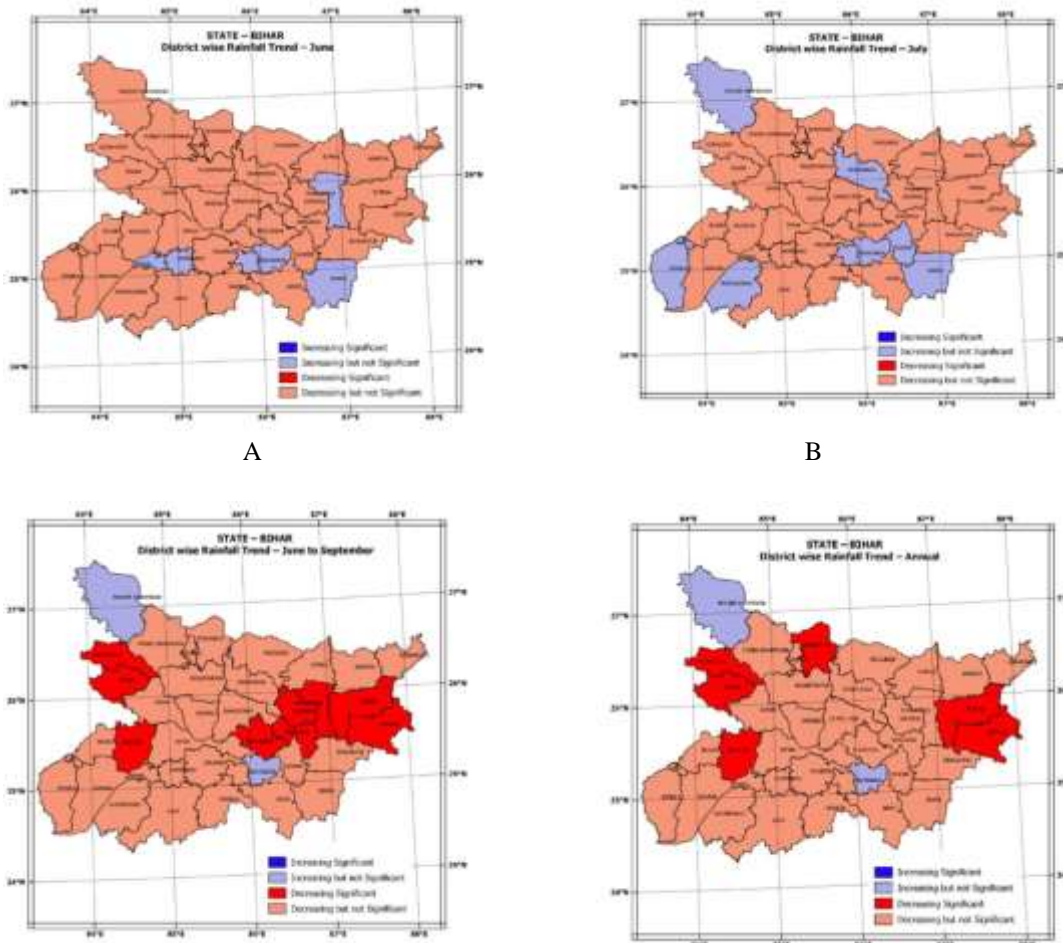
West												
Darbhangha	159.4	75.9	293.8	38.1	242.3	44.9	178.5	59.5	874.0	27.3	1025.1	24.6
Gaya	133.2	71.1	256.3	48.0	231.6	31.7	165.9	59.0	787.0	27.5	888.5	26.4
Gopalganj	144.9	58.4	314.4	49.1	261.1	39.1	193.4	61.2	913.9	21.9	1069.0	19.6
Jahanabad	116.0	70.0	267.1	54.2	243.1	39.8	166.2	59.6	792.4	29.0	888.9	31.7

Source: Statistical Hand book of Bihar Govt. of Bihar, Patna

Trend In District Rainfall

Fig. 1.4 shows the trends in district rainfall over Bihar. August rainfall has significant decreasing trend in the Bhojpur district and September rainfall has significant decreasing trend in the districts of Bhojpur, Purnia, Katihar and Nawada. June and July rainfall do not have any significant trend. Although, in June Arwal, Jahanabad, Lakhisarai, Sheikhpura, Madhepura and Banka districts have increasing trend whereas all other districts have a decreasing trend. But these trends are not significant. In July West Champaran, Darbhanga, Bhabua, Aurangabad, Sheikhpura, Lakhisarai, Munger and Banka districts have an increasing trend (not significant) whereas all other districts have decreasing trend (not significant). In August Kishanganj, Araria, Darbhanga, Samastipur, West Champaran, Arwal, Lakhisarai, Nawada districts have increasing trend whereas all other districts except Bhojpur, there is a decreasing trend. These trends are also not significant. The district rainfall in September has increasing trend in Arwal and Jahanabad and decreasing trend in all other districts (except Bhojpur, Purnia, Katihar and Nawada) which are not significant. In the southwest monsoon season, nine districts namely Katihar, Purnia, Madhepura, Saharsa, Khagaria, Begusarai, Bhojpur, Siwan and Gopalganj has a significant decreasing trend. While, Lakhisarai and West Champaran show an increasing trend and all other districts show a decreasing trend during the season, which are not significant. The annual rainfall shows a significant decrease in Katihar, Purnia, Siwan, Gopalganj, Bhojpur and Sitamarhi districts. It shows an increasing trend in Lakhisarai and West Champaran and decreasing trend in all other districts, but the trends are not significant.

Trends in district rainfall for (a) June, (b) July (c) August (d) September (e) southwest monsoon and (f) annual



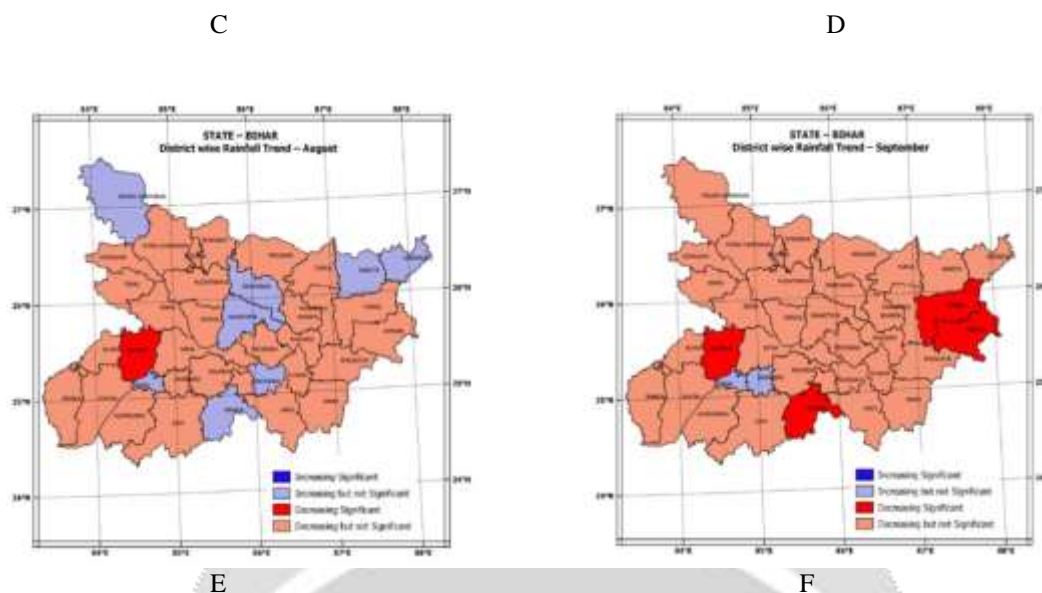


Fig. 1.4

Conclusion

Keeping all the points mentioned above it can be said that S.W. monsoon or rainy season is supposed to be everything in Bihar. Here nothing can move until and unless agriculture moves and agriculture can not move without scientific application of water to the standing. Normal incidence of rainfall in Bihar is fit for cultivation throughout the year, but its unreliability is a matter of concern. Hence conservation of rainfall received during the rainy season must be achieved. The analysis brought many significant feature of rainfall pattern and can be used for water agricultural managements. Some of the important results can be summarized as:

1. Bihar gets more than 85% of its annual rainfall in the southwest monsoon season.
2. The highest rainfall (33% of south west monsoon rainfall), is receive in July month, 28% (of south west monsoon rainfall), is received in August month , followed by September 24% of the south west monsoon rainfall.
3. The highest mean southwest monsoon rainfall (1694.1 mm) is observed over Kishanganj district and the lowest mean southwest monsoon rainfall (697.9 mm) is observed over Arwal district.
4. Three districts in the northeast viz. Kishanganj, Arariya and Purnia and one in the northwest viz. West Champaran receive higher rainfall over other districts during the southwest monsoon season.
5. Districts over the southwest of Bihar received less rainfall during the southwest monsoon season (698-897 mm).
6. The annual rainfall has a significant decreasing trend in Katihar, Purnia, Siwan, Gopalganj, Bhojpur and Sitamarhi districts.
7. In the southwest monsoon season, maximum number of rainy days (~ 44-48 days) is observed in Kishanganj and some parts of Arariya, Purnia, Katihar, Bhagalpur and West Champaran and minimum number of rainy days (~ 30-34 days) is observed in most parts of Madhubani, Sitamarhi, Sheohar, Muzaffarpur, Kaimur, Buxar, Bhojpur, Arwal, Saran and Siwan districts.
8. The maximum number of dry days during the southwest monsoon season is (~ 72-76 days) is observed mainly in the districts of Gopalganj, Siwan, Saran, West Champaran, East Champaran, Muzaffarpur, Sheopar, Madhubani, Sitamarhi, Buxar, Bhojpur, Patna, Jahanabad, Nalanda, Kaimur, Rohtas, Aurangabad and Gaya, and minimum number of dry days (~ 57-61 days)are observed in the districts of Kishanganj, Arariya, Purniya, Supaul, Katihar and Bhagalpur.
9. A significant decreasing trend for the number of rainy days in southwest monsoon in Banka, Begusarai, Bhabua, Bhagalpur, Buxar, West Champaran, Darbhanga, Gaya, Jamui, Katihar, Khagaria, Kishanganj, Lakhisarai, Madhubani, Munger, Muzaffarpur, Nawadah, Patna, Purnea, Rohtas, Samastipur, Saran, Sitamarhi, Siwan, Supaul, Vaishali and Arwaldistricts is observed.
10. A significant increasing trend for the number of rainy days in southwest monsoon in East Champaran, Madhubani, Muzaffarpur, Supaul, Arariya, Katihar and Gaya districts are seen.

11. In annual scale, a significant decreasing trend in the number of rainy days is seen in all the districts of Bihar except East Champaran, Gopalganj, Saharsa, Madhepura, Bhojpur, Arwal and Jahanabad and a significant increasing trend is observed in the districts of East Champaran, Madhubani, Muzaffarpur, Supaul, Arariya, Katihar, Gaya, Patna and Bhabua.

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