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AN EXPLORATORY IMPACT STUDY OF PRECIPITATION CHANGE AND ITS POSSIBLE RESILIENCE STRATEGY OVER WEST BENGAL

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Abstract: The Socio-economic structure of our state West Bengal as well as our country India is largely framed by agriculture. Whose one of major driver is the seasonal and annual rainfall. But the rainfall pattern changes and anomalies affect it in a havoc manner. Especially in 2022 a huge shortage in monsoon rainfall hampered the cultivation of paddy and jute, which are among the major crops cultivated in India for food and economy purpose. Being in Tropical region, West Bengal gets plenty of rainfall in the monsoon months like June, July, August and September every year. In this paper, an attempt has been made to analyze the rainfall patterns, trends and variability, based on the last 30 years data of West Bengal and last 120 years data of India. The results obtained are verified for the year 2019 to 2022 to confirm the situation. Throughout the year variety of crops like paddy, jute, sugarcane, cotton etc. are cultivated which largely depends on rainfall as well as other weather and soil parameters. District level rainfall pattern changes also studied to assess the situation and to select crop accordingly on urgent basis to save our glorious agricultural past. Crops like sorghum, millet and groundnut which has negative correlation with rainfall should be introduced. Otherwise in near future our economy and livelihood are going to be in distress.

Key words: Monsoon, Rainfall, Climate Change, crop

INTRODUCTION

The latitudinal and longitudinal extent of India lies roughly between21°30'N to 27°11'N and 85°49'30" E to 89°54'E. The state shows variation in geophysical features. The maximum part of it falls under the Gangetic plane. It has sub-Himalayan region in the north and Bay of Bengal in the south. Deltaic features of major rivers (Ganga and Brahmaputra) and its distributaries can be seen in the eastern and south eastern part of it. The plateau of Chotanagpur has been extended up to the western part of Bengal. It has the climate of varied nature in view of its geographical locations. This state is in the tropical climatic region. It gets plenty of rainfall in the monsoon. Mainly June, July, August and September are the monsoon months and gets heavy rainfall every year. In this project, an analysis of observed rainfall patterns, trends and variability has been done based on the last 30 years data and verified for last 4 years. It will help to get an idea of the changes in the rainfall pattern over the state. Also, an analysis of last 100 years data of India has done in comparison to identify its

changing nature. West Bengal is a state of agriculture. Different crops like paddy, wheat, Jute, sugarcane, vegetables etc. are being cultivated throughout the year which largely depends on rainfall as well as other weather and soil parameters. As there is a change in rainfall pattern in the state, the cultivation is getting hampered and the agricultural outcome is decreasing as it has been seen in other parts of India also [1-4]. Keeping this change in the priority, alternate cultivation method and the crop selection is to be done accordingly on urgent basis to save our glorious agricultural past. For example, for areas with inadequate rainfall, wet crops should be grown with the help of additional supply of water [5]. Otherwise in near future the economy and livelihood of this state is going to be in distress. Also, a study of rainfall pattern of our country, India has to understand the issue in a large scale. The rainfall pattern changes of some other states are also being studied by researchers and more micro level studies highly solicited [6-20]. Also, there are is a growing need exploratory study on district rainfall trends and variability of West Bengal state to understand the problem on regional basis as our state has a diverse geographical and agricultural pattern [21-24].

The objective of the analysis is to:

1. Identify the spatial and temporal pattern of the mean rainfall

2. Understand district wise rainfall trend and variability in annual and SW monsoon season

3. Introduce alternate agriculture method

4. Select crop accordingly

Data and Methodology

Monthly Rainfall data from 1989 to 2022 has been analyzed to calculate the change and mean rainfall patterns. Monthly district wise rainfall series has been computed by considering arithmetic average of all the station rainfall values within the district. The monthly rainfall series of the state has been computed by using area weighted rainfall values of all the districts within the state. Fig.1 gives the location of the districts of the state with rainfall variation. Due to South West (SW) monsoon the rainfall occurs in the month of June, July, august and September every year. So, these months are considered monsoon season.

Daily station rainfall data is utilized for identification of the mean spatial patterns and rainfall intensity trends. From mean and standard deviation (SD), the percentage of variation is calculated as follows:

% of variation = Standard Deviation/ Mean × 100

To validate the analysis and result thereon R^2 test has done and Microsoft excel is used for statistical analysis the data series and to draw the graphs.

Fig.1 District Map of West Bengal with rainfall variation

Results and discussion

Table 1 shows average rainfall (mm) over the state for monsoon months, monsoon season and annual during the calculation period. It is evident from the table that the state gets77 % rainfall during the southwest monsoon season. Highest rainfall of 30% in the month of July and the August month gets 26% of the south west monsoon rainfall. June and September months receive around 22 % of south west monsoon rainfall. The variability of monsoon or annual rainfall is also very less (14%) and highest variation of 28% found in the month of September. During the last 30 years highest rainfall received year wise in monsoon months, season and year in the state are tabulated below in table 2.

Table 1. Average rainfall over West Bengal

Time	June	July	August	September	Monsoon	Annual
Average	318.0	431.8	361.1	307.7	1418.7	1851.4
% variation	20	19	20	28	14	14

Table 2. Highest rainfall over West Bengal

	June	July	August	September	Monsoon	Annual
Year	2008	2007	1996	1995	1999	1990
Rainfall	445.8	638.0	494.7	482.2	1814.2	2384.5

In the time series analysis, it is clear that a decreasing trend is followed for the month of June, July, August and September continuously which is depicted in figure 2. Also, seasonal and annual decreasing pattern is

seen in figure 3. The regression equations (equations 1-4) for June, July, August and September are showing a negative gradient which in turn implies the decreasing trends of the rainfall pattern.

y = -3.3704x + 370.28…… (1)

y = -2.5404x +471.22 …… (2)

y = -1.14171x+ 383.04 …. (3)

y = -3.389x + 360.26 … (4)

And to establish stability and validity of the result a statistical test is done and the R^2 are values are found 0.2105, 0.0736, 0.0333 and 0.1183 respectively and which are valid as R^2 value less than 0.5 is good enough.

The annual and monsoon seasonal change is plotted in the time series and the negative slopes of the equations are establishing the decreasing fact. The regression equations are given below in equations 5 and 6. The R^2 values are 0.2857 and 0.2286 and which are again proofing the validity of the results.

y = -1.15171x +2086.6 ……. (5)

y = -10721x + 1584.9 … … (6)

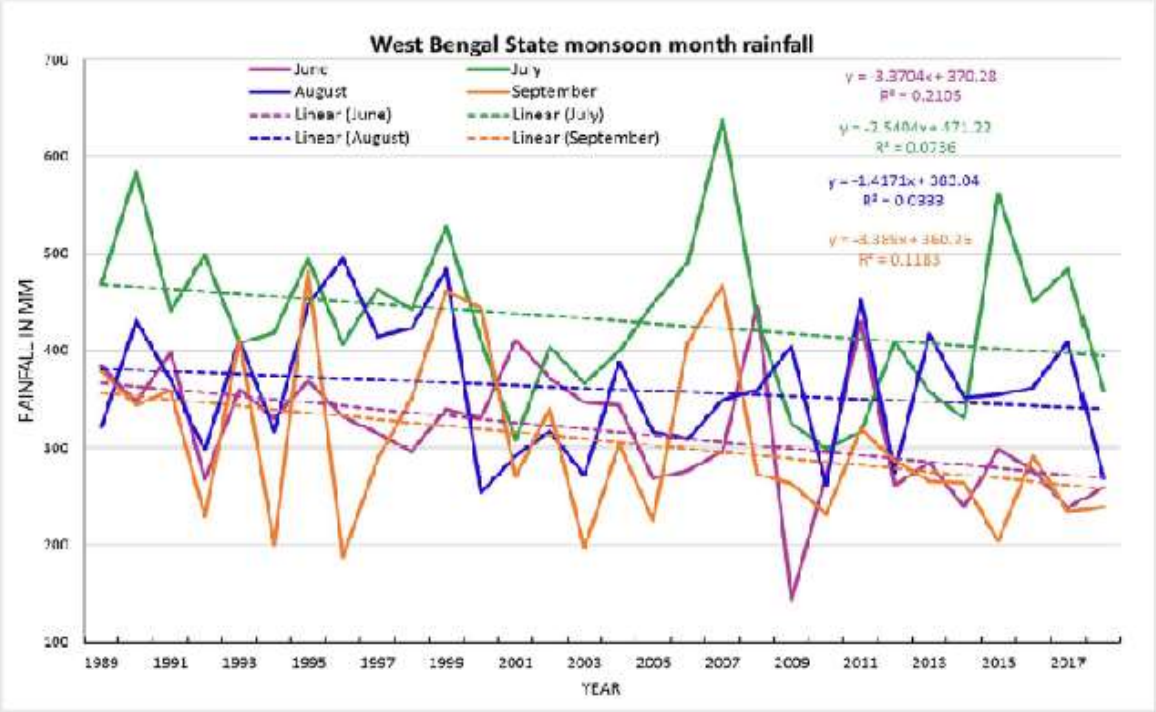

Fig. 2. Time series plotting of rainfall in monsoon months (source IMD)

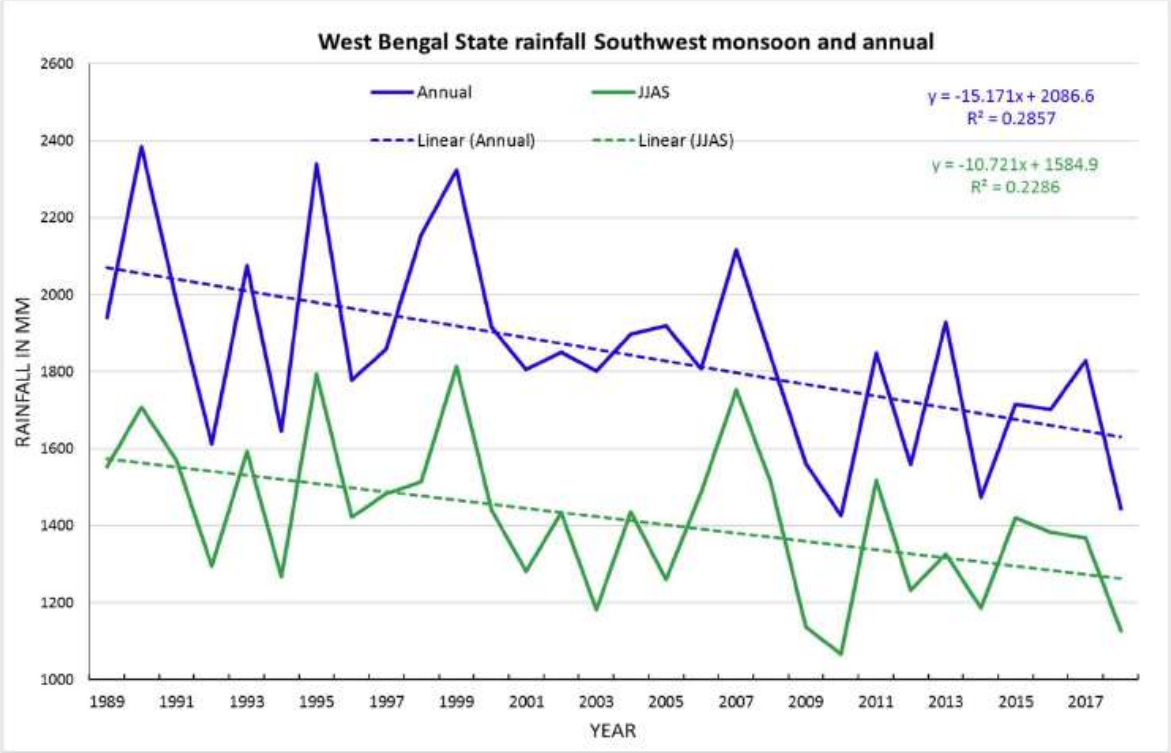

Fig.3. Time series plotting of Annual and seasonal rainfall (source IMD)

The rainfall statistics of all districts of West Bengal of four monsoon months (JJAS), SW monsoon and annual precipitation are given in the Figure 4. The district wise variation of the rainfall pattern is showing that the highest average SW Monsoon and annual rainfall of about 3000 mm and 3800 mm occurred in the northern districts like Darjeeling, Jalpaiguri of West Bengal.

The average lowest Monsoon seasonal and annual rainfall happened in our district Nadia among all the districts of our state. The amount of rainfall in JJAS and Yearly is 887.9 mm and 1259.4 mm respectively.

In the monsoon season CoochBehar, Howrah, Malda, South 24 Parganas and Dakshin Dinajpur districts has a significant decreasing rainfall trend and annually in addition to this district Murshidabad, Birbhum, Purulia, Jhargram, Paschim Medinipur district also getting lesser rainfall day by day.

Maximum rainy days of around 86 to 109 days are found in Northern districts whereas 51 to 86 days in rest of West Bengal. In JJAS 7-12 days and yearly 9-14 days heavy rainfall in North and 2-7 days and 2-9 days in rest part. The annual dry days are shown in the table 3 below. It is evident that Western part of the state suffers maximum dry days annually.

In figure 5, a plot of the rainfall in monsoon months over Indian subcontinent for the last 120 years. It is evident from the figure that a steady decreasing trend is also present in the whole country also.

Table 3. Annual dry days

Dry days	Districts
55-61	Purulia, Jhargram, Bankura, Paschim Burdwan, Birbhum, Murshidabad, Dakshin Dinajpur
38-55	Kalimpong, Jalpaiguri
23-38	Others

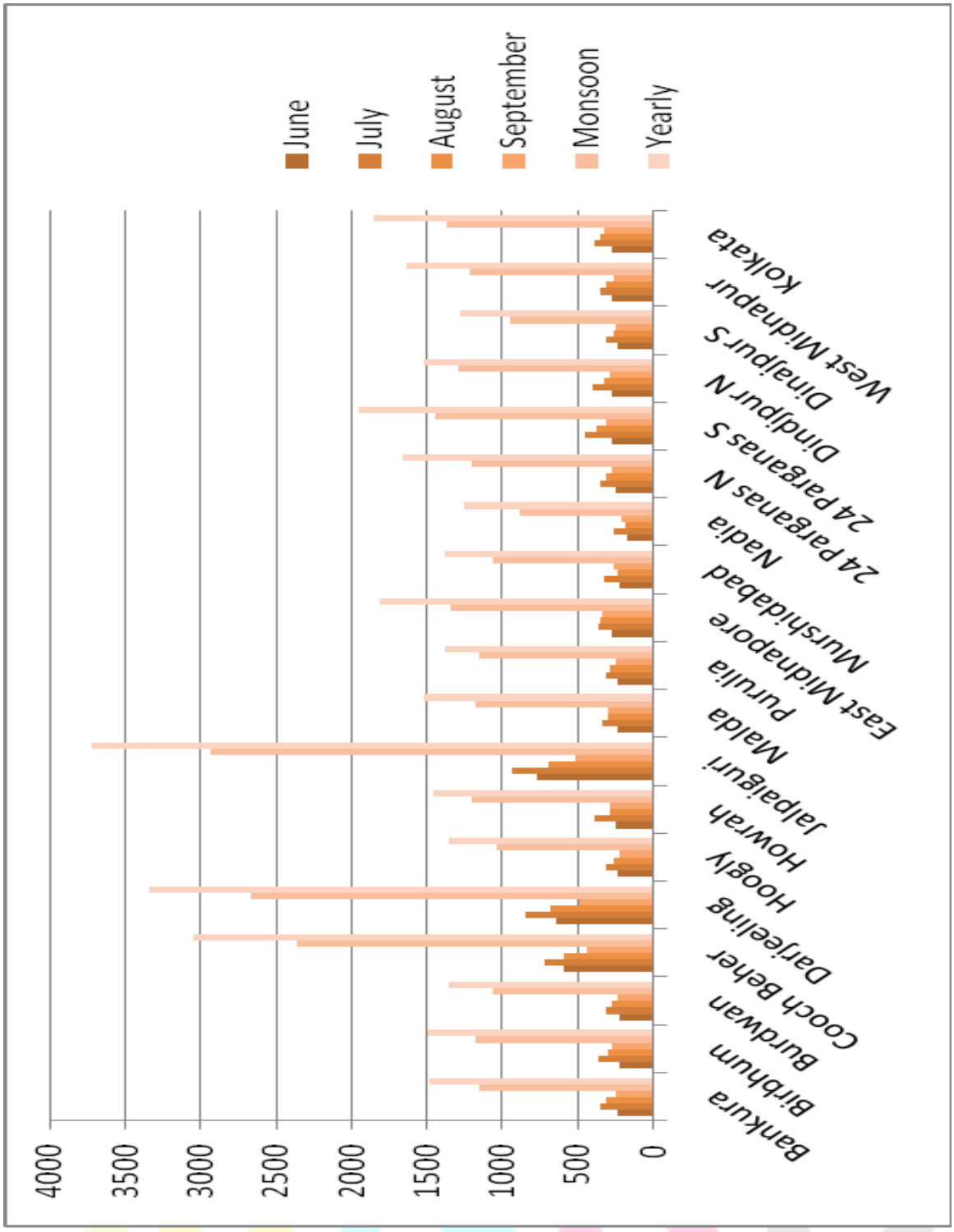

Fig. 4. Average rainfall in Districts of West Bengal in mm

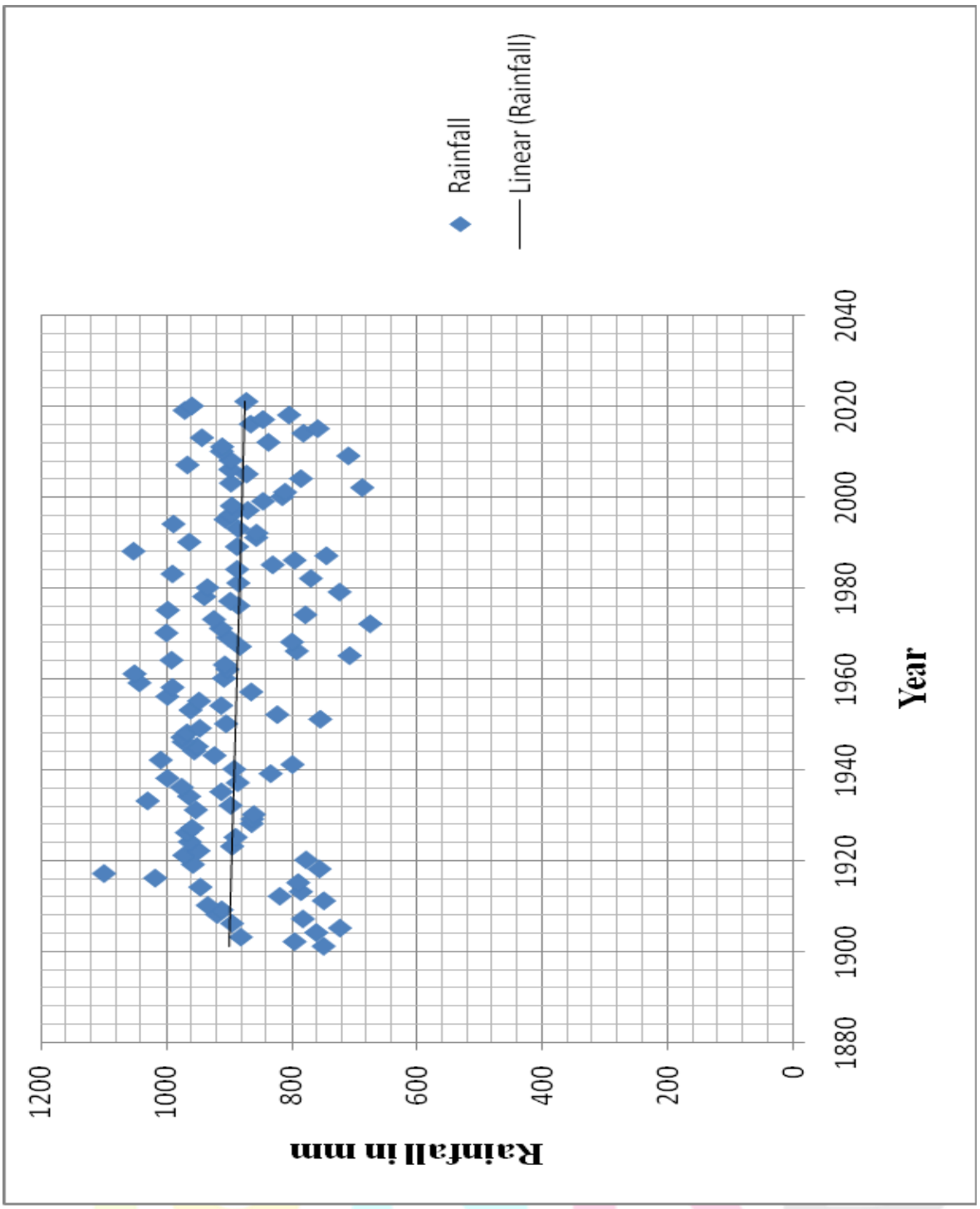

Fig. 5. Monsoonal rainfall in India (1901-2021)

Verification for the years 2019 to 2022

The results obtained after the study, we compared it with the average rainfall received yearly, monthly and also with monsoon. Yearly and monsoon average was 1851.4 and 1418.7 and the average for verification years is 1876.8 and 1352.4 respectively. Except in September the average rainfall of June, July and August decreased in verification years (Table 4). It is also seen in figure 6 that the district wise rainfall pattern shift is comparable to the results obtained. So, it is evident that the precipitation is really in decreasing trend. And the concern for crop production depending upon rainfall sustained.

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Table 4. Rainfall distributions for the years 2019 to 2022

Year	Total Rainfall in the year (mm)	Average annual rainfall from 2019-2022 (mm)	Rainfall received by WB in SW monsoon of that year (mm)	Average rainfall in SW Monsoon from 2019-2022 (mm)	Month Wise rainfall(mm)							
					June	Average rainfall in June from 2019-2022	July	Average rainfall in July from 2019-2022	August	Average rainfall in August from 2019-2022	September	Average rainfall Septem ber from 2019-2022
2019	1733.4	1876.8	1186.1	1352.4	167.1	220.8	363.3	367.12	313.7	343	341.9	337.97
2020	2012.6		1487		371.1		433.1		355.7		327.2	
2021	2202.7		1612.9		394.3		435.8		358.6		424.2	
2022	1558.8		1123.6		284.7		236.3		344		258.6	

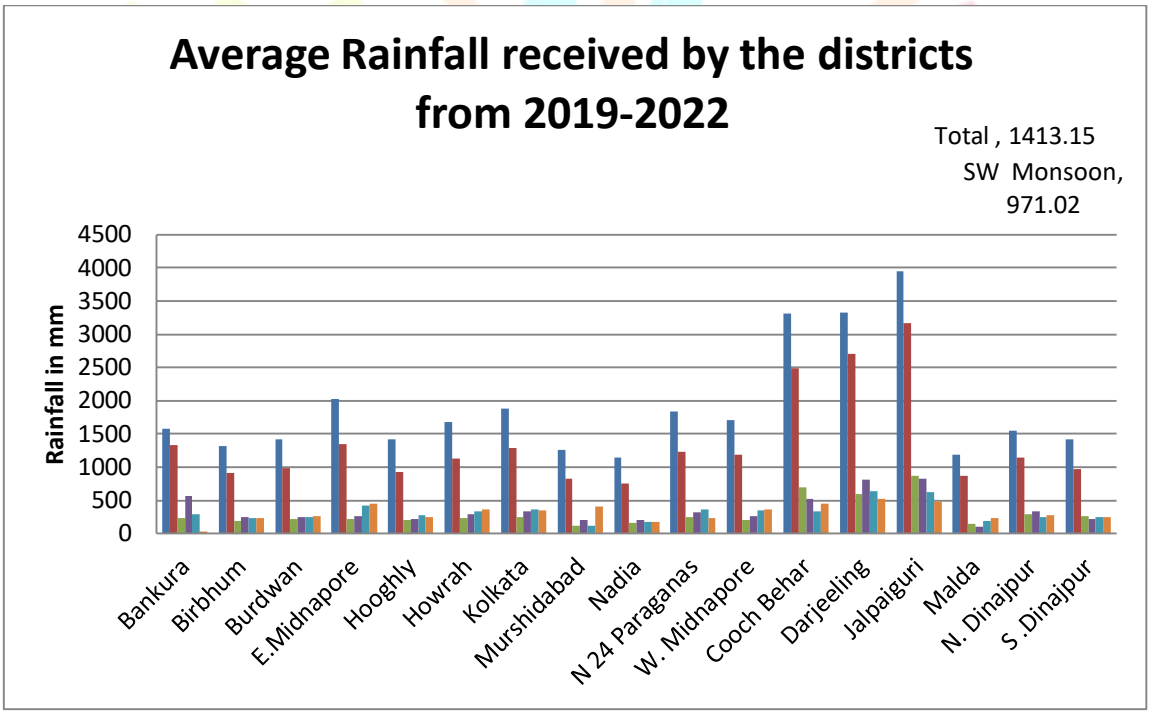

Fig. 6. Average Rainfall received by WB districts during SW Monsoon from 2019-2022

Conclusions:

We have studied rainfall pattern of West Bengal from 1989-2017 and verified the result for the year from 2019-2022 and the following conclusions can be drawn from our study.

1. Highest Rainfall occurs in July and almost 77% annual rainfall in JJAS.

2. In 1999, this state received highest rainfall of 1814 mm in JJAS.

3. Significant change in precipitation pattern in June, July and September.

4. Annual rainfall pattern decreasing sharply in comparison to JJAS.

5.JJAS and annual significant decrease in rainy days in Purulia, Kalimpong, Jalpaiguri, Paschim Medinipur, Purba Bardhaman, Nadia.

6. Jalpaiguri, Darjeeling, CoochBehar are getting heavier rainfall in every year.

7. In spite of being situated in middle Gangetic plain, Malda, Murshidabad and Nadia are experiencing lesser precipitation, which is insufficient for traditional proper crop production**.**

8. Increase in dry days in almost all the districts except Uttar Dinajpur, Jhargram and Dakshin Dinajpur is in turn decreasing ground water recharge.

9. The rainfall data for the verification years 2019-2022 are compared with the results obtained, it is seen that the trend is continuing.

Suggestions and scope for future investigations:

*Shift in precipitation pattern should be examined deeply

* Suitable agricultural environment to be studied accordingly

* Selection of Crop like sorghum, millet and groundnut to be made

* Small scale study highly solicited for proper and exact decision

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