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Agro-Climatic Characterization for Agro-Climatic Zone of Chhattisgarh

Hemant Kumar Bhuarya[1], A.S.R.A.S. Sastri[1], S.K. Chandrawanshi[2*], Pandhurang Bobade[1] and Deepak K. Kaushik[1]

[1]Department of Agrometeorology, Collage of Agriculture, Indira Gandhi Krashi Vishwavidhyalaya Raipur-4912 012, India
[2]Agricultural Meteorological Cell, Department of Agricultural Engineering Navsari Agriculture University, Navsari-396 450, Gujarat, India

**Corresponding author*

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A B S T R A C T

Agro-climatic characterization for Agro-climatic zone of Chhattisgarh was carried out in the Department of Agricultural Meteorology, I.G.K.V. Raipur to capture the agricultural and climatic features which in turn help for sustainable agriculture development in Chhattisgarh. A detailed study was carried out for Chhattisgarh state by considering the district wise rainfall for the period 1901-2010. When the rainfall was examined it was found that the rainfall was in decreasing trend in all the districts during the post- global warming period. The annual rainfall during post-global warming period decreased by about 30-40% in Mahasamund area as compared to pre-global warming period. In southern Chhattisgarh (Bastar) and parts of northern Chhattisgarh the decrease of rainfall during post-global warming period ranged between 10-20%. In central part of Chhattisgarh state the decrease of rainfall ranged between 20-30 percent. The result of LGP reveals that the highest >120 days was recorded in Bastar, Bijapur and Dantewada district and the lowest <110 days was recorded in Bilaspur, Dhamtari, Durg, Janjgir, Mahasamund, Raigarh, Raipur, Kawardha and Rajnandgaon.

Introduction

Chhattisgarh is located in the central part of India between the latitudes of 17° 46'N - 24° 5' N and the longitudes of 80° 15' E - 84° 20' E. Its proximate position with the Tropic of Cancer has a major influence on its climate. It is landlocked by the states of Maharashtra and Madhya Pradesh on the west, Uttar Pradesh on the north, Jharkhand on the north-east, Orissa on the east, and Andhra Pradesh on the south Sprawled in an area of 135,194 sq km.

The climate of the state is dry sub humid type. The average rainfall of the state is around 1400 mm of which more than 90% is received during the south west monsoon (June-September). The onset of monsoon is around 10 June in southernmost tip of Bastar district and extends over the entire area by 25 June. The monsoon starts withdrawing from mid-September and by 25th September it withdraws from the entire state. Chhattisgarh is divided into three distinct Agro– climatic zones viz., Chhattisgarh plains, Bastar plateau and

Northern hills and it covers 50.52%, 28.62% and 20.86% geographic area, respectively. Similarly, topographically also the state varies a lot from high elevated areas of the state makes it to differ in their climatic elements also. There is a wide variability in climatic factors also on an average a total of 1200-1600 mm. annual rainfall is recorded in different parts of Chhattisgarh in about 64-91 rainy days. (About 90% of rainfall in C.G. concentrated to four monsoon months i.e. June-September). It has been recorded that 1000-1200 mm, 1200-1400 mm and 1400-1600 mm. Annual rainfall are received in Chhattisgarh plains, Bastar plateau and northern hills respectively. Similarly variations can be seen in temperature and humidity.

Agro-climatic zones can be defined as a land unit having a greater degree of commonality or homogeneity with respect to various conditions and resources such as climatic parameters important for agriculture and cropping pattern etc.

Food and agriculture Organization (FAO) of United Nations and International Institute of Applied System Analysis (IIASA) have developed a methodology for characterization of Agroclimatic and Agro-ecological zones. This method provides a wide range of different activities, which are often related yet quite different in scope and objectives like characterization relevant to agriculture production, identifying crop specific limitations, quantification of land productivity and population supporting capacity of land and multi criteria optimization.

Agro-ecological zoning is one of the most important basis for agricultural developmental planning because the survival and failure of particular land use of farming system in a given region heavily relizes on carefull assessment of agro-climatic resources.

In view of these studies on environmental characterization for sustainable crop production in Chhattisgarh is carried out mainly to capture the important agricultural features of the districts and to analyze the long term rainfall records in order to understand the pattern of rainfall and its spatial and temporal variability. In this study, attempts are also made to examine the climate fluctuations and shifts in different districts to understand the pattern on climate variability that May influence the existing cropping pattern in the districts. Based on the historical data of crop productivity of major important crops like Rice, Wheat and Maize. The relationship between rainfall quantum and productivity were also worked out.

Materials and Methods

Description of the study areas: The present study is for different districts of Chhattisgarh state.

Chhattisgarh state

Chhattisgarh is located in the central part of India, between the latitudes of 17° 46'N - 24° 5' N and the longitudes of 80° 15' E - 84° 20' E. Its proximate position with the Tropic of Cancer has a major influence on its climate. It is landlocked by the states of Maharashtra and Madhya Pradesh on the west, Uttar Pradesh on the north, Jharkhand on the north-east, Orissa on the east, and Andhra Pradesh on the south, sprawled in an area of 135,194 sq km., Chhattisgarh has substantial plain area in the middle.

The plains are enclosed by forested hills and plateaus. On the basis of climate and topography the state is divided into three agro-climatic zone. The Bastar plateau comprises of Bastar, Dantewada, Bijapur and Narayanpur districts and a part of Kanker (excluding Charama, Narharpur and Kanker blocks).

Nothern parts of the state comes under "Northern Hilly Region" comprises of Surguja, Koriya and Jashpur districts. Bilaspur, Raipur, Janjgir-Champa, Raigarh, Rajnandgaon, Kawardha, Durg, Mahasamund, Dhamtari, Korba and parts of Kanker come under "Plains of Chhattisgarh" (Fig. 1).

Methodology

The basic work regarding the agro-climatic characterization of Chhattisgarh includes the screening of different agro-climatic parameters data base of the state was prepared.

Database used

Various data sets of Chhatisgarh state were used during the study course. The basic data which were collected and using during the work, were: precipitation, wind speed, relative humidity, radiation intensity, temperature, sunshine hour, length of growing period, digital elevation map and crop data.

Productivity of crops

District wise long term data for productivity of rice, wheat and maize Chhattisgarh state were obtained from Department of Agricultural meteorology, IGKV, Raipur for the period 2000-2010.

For the computation of water balance of different districts of Chhattisgarh the rainfall data for those areas as well as, temperature, humidity, wind speed, radiation data of the related areas were also collected.

Delineation of climatic regimes

Using the interpolated spatial surface of different meteorological parameters like the precipitation and moisture the state was delineated into different regimes depending upon the parameters such:

Rainfall zones

For creating rainfall zones ARC-View 3.2 software was used. In this step the rainfall data of different parts of Chhattisgarh were compiled. Different rainfall maps like average annual rainfall, rainfall during pre-global warming(1901-1970) and post global warming (1971-2010) and rainfall at different probability levels (70% and 50%) of the state were prepared.

Length of growing period

The length of growing period as defined Cocheme and Francquine (1967) was considered where Humid period is the period when rainfall exceeds potential evapotranspiration (R>PET) and Moist period is the period when the rainfall is less than PET but is in excess of PET/2.

Computation of Potential Evapotranspiration (PET)

The meteorological parameters used for the computation of potential evapotranspiration for different Districts and for different year, worked out by using the (Penman-Monteith equation).

In the PET computation, the inputs were rainfall, maximum and minimum temperature, humidity, wind speed and sun shine hours and the outputs were radiation and PET.

The historical rainfall data of 18 Districts of Chhattisgarh for the period 1901-2010 and Districts wise long term yield data for the period 2000-2010 were analysed to find out the fluctuations that have occurred in these districts.

The spatial variations of the all meteorological parameters were generated using ARC-VIEW 3.2 GIS software and maps were prepared.

Results and Discussion

Rainfall

Average annual rainfall

The entire state has been divided into five major categories namely very high rainfall zone >1500 mm, high rainfall zone 1400-1500 mm, medium rainfall zone 1300-1400 mm, low rainfall zone 1200-1300 mm and very low rainfall zone <1200 mm. A map for average annual rainfall was prepared (Fig. 2).

The spatial distribution of annual rainfall shows that southern parts of Bastar, north parts of Surguja and some parts of Korba come under very high rainfall zone, while some parts of Bastar, Dhamtari, Raipur, Mahasamund, Janjgir, Raigarh, Korba, Koriya, Surguja, Jashpur and Dantewada come under high rainfall zone. Most parts of Dantewada, Narayanpur, Bijapur, Kanker, Dhamtari, Durg, Raipur, Mahasamund, Janjgir, Bilaspur, and Koriya receive medium rainfall. Most geographical area of Bilaspur, Raipur, Durg, Rajnandgaon, Kanker, and Dhamtari come under low rainfall zone. Some parts of Kawardha, Durg, Rajnandgaon and Bilaspur districts are under very low rainfall zone.

Pre global warming and post global warming periods

The entire data from 1901-2010 had been divided in two periods namely pre-global warming 1901-1970 and post-global warming 1971-2010. The data for the period 1901-1970 and 1971-2010 was analysed and on the basis of data prepared digitalized map for pre-global warming and post-global warming which shown in Figure 3 and 4 on the basis of pre-global warming map 1000-1200 mm rainfall observed in Kawardha district which come under low rainfall zone. Some parts of Koriya, Korba, Bilaspur, Janjgir, Raigarh, Mahasamund, Durg, Dhamtari, and Kanker districts come under medium rainfall zone 1200-1400 mm. Dantewada, Narayanpur, Bastar, Bijapur and Raigarh districts come under high rainfall zone 1400-1600 mm. Some parts of Bijapur, Jashpur and Raipur districts come under very high rainfall zone >1600 mm. On the basis of post-global warming map 800-1000 mm rainfall observed in Kawardha, Bilaspur, Rajnandgaon, Durg, Raipur, Dhamtari, Kanker, Korba district and some parts of Raigarh, Ambikapur and Janjgir districts 1200-1400 mm rainfall observed. In Dantewada, Bijapur, Narayanpur, Bastar, Koiya, Surguja districts and some parts of Raigarh, Jaspur and Bilaspur districts 1400-1600 mm rainfall observed. More than 1600 mm rainfall seen in Jashpur district.

Percent change in rainfall

When the rainfall was examined it was found that the rainfall was in decreasing trend in all the districts during the period 1901-2010. Impact of global warming on regional rainfall could be assessed only during the global warming period and hence analysis was carried out for pre and post global warming periods that is 1901-1970 and 1971-2010.

This analysis was carried out for 18 districts of Chhattisgarh. On the basis of average annual rainfall data and prepared digitalized map as shown in figure 4.

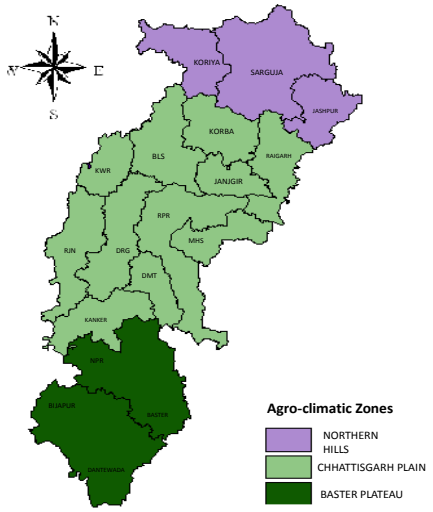
From the figure 4, it is clear that the annual rainfall during post- global warming period decreased by about 30 – 40% in Mahasamund area as compared to pre-global warming period. In southern Chhattisgarh (Bastar) and parts of northern Chhattisgarh the decrease of rainfall during post-global warming period ranged between 10-20%. In central part of Chhattisgarh state the decrease of rainfall ranged between 20 to 30 percent.

Table.1 Length of growing period in different districts of Chhattisgarh

	MOIST-1		Humid Period		MOIST-2	
Name of Districts	Date	Days	Date	Days	Date	Days
BASTAR	18May-1June	15	1 June-17 Oct	129	7 Oct-3 Nov	28
BIJAPUR	24 May-5 June	13	5 June- 5 Oct	122	5 Oct-30 Oct	26
BILASPUR	5 June-20 June	16	20 June-20 Oct	104	2 ocy-17 Oct	16
DANTEWADA	1 June-12 June	12	12 June-13 0ct	121	13 Oct-30 Oct	18
DHAMATARI	4June-24June	21	24 June-28 Sep	94	28 Sep-13 Oct	16
DURG	3June-18 June	16	18 June-1 0ct	105	1 Oct-18 Oct	18
JANJGIR	3 June-17 June	15	17 June-3 Oct	108	3 Oct-12 Oct	9
KANKER	31 May-13 June	14	13 June-1 Oct	110	1 Oct-17 Oct	17
KORBA	28 May-10June	14	10 June-2 Oct	116	2 Oct-13 Oct	11
KORIYA	1 June-15 June	15	15 June-4 Oct	111	4 Oct-13 Oct	10
MAHASAMUND	8 June-22 June	15	22 June-27 Sep	97	27Sep-12 Oct	16
NARAYANPUR	28 May-9 June	13	9 June-5 Oct	118	5 Oct-26 Oct	21
RAIGARH	28 May-16 June	13	16 June-2 Oct	108	2 Oct-11 Oct	10
RAIPUR	4 June-19 June	15	19 June-30 Sep	103	30 Sep-13 Oct	14
SURGUJA	26 May-10 June	16	10 June-3 Oct	115	3 Oct-14 Oct	11
KAWARDHA	3 June-26 June	23	26 June-25 Sep	91	25 Sep-11 Oct	17
RAJNANDGAON	5 June-19June	14	19 June-28 Sep	101	28 Sep-14 Oct	17

HUMID – R > PET
MOIST I & II - PET > P > PET/2

Fig.1 Agro-climatic zones of Chhattisgarh



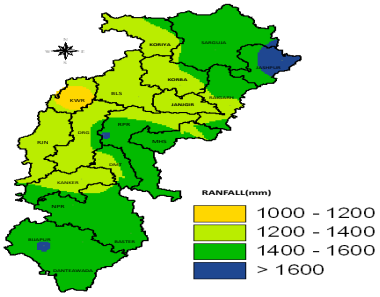


Fig.2 Average annual rainfall pattern during pre-global warming (1901-70) period in different districts of Chhattisgarh

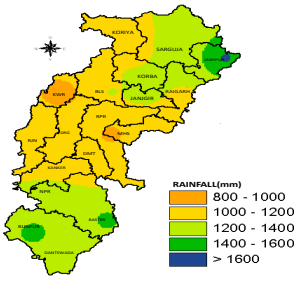


Fig.3 Average annual rainfall pattern during post-global warming period (1971-2010) in Chhattisgarh

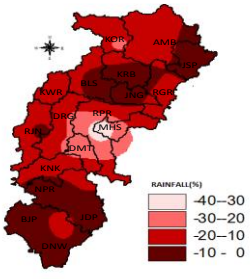


Fig.4 Percentage difference between pre (1901-70) & post (1971-2010) global warming rainfall period

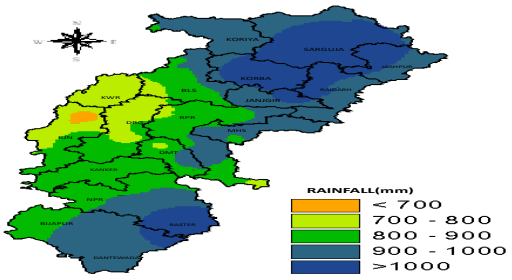


Fig.5 Average rainfall in 50% probability level in different districts of Chhattisgarh

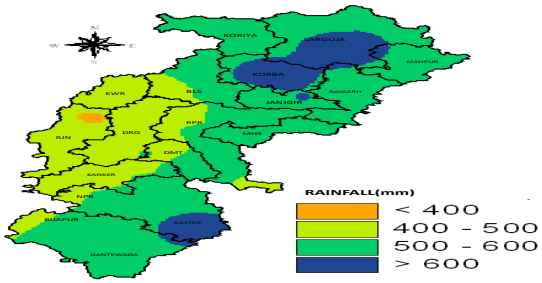


Fig.6 Average rainfall in 70% probability level in different districts of Chhattisgarh
These observations were based on 50% level rainfall probability.

Fig.7 LGP at Bastar, Bijapur, Dantewada and Narayanpur districts of Chhattisgarh

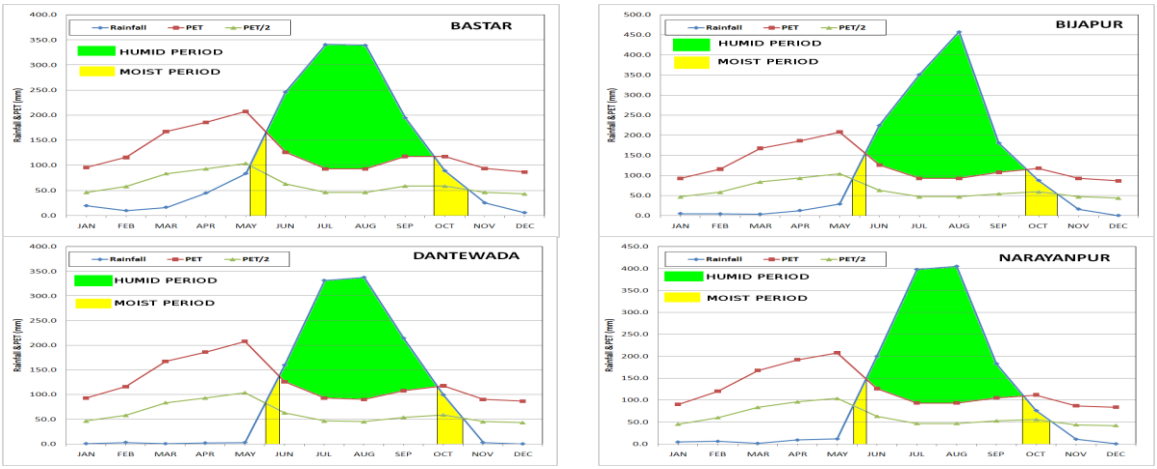


Fig.8 LGP at Sarguja, Janjgir, Koriya and Raigarh districts of Chhattisgarh

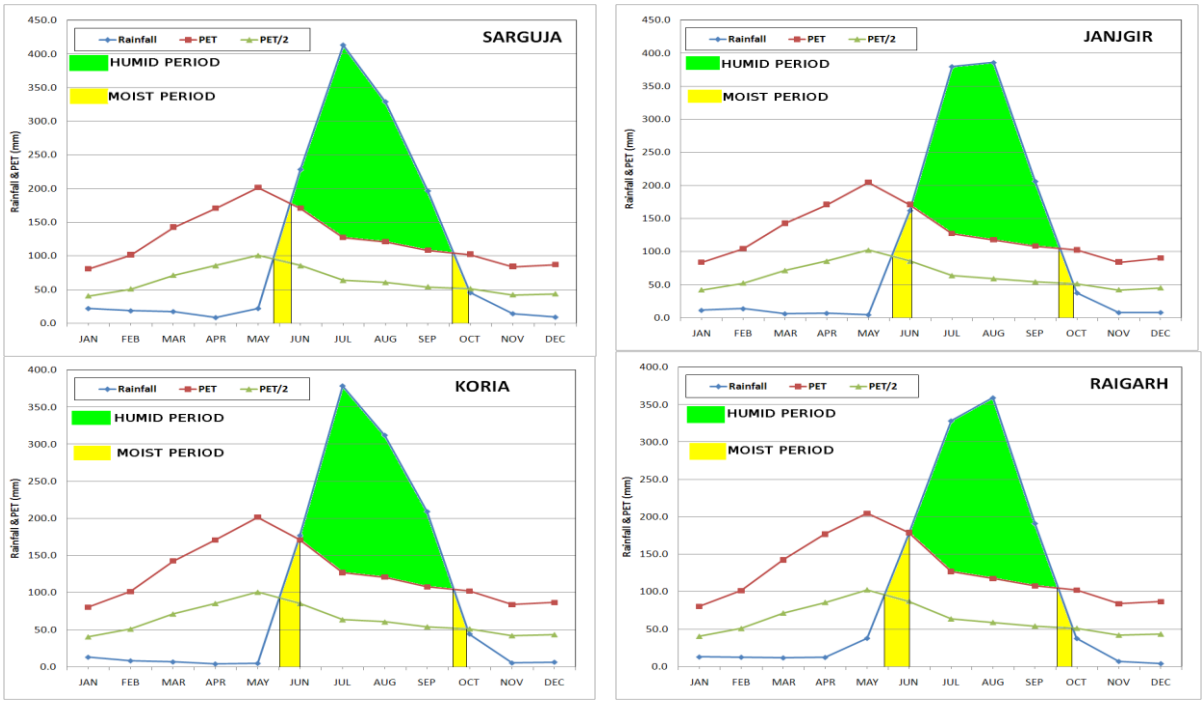


Fig.9 LGP at Raipur, Bilaspur, Dhamatari and Mahasamund districts of Chhattisgarh

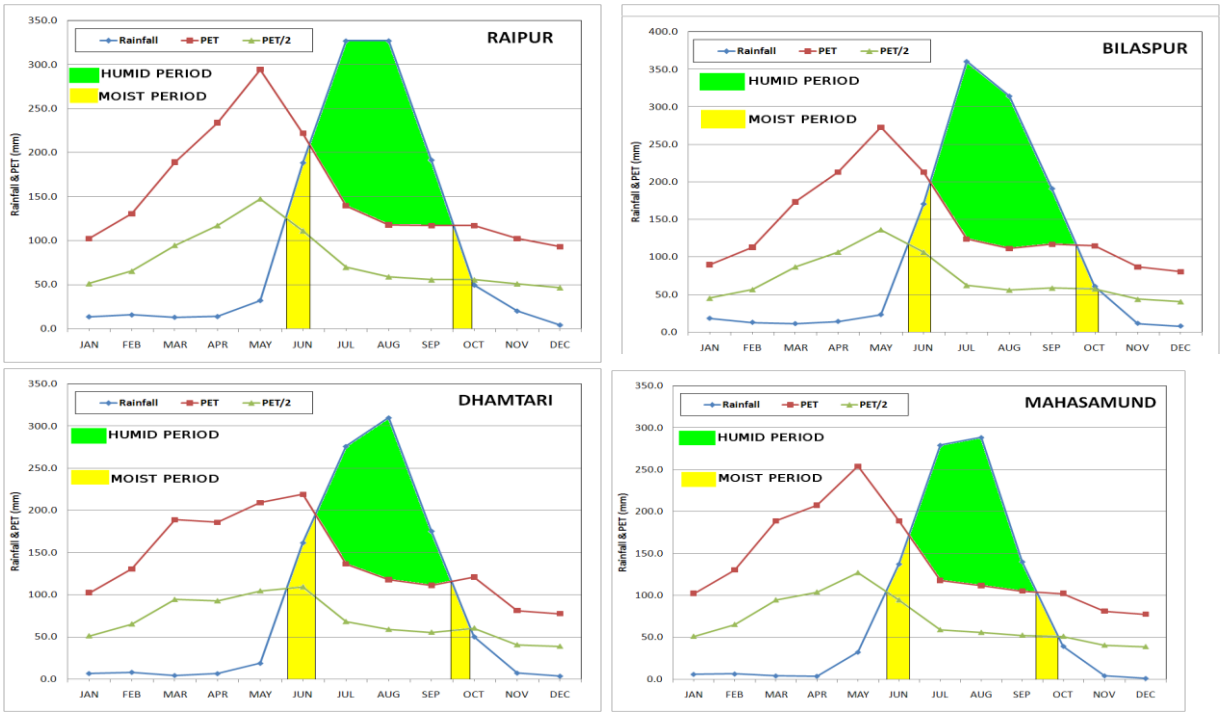


Fig.10 LGP at Rajnandgaon, Kawardha, Durg and Kanker district of Chhattisgarh

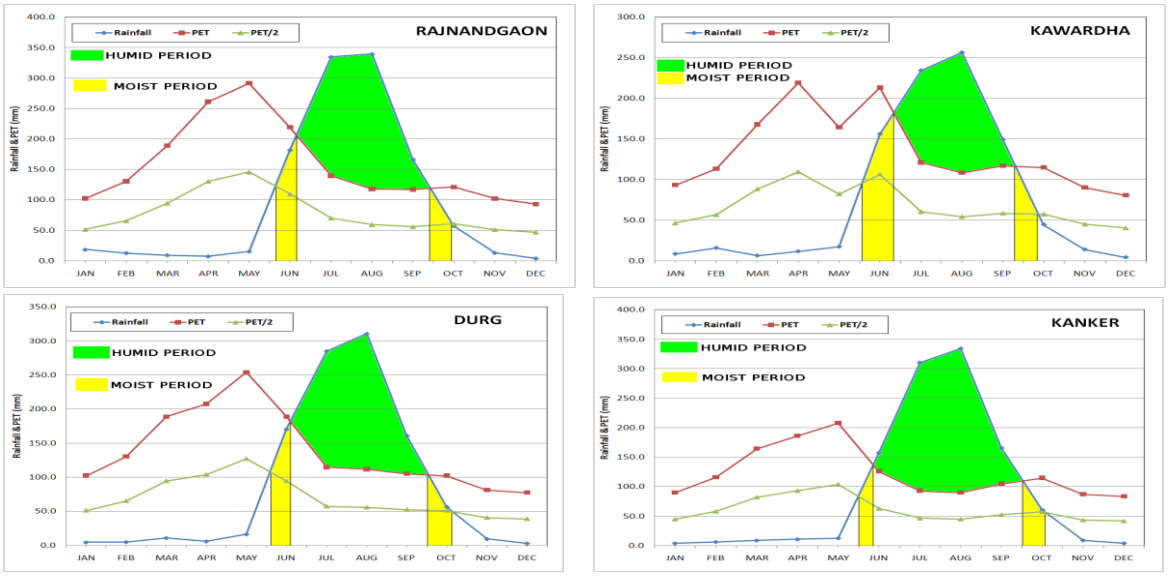


Fig.11 Length of growing period in korba district of Chhattisgarh

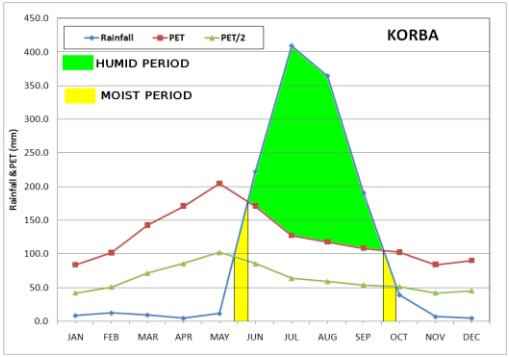
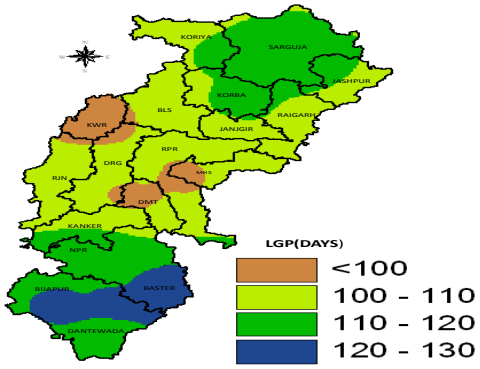


Fig.12 Length of humid period (r>pet) in different districts of Chhattisgarh



Earlier Choudhary and Sastri (1999) reported the decreasing trend of annual rainfall in Raipur, Durg, Bilaspur, Rajnandgaon and Raigarh districts. Later Sastri *et al.,* (2009) reported that the rainfall had decreased by about 35 % in Mahasamund district, which is similar to the present findings. Baghel and Sastri (1992) also reported the decreasing trend in annual rainfall in some pockets of Chhattisgarh.

Probability levels

Probability of rainfall at 50% and 70% levels was analysed. On the basis of the maps were prepared as sown in figure 5 and 6.

The spatial distribution of average rainfall in 50% probability level ranged between <700 - >1000 mm. On the basis of this map very low rainfall <700 mm rainfall was observed in some parts of Rajnandgaon. Low rainfall 700-800 mm was observed in Durg, Kawardha, Rajnandgaon and some parts of Bilaspur, Raipur & Dhamatari districts while medium rainfall 800-900 mm was observed in Bijapur, Narayanpur, Kanker, Raipur, Bilaspur and some parts of Koriya, Mahasamund and Rajnandgaon districts. High rainfall 900-1000 mm was observed in Bastar, Surguja, Jashpur, Korba, Raigarh or some parts of Janjgir and Dantewada district. These observations were based on 50% level rainfall probability.

The spatial distribution of average rainfall in 70% probability level ranged between <400 to >600 mm. On the basis of this map low rainfall zone was observed in some parts of Rajnandgaon. Medium rainfall zone was observed in some parts of Bilaspur, Raipur, Dhamtari, Narayanpur, Bijapur, Kanker, Durg, Rajnandgaon and Kawardha districts, while high rainfall zone was observed in most parts of Dantewada, Narayanpur, Bijapur, Bastar, Mahasamund, Raipur, Dhamatari, Raigarh, Jashpur, Koriya and Janjgir districts and some parts of Surguja and Korba districts. Similarly very high rainfall zone was observed in Bastar, Korba and Surguja districts. These observations were based on 70 % level rainfall probability.

Length of the growing periods

The moist period-I is useful for field preparation and sowing operation. The moist period start from 18th May in Bastar district and on an 8th June in Mahasamund district (Table 1). Similarly the moist period-I ends by 1st June in Bastar district and end by 26th June in Kawardha district. Thus the moist period in varies from 12 days in Dantewada to 23 days in Kawardha district. It is therefore observed that sowing operation starts early in Bastar district and starts very late in Mahasamund district.

Regarding humid period, which is very crusial for rainfed Rice cultivation, starts from 1st June in Bastar district and on 26th June in Kawardha district. Similarly the humid period ends by 17th October in Bastar district and it ends by 25th September in Kawardha district. Thus the humid period duration varies from 129 days in Bastar district to 91 days in Kawardha district.

Similarly the moist II period, which is useful for crop maturity and harvesting, starts from 25th September in Kawardha district and from 13th October in Dantewada district. The moist II period ends by 11th October in Kawardha and Raigarh districts and its ends by 3rd November in Bastar distric. Thus the moist II period varies from 10 days in Raigarh district to 28 days in Bastar district. Thus, the length of growing period is 172 days in Bastar district and 136 days in Koriya district. The length of growing period is highest in southern parts of Chhattisgarh while it is lowest in northern parts of Chhattisgarh. This is because the monsoon starts earlier in Bastar

district and withdrawn earlier in the northern parts of Chhattisgarh. The same trends are graphically depicted in figure 12. The graphical representation of computation of moist period I, humid period and moist period II are also sown in figure 7 to 11.

The rainfall was examined it was found that the rainfall was in decreasing trend in all the districts during the period 1901-2010. Impact of global warming on regional rainfall could be assessed only during the global warming period and hence analysis was carried out for pre and post global warming periods that is 1901-1970 and 1971-2010. This analysis was carried out for 18 districts of Chhattisgarh. The annual rainfall during post- global warming period decreased by about 30–40% in Mahasamund area as compared to pre-global warming period. In southern Chhattisgarh (Bastar) and parts of northern Chhattisgarh the decrease of rainfall during post- global warming period ranged between 10-20%. In central part of Chhattisgarh state the decrease of rainfall ranged between 20 to 30 percent. Again, the rainfall pattern in different districts was analysed in different probability levels 50% and 70%. The spatial distribution of average rainfall in 50% probability level ranged between <700 to >1000 mm. and average rainfall in 70% probability level ranged between <400 - >600mm. Regarding humid period which is very crucial for rainfed rice cultivation starts from 1st June in Bastar district and on 26th June in Kawardha district. Similarly the humid period ends by 17th October in Bastar district and it ends by 25th September in Kawardha district, thus the humid period duration varies from 129 days in Bastar district to 91 days in Kawardha district.

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