CHAPTER - II

REVIEW OF LITERATURE

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2.1. Introduction:

This chapter reviews the methodology,conclusions and limitations of the studies undertaken in the past on the behaviour of precipitation in our country and abroad .

The past studies are classified into five categories according to methodologies adopted by the respective objectives.This sequence of methodology also broadly reflects the chronological order in which this dissertation has been undertaken.

2.2 Variations of precipitation :

Walker (1914) in a study presented a procedure for classifying the years of deficit rainfall in three categories i.e. years with rainfall deficiency between 30 to 45 percent,45 to 60 percent and over 60 percent of the mean annual rainfall and called them years of "Large","Serious" and "Disastrous" deficiency.

Walker (1919) used the seasonal rainfall data during the period 1841 to 1908 in his study. However,he had some doubt about the degree of accuracy of the data. Drought concept was applied, perhaps, for the first time to agriculture by Ramdas (1967) in his study in 1950, where he defined drought to have occurred if the weekly rainfall was less than double the mean deviation. He identified 1877, 1899 and 1913 as years of outstanding agricultural drought while in 1920 the drought was only partial, affecting North, West and Central parts of India.

Mallik (1958) examined the occurrence of droughts in Bihar and Uttar Prades. He used the definition of drought which occurred when the actual rainfall during a week was less than or equal to half the normal rainfall.

Dhar and Changrancy (1966) attempted to study the meteorological situations associated with floods in Assam during the monsoon months. It was observed that the floods and the associated meteorological conditions were responsible for some spells of heavy rainfall in the region.

Sarkar (1979) studied the drought in India and their predictability. He mentioned the three facets of drought. These were drought in meteorology,drought in hydrology,and drought in agriculture. He tabulated areas which received less than 75 percent of the normal rain during the monsoon season. The years when the affected area exceeded 25 percent of the arable land were termed as drought years. From the table it was observed that the worst drought years, in terms of rainfall were 1877,1891,1901,1904 and 1972 during the study period in the meteorological region of Sub-Himalayan West Bengal.It was further found that the droughts on account of rainfall,were very rare in Gangetic West Bengal but it might occurr once in the period of 6-8 years in Sub-Himalayan West Bengal.

Chowdhury and Abhyankar (1984) attempted to compile and collect drought climatology of India. They used the seasonal rainfall deficiency of more than 25 percent for identifying meteorological drought over various sub-divisions of India.

It was also observed that the occurrence of good and bad monsoons was a random phenomenon though therewas weak tendency for a good monsoon year to recur in the following year. They observed that the meteorological drought might occur once in six to eight years in the region of Sub-Himalayan West Bengal.It was also revealed that using the power spectral analysis, none of the peaks was found significant at 95 percent level. However,a peak of 2.8 years cycle was found to be significant at 90 percent level. This, possibly, could be associated with a quasi-biennial oscillation.

Mooley *tl(1984) studied the droughts which affected the peninsular India during the period 1861 to 1980. They used a criterion for identification of well-marked drought. The criterion was expressed as an index of standard variate. It was observed from the study that Cox's test for randomization was applied to test the existence of trend on the time interval between the successive occurrences of well-marked droughts. The result of the test confirmed the randomness of the occurrence of well-marked droughts over the peninsula. They also concluded that the more frequent trough position over the foot-Himalayas during drought years were seen to be associated with large scale drought over peninsula.*

Ganesan and Rao (1986) in a study attempted to analyze the climatological conditions and their local difference. They analyzed the rainfall characteristics over a small area in Bangalore. Bangalore City centre and Bangalore Air-Port (within a

distance of 10 K.M.) were used for the study. It was revealed that the amount of rainfall in the city was in general larger except in post monsoon season than that in the Air-Port area. They also concluded that even within a limited area the rainfall varied considerably.

Elizabeth *tI.(1988) examined the changing rainfall patterns in Western Sudan. Particular attention had to be paid to the period since 1965 when annual rainfall total began to show a marked decline. It was observed from the study that the 20 years period (from 1965 - 85) was a period of progressive deterioration in relative rainfall.*

Gragam Farmer (1988) examined the rainfall anomaly for the short rains on the Kenyan coast during the period 1901 to 1984. It was revealed that there was a notable difference in the variability of rainfall series for the two sub-periods,1901-42 and 1943-84. A one-tailed variance ratio,F-test was performed for seasonal rainfall series and he concluded that the rainfall series of sub-period 1943 - 84 had significantly larger variance than the sub-period 1901-42But the interesting feature was that if the rainfall of 1967 was removed, then the two sub-periods might be considered homogeneous. Following on, from F-test,the means of the two sub-periods were tested by Berhrens-Fisher test. None of the series tested showed a significant difference between the means for two time periods.

Chowdhury t I(1989) attempted to examine the distribution of time intervals between the successive droughts.The

droughts in meteorology defined by the Drought Index of rainfall which was expressed as a standard variate. The index was divided into two equal parts and student's t-test was applied to ensure the homogeneity of the observations. They observed that the Drought Index series was homogeneous.

They also examined the intervals between the successive drought years which were very important in drought incidence. It was revealed from the study that the frequency distribution of time intervals between the occurrence of successive droughts followed the Poisson distribution. In the study,they observed that the largest time interval of droughts among the independent time intervals was not statistically significant.

They also observed that Drought Indices did not follow the normal distribution. The nature of distribution of the series was found to be positively skewed leptokurtic.

Prasad and Lal (1989) studied the long term variations of the annual and seasonal rainfalls at Jalpaiguri in North Bengal. The study of the annual and seasonal (June to September) rainfall variations for the period 1901-80 indicated that the highest annual rainfall (4546 mm) and seasonal rainfall (3997 mm) occurred in 1938 while the lowest annual rainfall of 1884 mm and seasonal rainfall of 1676 mm occurred in 1978.

It was also found that long term means of annual and seasonal rainfalls were 3276 mm and 2640 mm respectively for the eighty years rainfall series. The annual and seasonal coefficients

of variations were 16.1 percent and 18.2 percent respectively. It was also observed that the 30 years mean annual and seasonal rainfalls were highest for the period 1916-45. There was a steep rise in the mean annual and seasonal rainfall during this period in comparison to the mean rainfall of study period which decreased there after continuously till 1980.

Lakshmanaswamy and Jindal (1990) attempted to study the variability of area weighted annual and monsoon rainfall for the 35 meteorological sub-divisions of India for the period from 1901 to 1988 with a view to finding any increase or decrease of rainfall over India. It was revealed from the study that the peak annual rainfall occurred in 1917 followed by another peak in 1956. The least rainfall occurred in 1972. The entire period was divided into three sub-periods ,*iz. 1901-30,1931-60 and 1961-88. It was found that the area weighted average rainfall of the sub-period 1901-30 was greater than those of the other two sub-periodswhile the standard deviation of the sub-period 1961 8 was greater than that of the other two sub-periods in the meteorological region of Sub-Himalayan West Bengal and Sikkim. It was also observed from the analysis of the area weighted monsoon and annual rainfall during study period over India that there was a steady increase of rainfall in the period 1901-50 and gradual fall of rainfall from 1950.*

Mukhopadhyay (1992a) studied the long term variation of annual rainfall in Coochbehar district. The time series were made from the average of the annual rainfalls of two stations. He

identified the flood and drought years by an index. It was observed from the study that the years 1980 and 1921 were the lowest and the highest rainfall years in the study period. F-test and t-test were applied to establish the homogeneity of the time series. The tests were applied considering the two sub-periods. It is observed that the frequency distribution of the time intervals between the successive drought years was found to follow the Poisson distribution whereas the same for flood years,the Mixture of Poisson's distribution.

Mukhopadhyay (1992b) attempted to determine the probability distribution function of inter-arrival times of successive dry and wet years of two stations in Cooch Behar district separately . It is observed from the study that no significant trend for the occurrence of successive wet and dry years could be detected in the series of the two stations. The frequency distribution of the inter-arrival times for the dry and wet years could be considered to follow the negative binomial distribution. It was also observed that the wet sequence as well as the dry sequence for two places having negative binomial distribution could be considered as drawn from the same negative binomial population.

2.3. Pattern of rainfall.

Sundararaj and Ramchandra (1973) in a study determined the Markov-based geometric model for wet spells and dry spells,and

the lengths of weather cycle. It was revealed that the model was best fitted to the wet spells but the dry spells could not be considered to fit that model to the experimental observations. In the study the dry-wet cycles and wet-dry cycles were also computed and the behaviour of these cycles did not appear to confirm the Markov dependant geometric model.

Agnihotri et al. (1984)attempted to predict the behaviour of dry spells and wet spells as well as weather cycles in Chandigarh. The study period was 23 years of daily rainfall. The Markov chain model was fitted to the daily rainfall data. The parameters of two-state Markov chain model were used to fit the distribution of spells as well as weather cycles. It was also observed that the observed frequencies of weather cycles of various durations and dry/wet spells were found to follow the geometric distribution.

Chowdhury and Abhyankar (1984) briefly analyzed the seasonal rainfall by Markov chain method. They used the two-state Markov chain model. They studied the drought spells and non-drought spells for the various meteorological sub-divisions in India and also computed the climatic cycle of the regions. They came to the conclusion that non-drought cycles did not conform to the geometric model and the length of climatic cycle could not have much significance.

Aneja and Sribastava (1986) derived a model for occurrence of the daily rainfall under the assumption that successive day's rainfall did not occur independently but were

inter-dependent. The model was represented by two-state Markov chain. They also computed the average length of dry spells and wet pells and expected length of weather cycle.

2.4. Measure of uncertainty

Basu (1988) in a study evaluated the nature of rainfall with the help of information theory. It was revealed that the weighted entropy values over the transition probabilities during the beginning and closing months of monsoon at Maithon were less in comparison with the other monsoon months. The weighted entropy of the active monsoon months were higher. It was also revealed that the difference in uncertainty between the Markovian model and the random model were small,almost negligible. He observed that during the monsoon months the degree of uncertainty of heavy rainfall and very heavy rainfall were more than the light,moderate and non-rainy rainfalls. He used the redundancy test to determine the favourableness and unfavourableness of Markovian system.

Mukhopadhyay (1992c) attempted to examine the Markov dependence by entropy considering the three states of outcome. There normal, bad and good years of rainfall are accordingly defined. Redundancy test was applied to test the stochastic dependence on the one-step 3 x 3 Markov chain model. But it was observed from the study that the redundancy test could not favour the system of Markovian dependence. So,he came to the conclusion that the occurrence of individual state might not depend on the previous state of occurrence. Then he concluded that the

occurrence of annual rainfall was a random phenomenon.

2.5. Periodicity in rainfall.

Rao et al.(1973)ina study attempted to examine the periodicity of droughts in India for the period of sixty years. The power spectrum method was used to identify the periodicity. It was revealed from the study that there was a peak of the period 4.6 years which was significant at 95 percent level. And there was also a peak of the period 3.5 years which was significant at 90 percent level. The study was conducted for the various meteorological regions. The above result was observed for the region of Gangetic West Bengal. The same result was observed in meteorological region of Bihar plateau. They also concluded that the overall picture did not encourage one to look with confidence for the periodicity of droughts in India.

Pathack (1982) in a study investigated the periodicity of rainfall observations over the Island of Mauritius. Spectral analysis was used to determine the periodicity of the climatic time series for the various stations of that island.He observed that the climatic series contained the fluctuation corresponding to period of the order to record length. It was also observed in the study that the presence of periodicity of 10-13 years might be associated with the solar cycles,and some other less pronounced peaks were noted in the period ranges of slightly over two years, 3-4 years and 16-20 years.

Ogallo (1984) investigated to study the existence of the periodic or quasi-periodic fluctuations in the seasonal rainfall

over East Africa. He used the Spearman rank correlation test to examine the trend of the time series. The spectral analysis technique was used to detect the periodicity of the seasonal rainfall on the yearly basis. It was observed from the yearly time series that no significant trend was detected at 5 percent level in most of the time series. The result of the spectral analysis indicated the dominance of short period fluctuations. The most prominent spectral peaks were centered around 2-3 years and 5-6 years. This analysis also indicated that a weak peak of a period 10-11 years appeared in many time series.

Bhalme *tl(1984) attempted to studytheperiodicity of Drought Area Index in India. Power spectrum analysis was applied to detect the significant periodicities of droughts in monsoon season in India. It was observed from the analysis that the power spectrum of the Drought Area Index series showed quasi periodicity of about 2.5 to 3.5 years. The study also suggested that the principal cause of recurrence of large scale droughts over India, with most common period in the range of 3-6 years periodicity might possibly be the influence of the southern oscillation of monsoon.*

Ogallo (1986) examined the hidden periodicity of the regional annual rainfall in East Africa. Spectral analysis was used to detect the dominant spectral peaks. It was observed from the study that the dominant spectral peaks were centered around 2.2-2.8, 3-3.7, 5-6 years and 10-13 years. It was also revealed

that similar temporal characteristics were observed in the annual rainfall records of the individual stations within these regions.

Currie and O'Brien (1988) examined the 136 yearly total precipitation record in the North Eastern United States of America. The record length distribution of 136 series prior to maximum entropy spectrum analysis were used mostly between 80 to 89 length. In terms of spectra the evidence was found for strong band limited 19 years luni-solar signal and a weaker term of period 10-11 years on the yearly total precipitation on record. They established that the variations in climate data did not show the 'pseudo periodic' behaviour.

Olapido (1989) examined the spectra in the derived growing season Bhalme-Mooley drought index series for the Interior Plains of North America. He used the non-harmonic spectral technique for estimating spectra for frequencies in order to detect periodic and quasi-periodic components in the rainfall time series. It was further examined for evidence of periodic variation which had similar frequency of occurrence in adjacent stations. It was also found that the quasi-biennial,quasi-triennial and quasi-five year oscillations were concentrated in almost all the stations of the study region. It was further observed that the periodicities greater than the quasi-five year frequency bands was not significant in terms of the number of stations.

Fong Chao (1990) presented an interesting study on the use of maximum entropy spectrum in harmonic analysis of time series. This study critically examined the amplitude of the maximum spectral peak. It was observed that the maximum entropy power spectrum contained no information about the amplitude of the spectral peak . He suggested that the maximum entropy power spectrum could be used to estimate the complex frequency, but not the complex amplitude.

Currie and O 'Brien (1990) in a study presented the maximum entropy spectrum analysis of 120 yearly precipitation records in the corn belt region of United States of America. It was observed from the analysis that the 18.6 years luni-solar terms in 109 records and the 10-11 year solar cycle signal in terms of 100 records were found in the region.

Mitra *t I (1991) analyzed the rainfall data in North-West India,the Plains in Uttar Pradesh and North Central India. They applied the method of maximum entropy spectral analysis for the period of 50 years rainfall data. The result of the analysis indicated that 91 out of 115 rain-gauge stations appeared to respond to 18.6 years luni-solar signal and the statistical average value of the signal periodicity in rainfall proved to be 18.3 ± 1.6 years. The result also observed the existence of a 10-11 year solar cycle in 77 out of 115 rain gauge stations in the region.*

It was revealed that the presence of an 8-9 year component periodicity indicated in almost every stations in the experimental region.

2.6. Relation between rainfall and rice yield.

Jain tl (1980) in a study attempted to understand the effects of climatic variables on rice yield and to forecast the rice yield using the climatic variables. They observed that the maximum temperature,relative humidity and sunshine had small beneficial effects in general through out the crop season. But effect of rainfall was in general beneficial through out the crop season.

Agarwal tl (1983) in a study examined the joint effect of climatic variables on rice yield. They found that the rise of temperature and humidity had small beneficial effects,in general,throughout the crop season. But the increase in rainfall was beneficial for the yield of rice except during the ripening stage of the crop.

Agarwal tl (1986) attempted to study the individual effects of weather factors on rice yield. They concluded that above average rainfall had beneficial effect throughout the growth phase and detrimental effect during the ripening phase of the rice crop in general. The effects of rainfall and increase in the number of rainy days were fluctuating up to vegetable stage but beneficial during reproductive and detrimental during ripening stage of the crop.

Mongia and Gajja (1986) examined the influence of rainfall on productivity performance of paddy crop in Andaman & Nikobor Islands. They introduced mainly two independent variables

of which one (X_1) was normal rainfall when rainfall was above normal otherwise actual rainfall and other (X_2) was the difference between actual and normal rainfall in case of rainfall above normal otherwise zero. The estimated regression co-efficient revealed that it was positive and significant at various levels i.e.1 percent level5 *percent level in all the four regions under study. It was further revealed that impact of seasonal deviation of the rainfall on the yield of paddy was estimated positive and highly significant in the region.*

Mohendra dev (1987) examined that growth performance took explicit account of the impact of rainfall on crop production. It was revealed from the study that the variation of rainfall alone could help explain in a substantial measure the variation of crop production. A comparison of unadjusted and adjusted rainfall growth rate revealed that weather adjusted growth rate was higher in the states like West Bengal etc.

Prasad and Dudhane (1989) in a study investigated the relationship between rainfall and rice yield in the region of Gangetic West Bengal. The impact of agricultural technology on rice yield was analyzed also by modified model using technological trend as an independent variable. A systematic methodology was adopted to develop the model to forecast the rice yield in that region from the direct and derived parameters of rainfall data. It was revealed that all independent variables emerged significant functional relationship with the rice yield of that region. It was also observed that the satisfactory performance of the suggested model could forecast, successfully,the rice yield from the derived parameters of rainfall and agricultural technology.