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Spatial and Temporal Variability of Summer Monsoon Rainfall from the Period of 1971 to 2011 over Maharashtra State, India

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Abstract

This paper presents the results of an analysis of the decadal rainfall and rainy days from the period of 1971 to 2011 over Maharashtra, a state in India, during the summer monsoon season. Long term rainfall and rainy days data collected (1971–2011) over 35 districts of the Maharashtra state to understand the spatio-temporal variability. The long term analysis point of view decadal average rainfall and rainy days has been calculated. Variation of decadal rainfall and rainy days for the four monsoon months is analyzed. This study will be useful for agricultural planning, water resources management and other societal applications over different districts of the Maharashtra state.

Keywords: *Spatio-temporal, variability, rainfall, rainy days, summer monsoon, Maharashtra*

INTRODUCTION

The state of Maharashtra is located on the western side of the Indian peninsula between latitude 15°35’ to 22°02’ N and longitude 72°36’ E to 80°54’ E. Maharashtra, a state in India, has a monsoon climate. It receives major part of the annual rainfall during the summer (southwest) monsoon season (SMS), viz. June to September. Monsoons are characterized by phases such as the onset and advance (June), peak (July and August) and back away (September). By mid of June, most parts of the state comes under the influence of a monsoon. July is the wettest month and there is also substantial rainfall during August. The monsoon weakens during the month of September, and hence the rainfall decreases. Climatologically, Maharashtra

state has divided in to four subdivisions viz. (1) Konkan (2) Central Maharashtra (3) Marathwada and (4) Vidharbha (Table 1). The Konkan subdivision lies on the windward side of the Ghats and the other subdivisions lie on the leeward side. The interior portion of the state is semi arid. Large variations in rainfall in different regions of the state result in a wide range of climatic conditions.

Table 1: *Climatological Subdivisions of Maharashtra State.*

Nomenclature	**Districts**
Konkan	Thane, Raigadh, Ratnagiri, Sindhudurg and Mumbai
Central Maharashtra	Dhule, Nandurbar, Nashik, Jalgaon, Ahmadnagar, Pune, Satara, Sangli, Kolhapur, Solapur and Osmanabad
Marathwada	Aurangabad, Beed, Latur, Jalna, Parbhani, Hingoli and Nanded
Vidharbha	Bhandara, Gondiya, Gadchiroli, Nagpur, Chandrapur, Wardha, Amravati, Yawatmal, Akola, Washim and Buldhana

Maharashtra occupies the western and central part of the country and has a long coastline stretching nearly 720 kilometres along the Arabian Sea. The Sahyadri mountain range provides a physical backbone to the state on the West, while the Satpuda hills along the North and Bhamragad–Chiroli–Gaikhuri ranges on the East serve as its natural borders. The state has five distinct physiographic regions, namely Deccan Plateau, Central Highlands, Eastern Chhotanagpur Plateau, Western Ghats and Coastal Plains. Maharashtra state having 35 districts, for administrative purposes they are divided into six revenue division viz. Konkan, Pune, Nasik, Aurangabad, Amravati and Nagpur. Deficient rainfall in some parts of Maharashtra like Western Maharashtra and Marathwada regions, last few years in sequence has severely affected agriculture in the region, which is the main source of livelihood and employment in the region. Any change in rainfall patterns poses a serious threat to agriculture, and therefore, to the country's economy and food security. Agriculture is adversely affected not only by an increase or decrease in the overall amount of rainfall, but also by shifts in the timing of the rainfall.

Beer (1991) noted that there are numerous definitions of drought, none completely satisfactory [1–3]. The reason is that the term drought is used with at least three different meanings. A meteorological drought (normally measured in terms of rainfall decline) occurs when the rainfall,

over a period of time, is substantially below normal levels. An agricultural drought (measured, for example, by the moisture deficit in the top 200 mm of soil) occurs when the soil moisture, over a period of time, is substantially below normal levels. A hydrological drought (measured, for example, by water availability) occurs when drinking water impoundments, over a period of time, are substantially below normal levels. The summer monsoon is the main rainy season in Maharashtra which accounts for about 95 percent of the annual rainfall during summer monsoon season. Agriculture is the support to economy in Maharashtra and the country largely depends on the rainfall from the summer monsoon [4–7]. The life of all inhabitants of Maharashtra directly and indirectly depends on the summer monsoon rainfall. The fertility of farmland as well as the stability of land resources depends upon the activities of the summer monsoon. Most of development activities especially those of physical infrastructure like roads, flood control, irrigation canals and so on are dictated by the monsoon and most of natural disasters are also associated with the behaviour of the monsoon.

Success of farming in Maharashtra is heavily dependent on the timely arrival of monsoon rainfall and its distribution. Therefore, the present study focuses on the spatial and temporal variability and trends of summer monsoon rainfall in more details over Maharashtra by using data sets covering the period 1971 to 2011. Various statistics has been carried out over 35 districts of four meteorological subdivisions of the Maharashtra state to understand the spatio-temporal variability of rainfall. Variation of annual mean rainfall for the four monsoon months and a season as whole is analyzed for different rainfall statistics such as mean rainfall, rainfall variability and rainy days [8, 9]. The study also considers the investigation of the relationship of the monsoon rainfall variability. The results will improve the general understanding of the summer monsoon rainfall variability and trends over Maharashtra. First time Walker (1910) has analyzed the monsoon rainfall for the period 1841 to 1908 and reported that no trend would be observed. Later many authors reported that no significant trend in the all India monsoon annual rainfall series is to be seen [10–14, 15–20]. Agarwal (1952) reported steady increases in the annual rainfall series in between the years 1908 to 1940, but no uniform trend in between 1872 to 1947 [1].

Pramanik and Jagannathan (1953) noted increasing trends in annual rainfall over southwest coast and northwest India, a decreasing trend in north Andhra and Orissa and no trend in other areas from 60 to 100 years data before 1950 [13]. By studying the 100 to 120 years monsoon rainfall data up to 1967, Koteswaram and Alvi (1969) observed a decreasing trend towards the end of the 19th century and significant rising trend in the present century [7]. Prathasarathy and Dhar (1974) noted a positive trend over central India, the adjoining part of Peninsula, Punjab, Himachal Pradesh and north Assam and a negative trend over south Assam for the period 1901 to 1960 [11]. According to Mukherjee and Singh (1978), there was an increase in the rainfall period 1910 to 1955 and then a decrease till 1974 over west coast and no significant trend over Trivandrum during 1890 to 1972 [9]. Chowdhary and Abhyankar (1979) reported no trend in monsoon rainfall in the period 1895–1970 in Gujarat [4].

Krishnan *et al.* (1984) reported a higher mean rainfall over coastal and north interior Karnataka during 1951 to 1975 as compared to the period 1901 to 1950 and a decrease in many regions of Tamilnadu [8]. Alvi and Koteswaram (1985) observed increasing trend in the rainfall over the west coast stations north of Trivandrum and over Delhi from the beginning of the present century and a minor decreasing trend at Ahmadabad, Nagpur and Gaya [2]. Soman *et al.* (1988) noted a significant negative trend in the annual as well as monsoon rainfall over most of the station of Kerala for the period 1901 to 1980 [16]. Rupakumar *et al.* (1992) reported significant decreasing trends in the monsoon rainfall for 1871 to 1984 over northeast and northwest peninsula and northeast India and increasing trend over west coast, central peninsula and northwest India [15]. By analyzing 1871 to 1988 monsoon rainfall data, Subbaramayya and Naidu (1992), (1995) reported the decreasing trend in rainfall during late 19th century and again in the 1960s and variability of monsoon period [18, 19].

METHODOLOGY

The present study deals with the spatial and temporal variations of annual and decadal rainfall and rainy days over Maharashtra during the summer (southwest) monsoon season only, as most of the annual rainfall over this region is received during this period. The records of annual rainfall (mm) for summer monsoon season for the 40 year period (1971 to 2011) obtained from the Department of

Drinking Water Supply, Government of India [5]. Rainy days obtained from Indian Meteorological Department, Government of India [6]. The obtained data has been converted into decadal average rainfall and rainy days [21].

RESULTS AND DISCUSSIONS

In presented work detail analysis of summer monsoon rainfall and rainy day of over Maharashtra state for the 40 years period from 1971 to 2011. Central Maharashtra region is one of the uneven rainfall areas in state, rainfall data shows that the increasing trends from 1981 to 1990 and 2001 to 2010 except 1971 to 1980 (Figure 1). Rainy days data shows that the all districts of Central Maharashtra region decreasing trend from 1971 to 1980 and 2001 to 2010 (Figure 2). Kolhapur, Pune, Satara and Nashik district receives heavy rainfall compared to the other districts in Central Maharashtra region. Decadal rainfall and rainy day variability in Marathwada region shows that 1981 to 1990 and 1991 to 2000 receives better rainfall however, 1971 to 1980 and 2001 to 2011 decade receives scanty rainfall (Figure 3). Last 40 year rainfall data shows that the Marathwada region decreasing trends except Nanded, Parbhani and Hingoli districts. Rainy days data shows that the all districts in Marathwada region decreasing trends except 1981 to 1990 (Figure 4).

Konkan region is one of the heavy rainfall areas in state, rainfall data shows that the increasing trends from 1981 to 1990 and 2001 to 2010 except 1971 to 1980 (Figure 5). Rainy days data shows that the all districts of Konkan region decreasing trend from 1971 to 1980 to 2001 to 2010 (Figure 6). Southern part of the Konkan is heavy rainfall compared to northern part except Mumbai urban area. Decadal rainfall and rainy day variability of Vidharbha region 1981 to 1990 and 1991 to 2000 receives better rainfall and least rainfall during 2001 to 2011 and 1971 to 1980 over Vidharbha region (Figure 7). Over Vidharbha does not receive good rainfall except eastern Vidharbha. Akola, Buldhana and Washim districts receives scanty rainfall therefore, this districts suffering water crisis. Rainy days data shows that increasing trend of rainfall from 1971 to 2000 and reverse trend for the last decade for Akola (Figure 8).

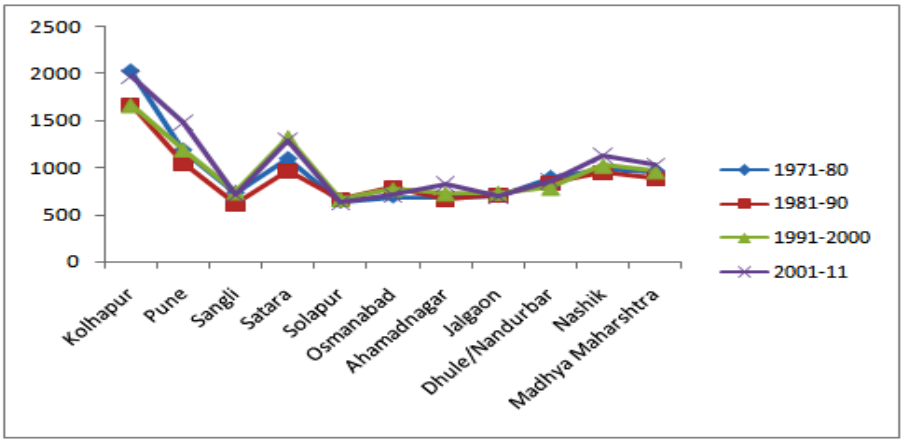

Fig. 1: *Decadal Average Rainfall (mm) in Central Maharashtra Region.*

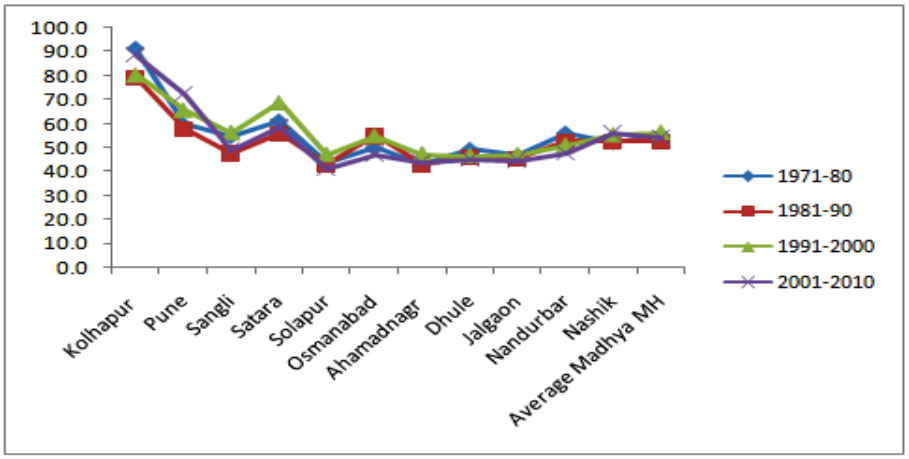

Fig. 2: *Decadal Average Rainy Days in Central Maharashtra Region.*

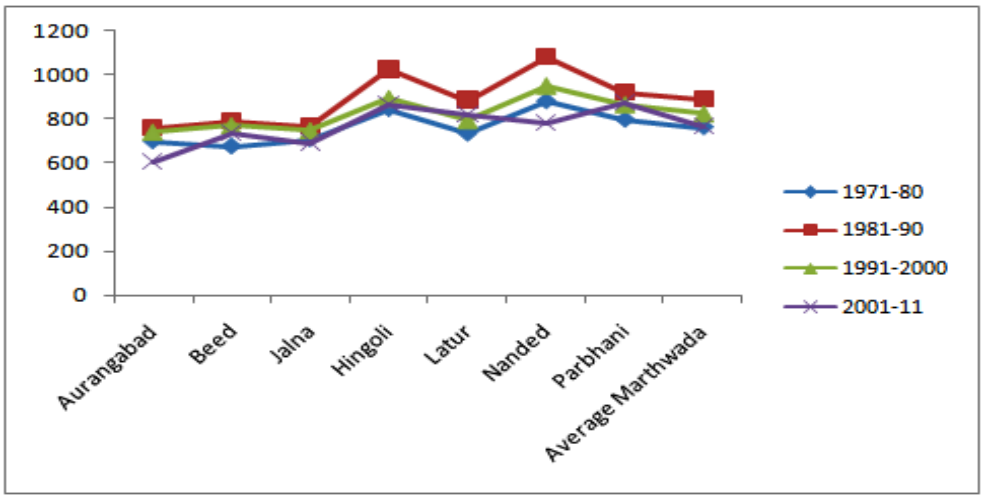

Fig. 3: *Decadal Average Rainfall (mm) in Marathwada Region.*

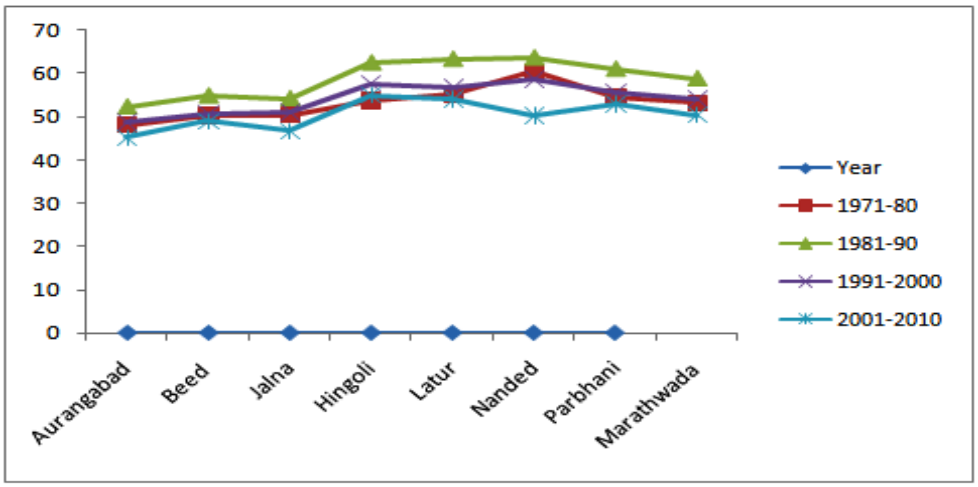

Fig. 4: *Decadal Average Rainy Days in Marathwada Region.*

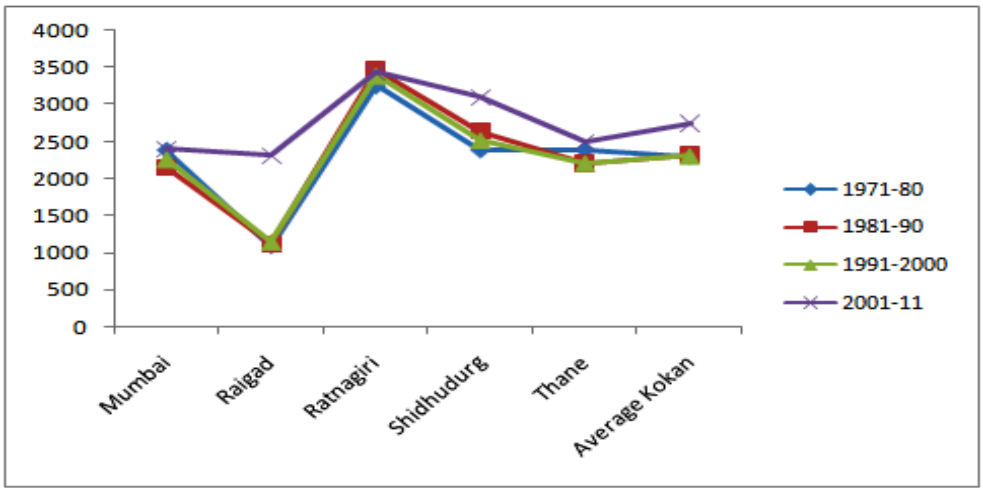

Fig. 5: *Decadal Average Rainfall (mm) in Konkan Region.*

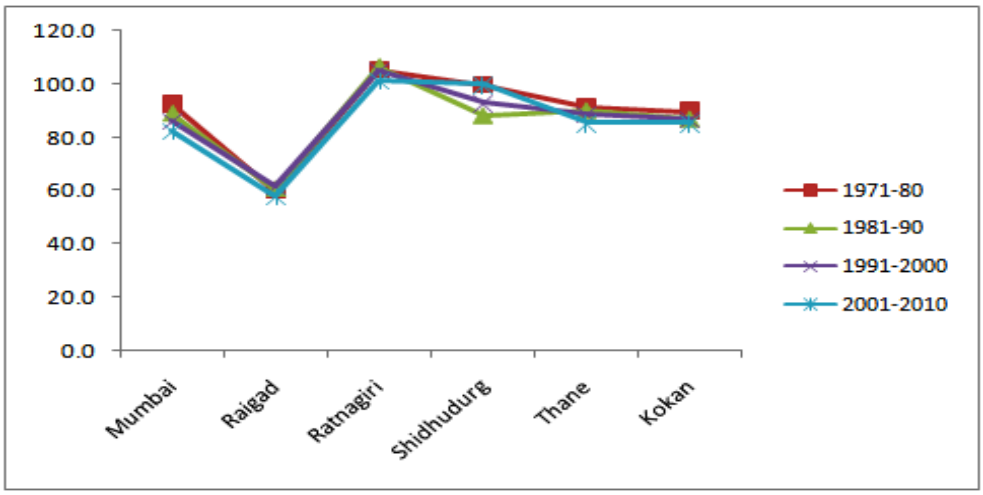

Fig. 6: *Decadal Average Rainy Days in Konkan Region.*

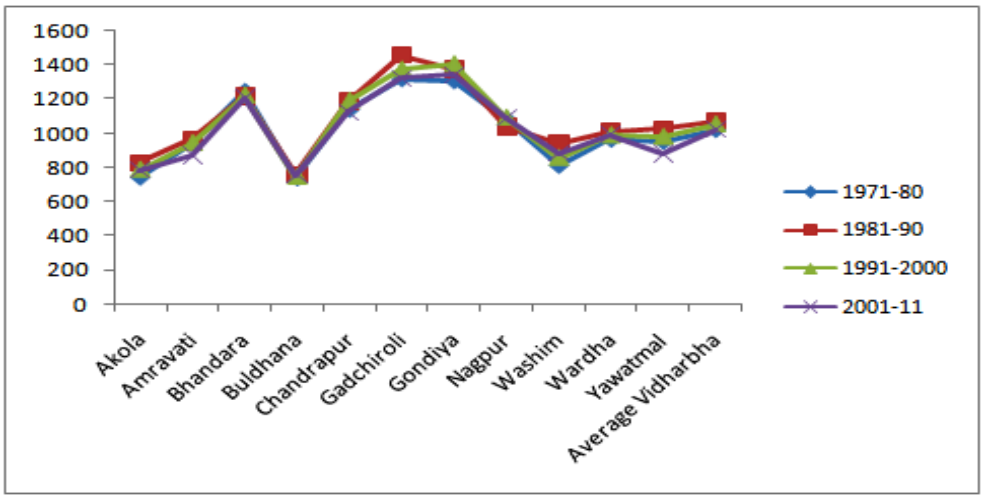

Fig. 7: *Decadal Average Rainfall (mm) in Vidharbha Region.*

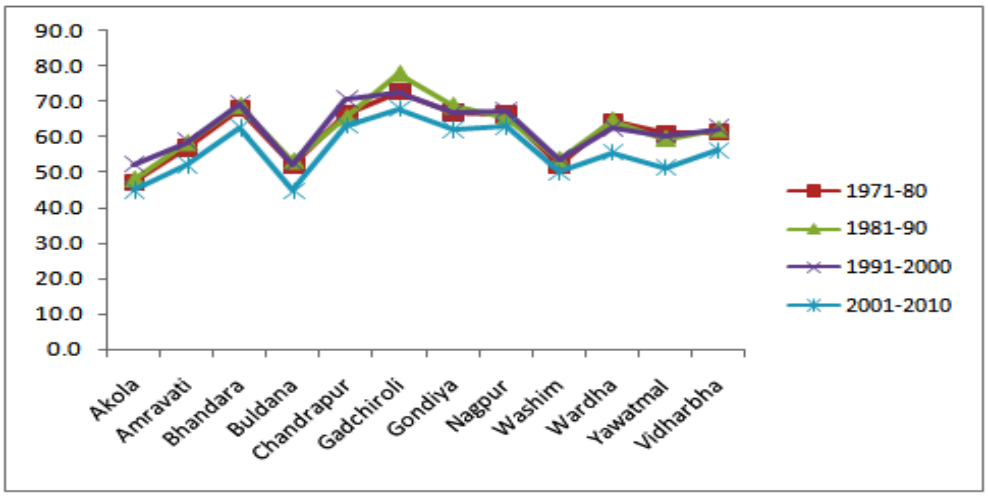

Fig. 8: *Decadal Average Rainy Days in Vidharbha Region.*

CONCLUSION

The present study has examined variability in the rainfall and rainy day's on the meteorological subdivision scale, regional scale and for the whole Maharashtra. Rainfall distribution over the state shows that 2400 mm rain receives in Konkan region and 500 to 600 mm in the leeward side. From central Maharashtra to Marathwada rainfall decreases and then again increases towards Vidharbha zone. Eastern Maharashtra receives rain (1200 mm) under the influence of both the Arabian Sea and Bay of Bengal branches of the monsoon. The central Maharashtra region receives less rainfall than other regions of Maharashtra except Kolhapur district which receive the heaviest rains. The rainfall is highly variable over the entire state and shows complexity of the

rainfall occurrence over the state. The number of rainy days is more over the Konkan region followed by the eastern Vidharbha and then the rest of the Maharashtra. Seasonal distribution of the number of rainy days are 80 to 100 over Konkan, 50 to 60 over eastern Vidharbha and about 20 to 50 over the rest of the Maharashtra state. The study indicated large spatial and temporal variability in the rainfall trends over Maharashtra. The average decadal rainfall indicated the same direction of trend for the majority of the sub divisions.

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