

Climatic Changes in the Irrigated Tracts of Indira Gandhi Canal Region of Arid Western Rajasthan, India

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Abstract: The climatic changes at three selected locations, along the Indira Gandhi canal region, were studied using the records of annual rainfall (1926-93) and air temperature (1950-93). Though, Ganganagar region has been imposed with canal irrigation since the past around six decades, the increase in annual rainfall was apparent only during the last three decades (1961-93). The long term rate of increase in the annual rainfall of Ganganagar was $1.029 \text{ mm year}^{-1}$. However, in the areas where irrigation has been imposed during the past two decades like Bikaner and recently at Jaisalmer, the irrigation effect on rainfall was not observed. In general, decrease in the air temperatures was observed in the region at a rate of $0.039^\circ\text{C year}^{-1}$ at Ganganagar, $0.023^\circ\text{C year}^{-1}$ at Bikaner and $0.009^\circ\text{C year}^{-1}$ at Jaisalmer.

Key words: Climatic changes, impact of irrigation, Indian arid region.

Thar desert region of western Rajasthan around 196,150 sq. km, is very fragile and is subjected to excessive stresses due to frequent droughts and low rainfall. The arid phase of north-west India has a history of about 3000 years (Pant and Maliekal, 1987). Winstanley (1973, a&b) analysed the rainfall at Bikaner and Jaisalmer and reported that the monsoon in the arid region of north-west India was favourable during 1700 to 1930 and has been unfavourable since 1970. Pant and Hingane (1988) studied the trends in rainfall and temperature during 1901-82 for the north-west India covering the meteorological subdivisions of Punjab, Haryana, west Rajasthan and west Madhya Pradesh. Their studies showed an increasing trend in the mean annual rainfall (141.3 mm per 100 years) and a decreasing trend in air temperatures (-0.52°C per 100 years) contradicting the earlier studies made by Winstanley (1973 a&b). Ramakrishna and Rao (1991) also observed an increase in the mean decadal rainfall of Ganganagar which was under irrigation for a considerable period. In the irrigated areas

of the Middle Asia, the humidity of air in July at 2 m height increased by 3 to 5%, while the air temperature decreased by 2.5 to 3.0°C , resulting in decrease of the accumulated air temperature of the growing period by 200 to 500° days (Orlovsky and Utina, 1977; Orlovsky and Durdyiev, 1978). The Famine Commission and Irrigation Commission emphasised the urgent need for irrigation in dry lands to bring stability and improve the agricultural productivity (Roy, 1983). The Gang Canal in 1927 and the Indira Gandhi Nahar Project (IGNP) in 1961 were initiated for diverting water from Punjab to the arid western Rajasthan. The canal aims at utilizing 7.59 MAF of water from Ravi-Beas water to irrigate 11.43 lakh ha area, thereby, aiming for additional food production of 31.00 lakh tonnes per annum. In Ganganagar district 708,775 ha, in Bikaner 37,022 ha and in Jaisalmer 84 ha land were put under irrigation with net crop sown area of 78.02, 36.23 and 7.93%, respectively (Roy, 1983). The stage-I of the project began in 1961, construction of 204 km feeder canal from Harike

Barrage to Hanumangarh and another 189 km-long main canal extending upto Chat-targarh. The work of stage-II on main canal of 256 km from Chattargarh to Mohangarh

The impact of irrigation in the arid Rajas-than is seen from the vegetational and micro-climatic changes that occurred in the region. In the present paper, the trends in annual

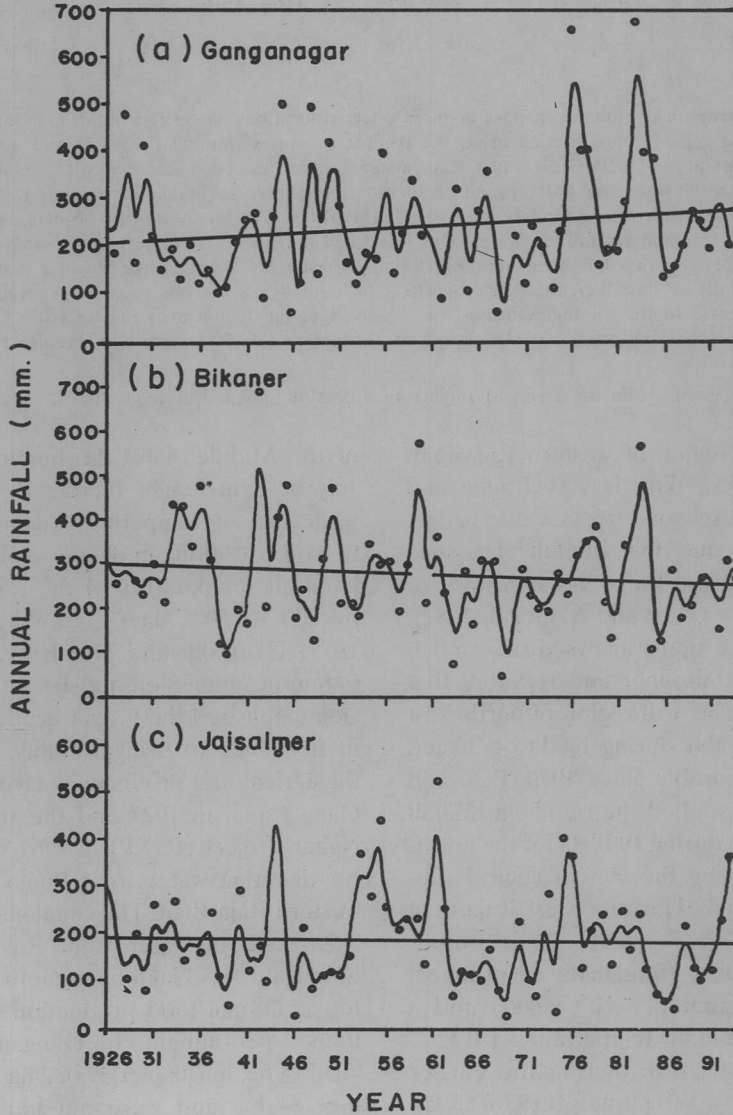


Fig. 1. Trends in annual rainfall of (a) Ganganagar, (b) Bikaner and (c) Jaisalmer.

in Jaisalmer district began in 1970 (Chouhan, 1993).

rainfall and air temperatures at selected loca-tions along the canal irrigated tracts of arid

Table 1. Decade-wise percentage departures of annual rainfall at some locations in western Rajasthan

Decade	Ganganagar	Bikaner	Jaisalmer
1921-30	+23	+ 4	- 18
1931-40	- 34	+ 3	0
1941-50	+ 9	+15	- 9
1951-60	- 6	+ 9	+30
1961-70	- 17	- 21	- 8
1971-80	+12	- 9	+ 8
1981-90	+22	- 1	- 22

western Rajasthan, which are exposed for varying lengths of irrigation, are presented.

Materials and Methods

Three locations, viz., Ganganagar (29° 55' N; 73°53'E; 177 m), Bikaner (28°00'N; 73° 18'E; 224 m) and Jaisalmer (26°54'N; 70° 55'E; 242 m) along the irrigated tract of the Indira Gandhi canal, were selected for the study of long term climatic changes. The annual rainfall during 1926 to 1993 and air temperatures (°C) during 1950 to 1993 of these stations were collected from the India Meteorological Department, Pune, and the Central Arid Zone Research Institute, Jodhpur.

The meteorological droughts were based on departures from the aridity index of Thornthwaite in terms of the standard deviation of aridity index (Subrahmanyam and Subramaniam, 1964). The air temperature data of Ganganagar for the period 1926-40, and of Jaisalmer for the period 1926-48, are not available and so the normal potential evapotranspiration (PE) of these stations was used for the climatic study of droughts.

The long term trends in respect of annual rainfall and mean annual air temperatures of the locations for the period 1950-93, were analyzed using linear regression analysis with time as dependent variable and tested for significance. To support the increase in annual rainfall over Ganganagar region, rainfall

trends of neighbouring stations, viz., Anupgarh, Hanumangarh and Raisinghnagar of the area were also analyzed for the period of 1961-93.

Results and Discussion

Trends in annual rainfall

Ganganagar receives a mean annual rainfall of 243 mm with the arrival of monsoon by around 1st of July. The coefficient of variation in annual rainfall of the location is high (54%) as a result of inter-annual fluctuations in rainfall. On an average, climatic droughts prevailed in the region in every one out of five years (22% chances) during 1926-93 resulting in the failure of crops. In the Ganganagar region, severe drought prevailed during 1946, 1965, 1968, 1969 and 1991 and moderate drought during 1936, 1939, 1943, 1947, 1949, 1953, 1974, 1979, 1980 and 1990.

The annual rainfall of Ganganagar showed an overall increasing trend, at the rate of 1.029 mm year⁻¹, during the period 1926-93 (Fig. 1a). The decade-wise mean annual rainfall showed that the increase in rainfall was high during the last three decades since 1961, the periods of intense irrigation given in the region. Even in drought periods faced by western Rajasthan, Ganganagar area received adequate rainfall for crops, which is a factor attributed to the increased moisture through irrigation imposed for longer periods in the region.

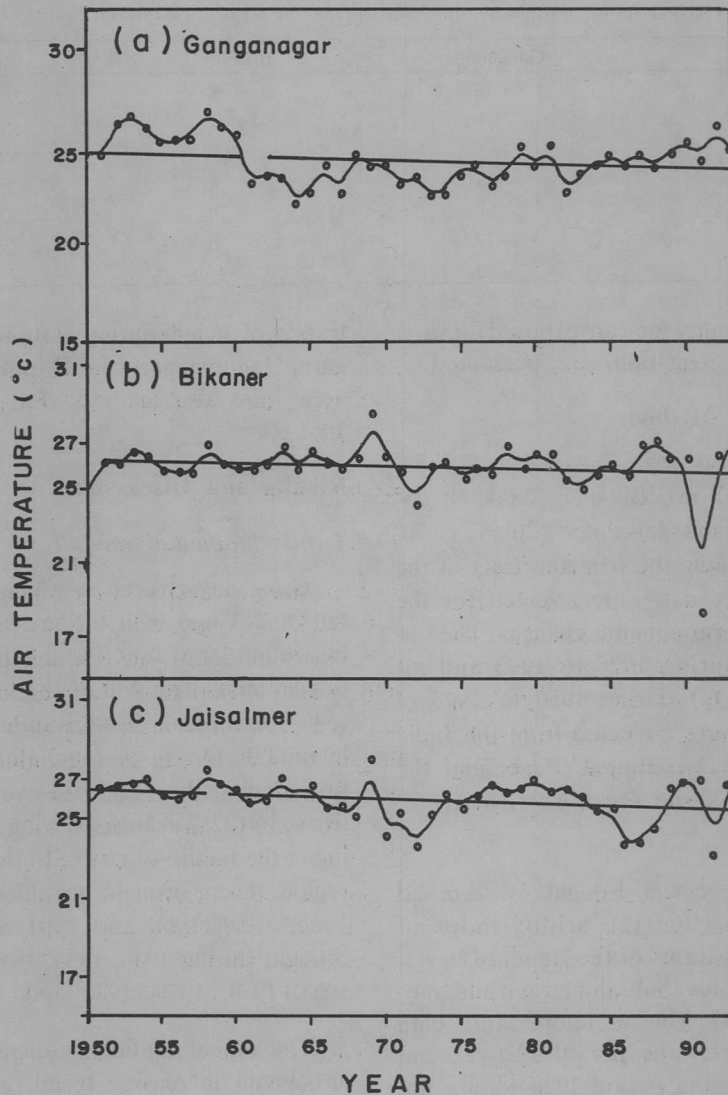


Fig. 2. Trends in annual air temperature of (a) Ganganagar, (b) Bikaner and (c) Jaisalmer.

The mean annual rainfall of Bikaner is 286 mm with a coefficient of variation of 48%. Bikaner region experienced droughts in one out of every three years (38% chances). Severe drought occurred in the region during the years 1928, 1939, 1948, 1963, 1968, 1969, 1979, 1984, 1985, 1990, 1991 and moderate

drought during 1932, 1940, 1941, 1943, 1946, 1951, 1952, 1953, 1957, 1960, 1965, 1971, 1975, 1987, 1988. However, the annual rainfall at Bikaner showed an overall decreasing trend at a rate of $-0.147 \text{ mm year}^{-1}$ during 1926 to 1993 (Fig. 1b), which may be due to consecutive droughts experienced after 1961.

Jaisalmer, which is located in the extreme west of Rajasthan, receives a mean annual rainfall of 185 mm, with a coefficient of variation of 64%. The rainfall in the area is very erratic and poorly distributed with droughts occurring once in every four years (24%). Jaisalmer experienced severe droughts during 1939, 1946, 1963, 1969, 1972, 1974, 1986, 1987, 1990, 1991, and moderate droughts during 1928, 1930, 1938, 1941, 1943, 1948, 1949, 1950, 1951, 1964, 1968, 1971, 1985. However, the overall trend in annual rainfall at Jaisalmer remained the same during 1901-93 (Fig. 1c).

In support of the increase in annual rainfall in the Ganganagar region, the annual rainfall trends of nearby stations to Ganganagar, viz., Anupgarh, Hanumangarh and Raisinghnagar were also analyzed. The study showed that the increase in annual rainfall during 1961 to 1993 was 37.8 mm at Anupgarh, 32.3 mm at Hanumangarh, 110.0 mm at Ganganagar, and 93.4 mm at Raisinghnagar.

Shifts in decade-wise annual rainfall

The decade-wise annual rainfall departures (Table 1) showed that the Ganganagar region continuously put up positive (increasing) trend by 12 to 22% during the current decades 1971-80, 1981-90 and 1991-93, whereas, a negative (decreasing) trend was observed during the same period at Bikaner. Even in the recent decade 1981-90, Jaisalmer experienced a negative trend in annual rainfall due to recurring droughts prevailed in the region during the period. Out of the 7 decades starting 1921-30 to 1981-90, the annual rainfall was below the normal for a period of 3 decades at Ganganagar, 4 decades at Bikaner and Jaisalmer (Table 1). The cumulative departure values during 1921-30 to 1981-90 decades were +9 at Ganganagar, -8 at Bikaner and -19 at Jaisalmer indicating the lineament in the rainfall departure was more towards positive side at

Ganganagar, whereas, it was towards negative side at Bikaner and Jaisalmer.

Changes in air temperatures

The air temperatures at all the three locations showed a general decreasing trend with $0.039^{\circ}\text{C year}^{-1}$ at Ganganagar, $0.023^{\circ}\text{C year}^{-1}$ at Bikaner, and $0.009^{\circ}\text{C year}^{-1}$ at Jaisalmer (Figs. 2 a, b & c).

Further, the humidity measurements over irrigated cropped surfaces were 5 to 10% higher than over the unirrigated surfaces at 1 m height, which indicate that the amount of canal water that is applied can influence atmospheric humidity, but it is not known how far this increase in humidity can enhance precipitation, which mainly depends upon the dynamical conditions of the atmosphere and subsidence phenomena. However, the above study clearly brought out that the irrigation imposed for longer periods in the Ganganagar region enhanced the precipitation process in Thar desert region.

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