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Climate Variability and Crop Planning in Narmada District of Gujarat

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ABSTRACT

This research study was planned to find long term changes in the temperature and rainfall in the Narmada district of Gujarat, India. Long term data were collected and observed the monthly maximum temperature trend in the months of February, March, April, August and December with Sens's slope of 0.061, 0.041, 0.030, 0.046 and 0.036, respectively. Similarly, monthly minimum temperature had trend as Sen's slope in the months: February, March, April, July, August, September and October as 0.053, 0.039, 0.044, 0.015, 0.021, 0.024 and 0.034 respectively. Similarly, monthly mean temperature has trend in the February, March, April, May, August and December, Sen's slope as 0.059 0.039, 0.041, 0.030, 0.035 and 0.026 respectively. The annual precipitation in the Narmada district was estimated at 3463.9 MCM and nine major crop water requirements were 776.3 MCM and gross irrigation requirement was 277.83 MCM which was useful for the crop planning in the Narmada district.

Key Words: Climate; Crops, Narmada, Temperature, Variability.

INTRODUCTION

Climate is defined as the average weather condition of the particular area. According to Bernstein (2008), climate is statistical described as mean and variability of relevant weather parameters over a period of time, which range from weeks, months, years to millions of years. In this fast pacing generation, data set availability and their analysis is become easier, therefore information about past and present climate change has received much attention across the world. Analysis of temperature data compiled over the past century revealed that temperature is increasing but there are significant differences at regional level (Rupa Kumar, 2003). This study was designed to find trend in the temperature and rainfall of the Narmada district. Monthly and annual variations of temperature and rainfall and the uncertainties associated with them provide a knowledge base for effective management of irrigation in agriculture and other water dependent sectors.

Long-term annual and monthly trends of mean of maximum, minimum and mean temperature were investigated for the Narmada district of Gujarat. The statistical significance of trends was assessed using the Mann–Kendall test and Sen's slope for the magnitude of trend. Agriculture and allied sectors are majorly dependent on sufficient and timely application of water and surrounding environment.

MATERIALS AND METHODS

Study area

The study area: Narmada district is situated in southern part of Gujarat state of India. The study area covers 2817 sq. km geographical area and lies between 21°23' and 22°05' north latitudes and 73°17' and 73°59' east longitudes. Narmada district shares its boundary with Vadodara district in north direction, Surat district in south, Bharuch district in west and in east with Maharashtra State

Data collection

The data of daily maximum temperature,

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minimum temperature, relative humidity, wind velocity, sun shine hours and rainfall were collected from year 1979 to 2020 and the mean value of temperature and rainfall were calculated. For seasonal analysis of temperature, monsoon season was considered from month June to September, winter season from October to January and summer season from February to May was considered.

To find significance of the trend Mann Kendall statistical test was been used and the magnitude of the slope has been calculated using Sen's Slope estimator method as these methods are widely adopted for the time series analysis.

1. Mann-Kendall analysis

A non-parametric test the Mann-Kendall test (Mann, 1945 and Kendall, 1975) is used to identifying trends in time series data. The temperature and rainfall data were evaluated as an ordered time series.

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{Sign}(x_j - x_k)$$

Where, n = number of data points in given time series

Variance :

$$VAR(S) = (1/18)[\, N\,(N-1)\,(2N+5) - \sum_{p=1}^{n} t_p\,(t_p-1)\,(2t_p+5)]$$

Where, N = sample size

n = the number of tied (zero difference between compared values) groups and

t_p = the number of data points in the p^{th} tied group.

The standard normal deviate (*Z*-statistics) will be then computed as,

$Z = \{[S-1]/ [VAR(S)]^{½}\}$ if, S>0

$= 0$ if, S=0

$= \{[S+1]/ [VAR(S)]^{½}\}$ if, S<0

If, $Z_{cal}>0$ and $Z_{cal}>Z_{tab,}$ where, Z_{tab} = 3.090, 2.326, 1.645, 0.282, then the trend is considered as increasing and if, $Z_{cal}<0$ and $-Z_{cal}>Z_{tab}$ then the trend is considered as decreasing at 0.1%, 1%, 5% and 10 %.

Sen's slope method

In environmental field data, it is difficult to interpret the quantification of trends (e.g., calculation of slope) and demonstration that this estimation of trend is statistically different from zero.

$$f(t) = m\,t + c$$

Where, m = the slope and

c = constant.

2. Crop water requirement and Irrigation scheduling of major crops

Model CROPWAT 8.0 was used to find crop water requirement and irrigation scheduling, which is a decision support system developed by the Land and Water Development Division of FAO, Italy. For various management conditions and crops, the model calculates reference evapotranspiration, crop water requirements and irrigation requirements to develop irrigation schedules.

A. Crop and soil data

As per guidelines of Ministry of Irrigation, Govt. of India and FAO for estimating irrigation water requirement various crops parameters i.e. crop coefficient, length of growing stages, yield response factor and crop height etc. of were considered for the study. Crop coefficient values were taken from available published data. The soil in the Narmada district is clay loam type. Soil data was collected by conducting experiments as shown in Table 1.

Table 1. Soil characteristics.

Soil data	Parameter value
Total available soil moisture	200 mm/meter
Maximum rain infiltration rate	30 mm/day
Maximum rooting depth	900 centimetres
Initial soil moisture depletion	50 %
Initial available soil moisture	100 mm/meter

Table 2. *Kharif* Season Crop.

Crop	Price (Rs/Kg)	Income (Rs/Ha)	Priority if irrigation water not available	Priority base on income
Cotton (Un irrigated)	81.00	50078	7	4
Cotton (Irrigated)	81.00	36369	8	7
Sorghum	52.25	71987	3	2
Pigeon pea	70.00	70274	5	3
Maize	26.05	43465	2	5
Pearl millet	25.00	42712	1	6
Rice	15.78	13965	6	8
Groundnut	69.05	146026	4	1

B. Reference evapotranspiration

Reference evapotranspiration was calculated using CROPWAT8.0 model which uses the FAO Penman-Monteith method (Allen *et al*., 1998).

C. Effective rainfall

Effective rainfall was calculated using the USDA Soil Conservation Service method (Smith, 1991).

D. Crop evapotranspiration

CROPWAT 8.0 model uses crop coefficient approach for calculation of crop evapotranspiration which was used in this study.

RESULTS AND DISCUSSION

The weekly and monthly, seasonal and annual data of rainfall, maximum temperature, minimum temperature and mean temperature was calculated from the daily data. Thirty years moving averages of seasonal rainfall indicate an increase in rainfall over normal values for Narmada district. The similar results obtained by Parthasarthy (1984).

Annual Trend of Tmax, Tmin, Tmean and Rainfall

It was observed that there is no trend observed in the annual Tmax while positive trend was observed in Tmin and Tmean with Sen's slope of 0.025 and 0.023 respectively. The similar results were obtained by Ray Kamaljit *et al* (2009) for some parts of Gujarat. Furthermore, there was no significant trend observed in annual rainfall at significance level of 0.05 as shown in Fig 2. Also, there was rising trend was observed in annual minimum and annual mean temperature for the Narmada district at significance level of 0.05. There was increase of 0.023 °C and 0.017 °C in mean minimum temperature and mean annual temperature respectively. Annual rainfall was found non-significantly increasing trend for the

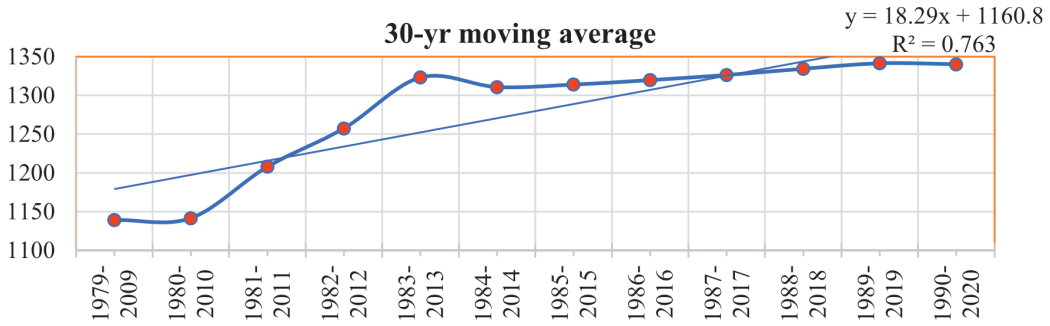

Fig. 1 Moving average trend of rainfall for 30 years normal rainfall

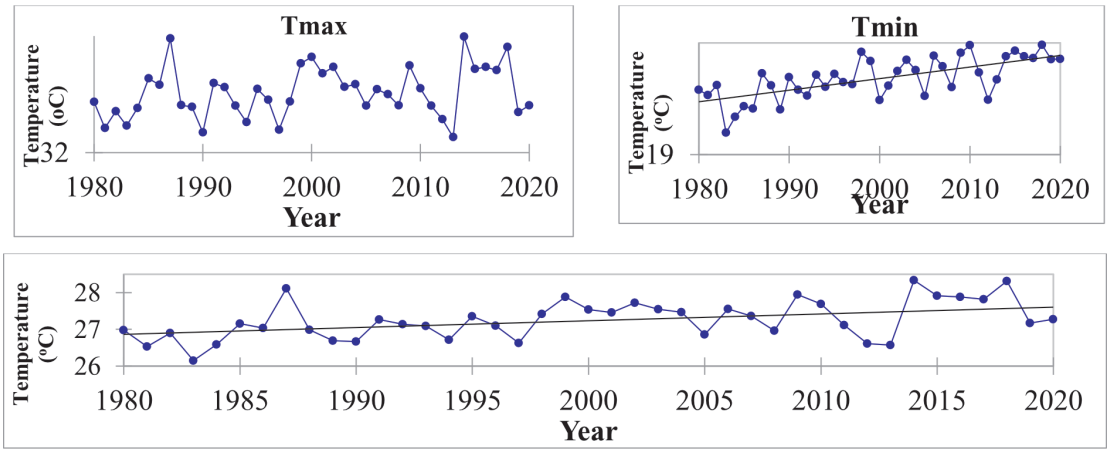

Fig. 2 Maximum Minimum and Mean temperature trend in Narmada district

duration.

Seasonal Trend of Temperature

The mean maximum temperature trend in the Narmada district was observed increasing in the summer season while no significant trend observed in winter and monsoon season at significance level of 0.05 as shown in Fig. 3, 4 and 5. Summer season mean maximum temperature is increasing with magnitude of 0.036 and increase average 0.034 °C per decade. The mean minimum temperature trend in the Narmada district was observed increasing in summer and monsoon season with Sen's slope as 0.05 and 0.014 respectively at the significance of 0.05 % as shown in Fig. 3, 4 and 5. There was 0.046 °C and 0.004 °C rise in the minimum temperature per decade is observed for the summer and monsoon season respectively in the Narmada district.

The mean temperature in the winter, summer and monsoon season was analysed and found that there was increasing trend in summer mean temperature with significance level of 0.05. The magnitude of the rising slope was determined with Sen's slope method as 0.046 as shown in Fig. 3, 4 and 5. There is rise in the mean summer temperature as 0.04 °C per decade.

Irrigation scheduling of the major crops of the Narmada district

In Narmada district, about 51 percent of the area comes under rainfed cultivation while 49 percent of the total gross cropped area has irrigated cultivation.

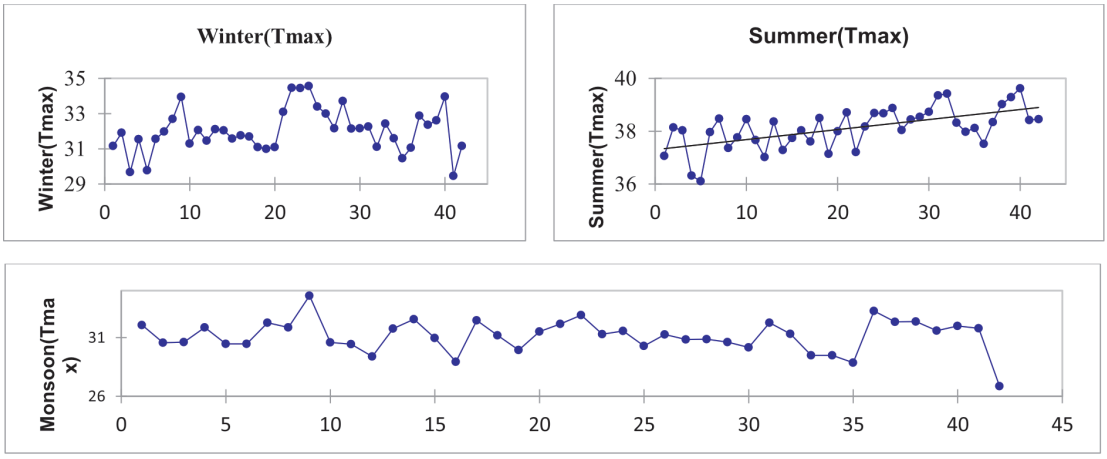

Fig. 3 Mean maximum temperature in winter, summer and monsoon season.

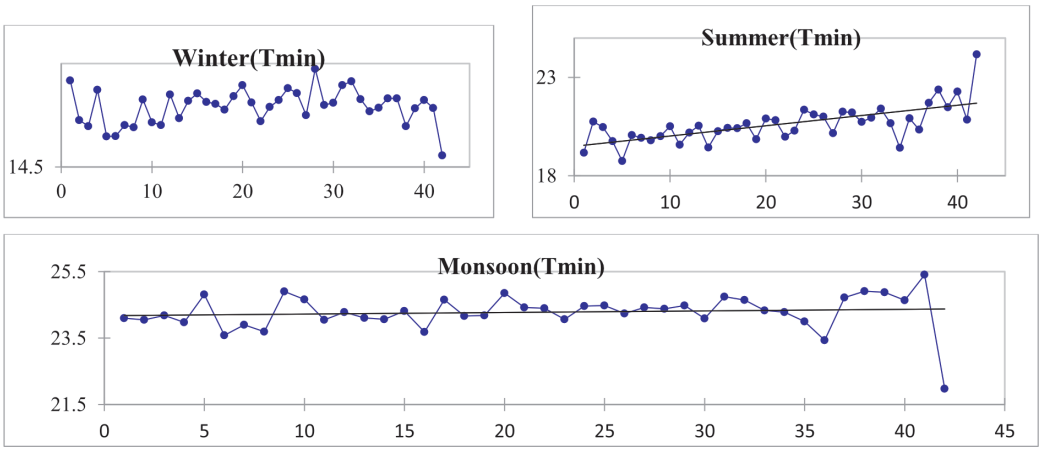

Fig. 4 Mean minimum temperature in winter, summer and monsoon season

Due to characteristic of hard rock formation in most part of the district shows groundwater occurred under unconfined condition and its movement is controlled by Weathered, Joints, Fracture of Secondary Porosity, (Anonymous, 2021). Narmada district is primarily an agricultural base district with Cotton and Tuver (Pigeon pea) as the predominant crops. In the district about 58.20% of land holdings are with small and marginal farmers and the average size of the holdings is 2.50 ha. (NABARD, 2016). For the irrigation scheduling of the Narmada district 9 crops i.e., Cotton. Pigeon pea, Sugarcane, Rice, Sorghum, Wheat, Groundnut, Pearl millet and Maize were taken in to consideration. Various phenological crop data were adopted from FAO Irrigation and Drainage and various literatures (Allen *et al*., 1998).

For the irrigation scheduling in the Narmada district, CROPWAT model were used for the determination of irrigation water requirement and irrigation scheduling. In the subsequent sections irrigation scheduling for the major agricultural crops for the Narmada district is given. Narmada district receives about 3476.5 MCM water annually. Crop water requirement from the major crops is 277.8 MCM.

Water requirement of major crops of the region

The area under cultivation of Cotton(rainfed), Cotton (Irrigated), Pigeon pea, Rice, Sugarcane, Maize (Rabi), Sorghum (Kharif), Sorghum (Rabi), Wheat, Maize (Kharif), Pearl millet (Summer),

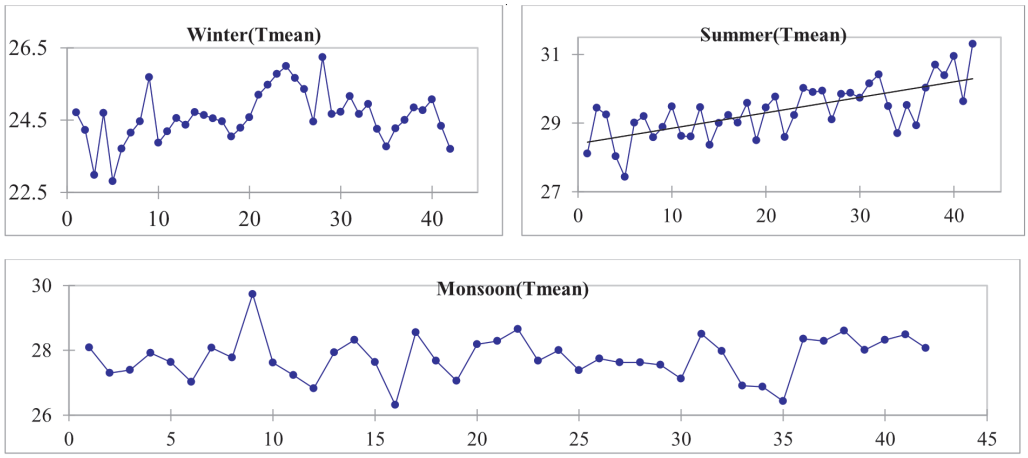

Fig. 5 Mean temperature in winter, summer and monsoon season

Table 3. *Rabi* Season Crop.

Crop	Price (Rs/Kg)	Income (Rs/Ha)	Priority if irrigation water not available	Priority base on income
Sorghum	52.25	42958	3	4
Maize	26.05	56989	1	3
Wheat	27.90	86581	2	2
Sugarcane	3.00	214566	4	1

Table 4. Summer Season Crop.

Crop	Price (Rs/Kg)	Income (Rs/Ha)	Priority if irrigation water not available	Priority base on income
Pearl millet	25.00	72358	1	2
Groundnut	69.05	136581	2	1

(Price, Source:https://www.enam.gov.in/ accessed on 23/02/2023)

Groundnut (Summer), Pearl millet (Kharif) and Groundnut (Kharif) with 21%, 17%, 16%, 9%, 5%, 3.94%, 2%, 1%,1%, 0.88%, 0.13%, 0.1%, 0.09% and 0.06% respectively. It was observed that the highest water Cotton rainfed followed by cotton (Irrigated) and lowest water consumes by the Pearl millet (Kharif) respectively. About 94.56 % rainwater is available in 4 months of the year i.e., June, July, August and September. After September water requirement for the crops increases the available rainwater in the month up to the end of March month. During this period water may be available from surface water storage and after withdrawn all surface storage, water may be explored from the ground water. From the average yield and market price of the crop, following points should be considered Yield of major crops grown in Narmada district. (Source: District wise area, Production and yield of important food and non-food crops in Gujarat state: Year 2017-2018, 2018-19 and 2019-20, Director of Agriculture, 2021). Average price was taken from the National agricultural market portal. Based on the market price income generated per hectare were calculated and shown in Table 2, 3 and 4 for *kharif, rabi* and summer season respectively.

CONCLUSION

In Kharif season if enough water available for irrigation, priority should be given to Groundnut crop to get high income and if irrigation water is not enough, priority should be given to pearl millet

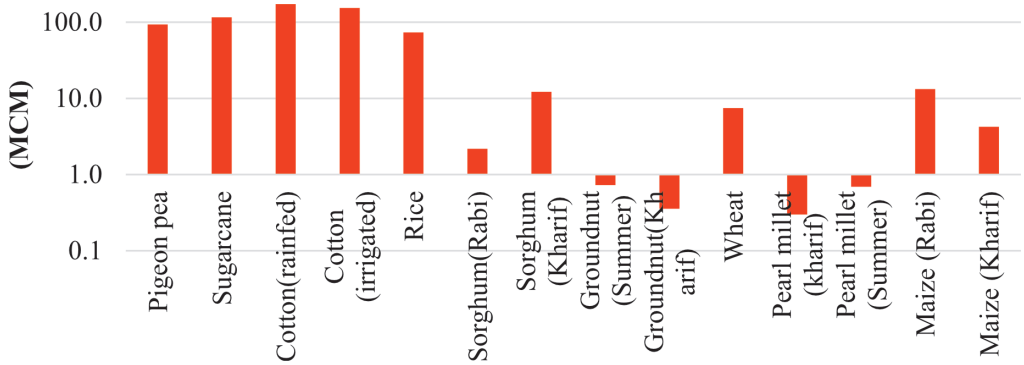

Fig 6. Annual water requirement (MCM) of major crops in Narmada district

crop. In Rabi season if enough water available for irrigation, priority should give to Sugarcane crop to get high income and if irrigation water is not enough, priority should be given to Maize crop. In Summer season if enough water available for irrigation, priority should give to Groundnut crop to get high income and if irrigation water is not enough, priority should be given to Pearl millet crop.

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