Spatial Variation of Annual and Monthly Rainfall in Orsang River Basin, Gujarat, India

Geeta S. Joshi, Jainy Shah

Abstract*: Climate change is one of the most discussed issues affecting the environment nowadays. Many researchers have been agreed that the increase in temperature in comparison to the previous century is due to anthropologically related activities, though there are enough historical evidence to support the theory that climate change is a natural phenomenon. This paper reviews the impact of climate change by assessing the trend of annual and monthly rainfall and representing spatial variability over the Orsang river basin in Narmada lower river basin in the state of Gujarat, India. This will be helpful to study the impacts of climate change on hydrology and water resources, and planning & management of water resources, environmental protection, and ecological balance over the orsang river basin, India.

Key word - Climate change, Annual and monthly rainfall, Spatial distribution, Trend

I. INTRODUCTION

Climate change is a threat to the world, causing the long term impacts on sustainable living of the mankind. The climate change is causing the changes in rainfall and temperature[1]. Climate change is caused due to increase in the greenhouse gases in the atmosphere. It has significantly influenced the water balance by causing changes in evapotranspiration rates, evaporation, temperature and rainfall [2]. The most importnt parameter in the hydrological cycle is rainfall. The climatic condition in India covers summer and winter periods and with monsoonal season as the wet periods. Indian monsoon rainfall shows significant spatial and temporal variations. India is pre-dominantly an agricultural country, so variability in rainfall drives the national economy [3] [4]. It is important to analyze the impacts of climate change for framing the water resources planning and management policies [5] [6] [7][8][9][10]. The change in the average temperature due to global climate change caused the changes in rainfall pattern and its distribution. It is important to analyze the trend within the river basin area so that the impact of it can be assessed in it.

Revised Manuscript Received on September 2, 2019.
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The Narmada - the largest west flowing river of the Peninsula is a fifth largest river in the country of India with the largest one in Gujarat state. The tributaries of Narmada River in Gujarat are Orsang, Unch, Karjan, Aswin, Men, Heran, Bharaj, etc. This study examines the spatial variability in Orsang river basin comprising of three small – scale regions - Heran river basin, Uchh river basin and upper watersheds of Orsang river basin in the Narmada lower sub-basin in Gujarat, India.
This paper analyzed the temporal trends of monthly and annual rainfall and spatial variations of it over the Orsang river basin using MK test with Sen's slope estimator.

II. STUDY AREA AND DATA COLLECTION

The Orsang River - one of the main tributaries of the Narmada River, originates in the Jabua district of Madhya Pradesh state in India and flows for a distance of around 20 km in the vast alluvial plain in a South westerly direction passing through Chhotaudepur, Bodeli and Sankheda tehsils before it meets the Narmada River at Chandod, Gujarat. It has a channel length of 135 kilometers. The valley covers an overall area of 4000 Sq. Kilometers. Except for a small length of 8 Kilometers in its source region – Jabua district of Madhya Pradesh, the major part of the valley lies in the Chhotaudepur, Sankheda, Jetpur, Dabhoi and Naswadi tehsils of the Vadodara district in Gujarat. The north-western margin of the valley forms the boundary between Vadodara and Panchmahal districts and at places the valley gets into Jambughoda tehsil of Panchmahal district in Gujarat. For most of its part, the river flows in the trappean uplands. Figure 1 shows the location of the study area - Orsang River basin in Narmada lower sub-basin, Gujarat, India. Figure 2 shows the basin map showing sub-basins Upper watersheds, Heran and Uchch sub-basin of Orsang River basin with locations of rain gauge stations.

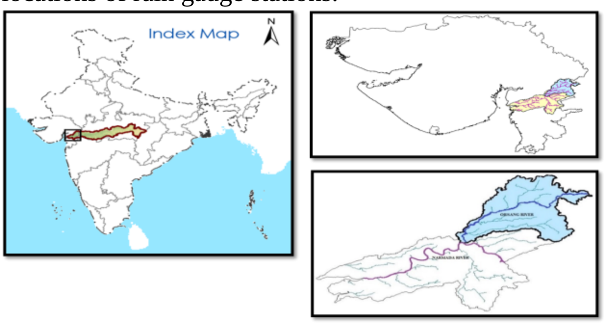

Figure 1 Location of Study area – Orsang River Basin

Retrieval Number K15790981119/2019©BEIESP
DOI: 10.35940/ijitee.K1579.0881119

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Figure 3 shows elevation map – DEM (Digital Elevation Model) for the Orsang river basin.

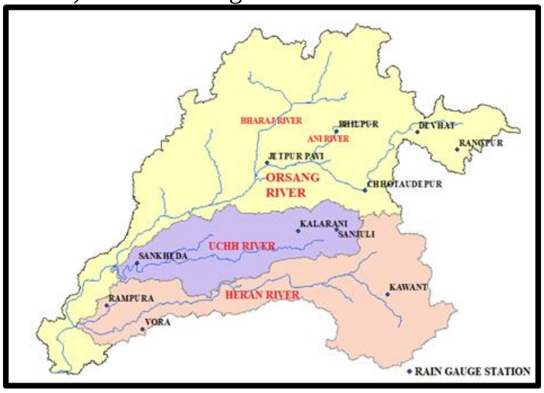

Figure 2 Orsang River basin with locations of Raingauge stations and sub-basins.

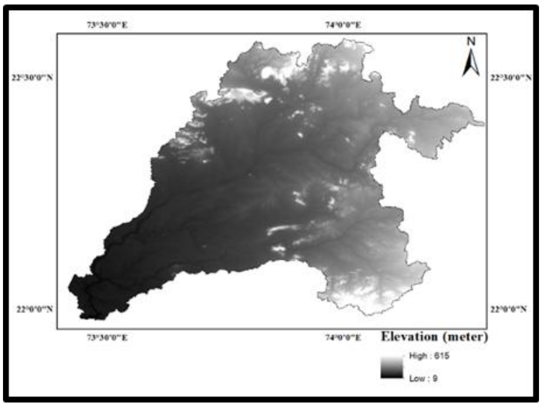

Figure 3 DEM (Digital Elevation Model) for the Orsang river basin.

A. Data

The daily rainfall data has been collected from IMD (Indian Meteorological Department) and SWDC (State Water Data Centre). Following table – Table 1 give station details.

Table 1 SWDC and IMD Raingauge Station detail

Sr. No	Station	Latitude	Longitude	Data length
1	Devhat	22°23’34”	74°06’29”	1972-2016
2	Rangpur	22°21’48”	74°10’48”	1978-2016
3	Jetpur-pavi	22°20’26”	73°50’19”	1973-2016
4	Bhilpur	22°23’42”	73°57’49”	1964-2016
5	Sanjuli	22°13’36”	73°57’49”	1970-2016
6	Kalarani	22°13’28”	73°53’38”	1970-2016
7	Sankheda	22°10’12”	73°36’18”	1962-2016
8	Kawant	22°06’59”	74°03’19”	1964-2011
9	Rampura	22°05’50”	73°33’01”	1972-2016
10	Vora	21°51’58”	73°36’20”	1969-2016
IMD station				
Sr. No	Station	Lattitude – Longitude		Data length
11	Chhotaudepur	22° N 74° E		1901-2013

III. METHODOLOGY

This section comprises of methods for trend analysis of the annual and monthly (June to October) rainfall. There are eleven rain gauge stations installed in the study area including Devhat, Rangpur, Jetpur-pavi, Bhilpur, Kalarani, Sankheda, Sanjuli, Vora, Kawant, Rampura and Chhotaudepur. The normal annual rainfall at stations - Devhat, Rangpur, Jetpur-pavi, Bhilpur, Sanjuli, Kalarani, Sankheda, Kawant, Rampura, Vora, and Chhotaudepur are found to be 1142.16mm, 982.10mm, 1001.27mm, 1108.93mm, 919.34mm, 969.57mm, 1078.04mm, 724.82mm, 999.14mm, 909.05mm and 1089.05mm respectively. These eleven stations in the study are found adequate as the optimum number of rain gauge stations, even with 5% error in determining mean rainfall. Trend analysis methods – Mann-Kendall test (MK test) with Sen's slope estimator has been used in this study to obtain the trends of rainfall.

The Mann-Kendall test is a most popularly used non-parametric test which does not require the data to be normally distributed. The null hypothesis suggested that the data series has no trend. Alternative hypothesis is that the data series has either positive or negative trend. Considering the annual time series Xt, t =1, 2,…n. Each value of the data series Xt is compared with all subsequent values Xt+1, and a new series is generated.

The parameter Sen’s slope (β) indicating the variation rate within the time series, and can be obtained as follows [11].

$$\beta = Meadian\left(\frac{(x_i - x_j)}{i - j}\right) \quad for\ all\ j < i \qquad \ldots(1)$$

The data points, xi and xj are the sequential data in the series.

Spatial-temporal variation of monthly and annual rainfall trend

The Spatial variation of trend (Sen’s slope) of annual and monthly rainfall is represented in Arc- GIS 10.3 in the following Figure 4 to Figure 8.

IV. RESULTS

A. Temporal variation of rainfall trends

The temporal variations of the rainfall trends detected by the MK test and Sen’s slope estimator test is carried out.

B. Spatial - temporal variation of rainfall trends

Figure 4 shows spatial variation of trend (Sen’s slope) of annual rainfall in the study area which has been calculated based on the SWDC and IMD data for various station. Likewise, spatial variation for monthly rainfall (monsoon – June to October) has been developed and represented in Figure 4 to Figure 8.

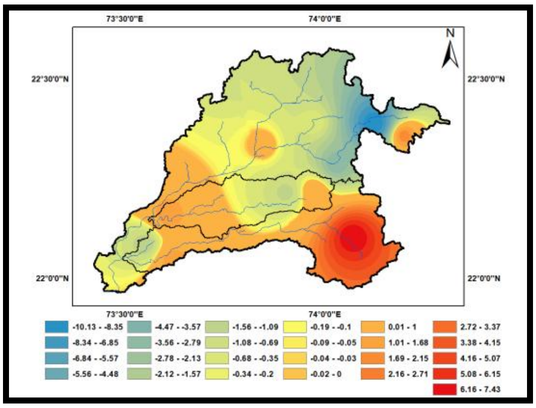

Figure 4 Spatial variation of Sen's slope (trend) of annual rainfall in Orsang river basin

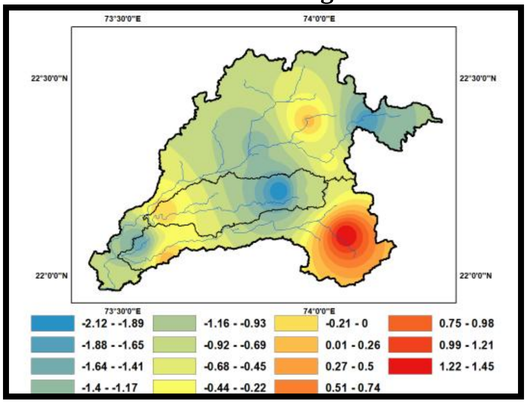

Figure 5 Spatial variation of Sen's slope (trend) of rainfall in the month of June

Figure 4 indicates that annual rainfall shows negative trend in upper watersheds except two stations, while it is showing positive trend in Uchh and Heran river sub-basin except at two stations. Figure 5 shows that monthly rainfall of the month of June follow negative trend in most of the part of the basin. Figure 6 and Figure 7 show the spatial distribution of Sen's slope of trend of rainfall for the months of July and August respectively.

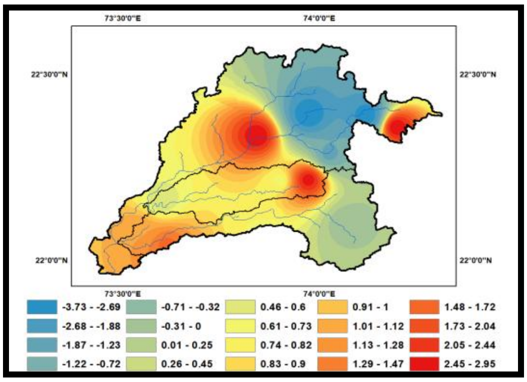

Figure 6 Spatial variation of Sen's slope (trend) of rainfall in the month of July

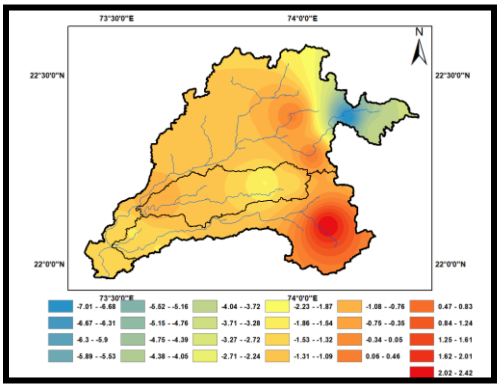

Figure 7 Spatial variation of Sen's slope (trend) of rainfall in the month of August

It is observed from Figure 6 that monthly rainfall in the month of July shows positive trend in the basin except upper watershed area of the Orsang basin. Figure 7 shows that monthly rainfall in the month of August shows positive trends in almost entire Orsang river basin. Figure 8 shows the spatial distribution of Sen's slope of trend of rainfall for the month of September.

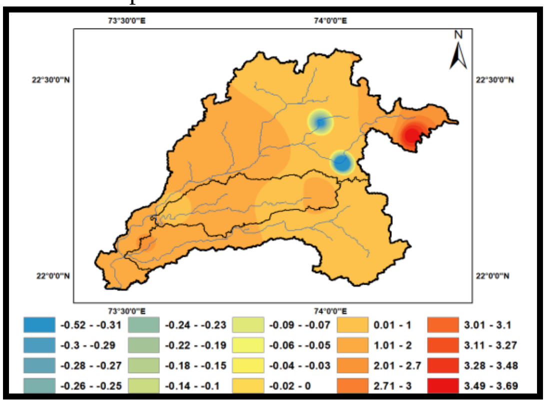

Figure 8 Spatial variation of Sen's slope (trend) of rainfall in the month of September

From Figure 8, it is analyzed that most of the part of the study area carries positive Sen's slope of trend of rainfall in the month of September except small area covered by two stations. Thus, it can be analyzed that the monthly rainfall in the month of September shows positive trend in almost entire basin.

V. CONCLUSION

The objective of this study is to analyze the regional impact of climate change over Orsang river basin in Narmada lower sub-basin. From the results obtained in this study, it is summarized that the climate change impacts on the small - regional scale study area confirms increase in the annual rainfall magnitude in the middle watersheds of the study area. The monthly rainfall in the month of June shows negative trend in almost entire river basin. The monthly rainfall in the month of August and September shows positive trend in almost entire Orsang river basin. Thus it can be concluded for the entire Orsang river basin that monsoon season less likely to start from June now a days, and also it is shifting towards the month of September.

Retrieval Number K15790981119/2019©BEIESP
DOI: 10.35940/ijitee.K1579.0881119

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VI. ACKNOWLEDGMENT

The authors are thankful to the Climate Change Department of Government of Gujarat of India and Higher Education Department of Gujarat for funding the climate change project, under which this study has been carried out. Also, the authors are thankful to the Central water commission (CWC) of India and State Water Data Centre (SWDC), Gandhinagar, India for providing the necessary data.

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