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Monotonic Trend Analysis of Temperature Series over Mandya City, Karnataka

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Abstract: Climate change is mostly driven by global warming. Climate change is one of the most critical long-term development issues, particularly for developing countries like India. India is one of the world's most climatically diverse countries, making it sensitive to climatic change and impacting the livelihoods of millions of people who rely on agriculture. Temperature and its fluctuation have direct and indirect impacts on crop development in the agricultural sector. Understanding the temperature and its variability in a changing environment would aid in improved decision-making and suggest feasible adaption strategies. The present study focuses on temperature trend analysis in Mandya city, Karnataka, India. The analysis was carried out through the non-parametric Mann-Kendall test and Sen's slope estimator. The findings demonstrate that, there has been a rising trend in temperature in the study area over the last 30 years as a result of climate change. From the analysis, there is a significant positive trend for all the seasons considered for the significance level of 90%, 95% and 99%. The magnitude of the increasing trend will be in the range of 0.46 °C/year for the average time series. Also, there will be an average increase of 0.07 °C/year for the various scenarios considered in Mandya city for the Maximum temperature series.
Keywords: Climate change, Mann-Kendall test, Sen's slope estimator, Trend analysis, Significance level, etc.,

I. INTRODUCTION

Climatic change is one of the greatest developmental challenge facing mankind today. Modern world is experiencing global warming due to the release of million tonnes of GHG (Green House Gases) into atmosphere through anthropogenic activities. Temperature have been rising significantly over the last decade causing global climate change. Global warming is one aspect of climatic change and is indeed an important driver of climatic change. Climatic change has become one of the most essential concerns in the field of sustainable development, particularly developing countries like India.

India is one of most climatically diverse country in the world vulnerable to the climatic changes. Temperature and its changes (Smadi, 2006; Tabari and Talaee, 2011), impact a number of hydrological processes including rainfall, evaporation, evapotranspiration, etc., The high temperature in urban areas affects mostly health, economy, leisure activities, and well-being of urban residents. Thermal stress caused by warming highly affects the health of vulnerable peoples (Tan et al., 2010; Patz et al., 2005). Climate change has become one of the most essential concerns in the field of sustainable development, and its impacts (rising of sea levels, melting of polar ice caps, wild bush fires, intense droughts etc.,) can be felt in different parts of the globe (Dioha and Kumar 2020; Ali et al., 2013). The warming of our planet due to the emission of greenhouse gases is now unquestionable; and over the last century, the CO_2 atmospheric concentration has increased significantly and has, in turn, induced the average global temperature to increase by 0.74 °C as compared with the preindustrial era (UNFCCC 2007). The high temperature in urban areas affects mostly health, economy, leisure activities, and wellbeing of urban residents. Thermal stress caused by warming highly affects the health of vulnerable peoples (Tan et al., 2010; Patz et al., 2005).

As per the Sixth Assessment report of IPCC, warming has resulted in an increased frequency, intensity and duration of heat-related events, including heatwaves in most land regions. Frequency and intensity of droughts has increased in some regions (including the Mediterranean, west Asia, many parts of South America, much of Africa, and north-eastern Asia) and there has been an increase in the intensity of heavy precipitation events at a global scale. Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred.

One of the consequences of climatic change is the alteration of rainfall pattern and increase in surface air temperature. The agriculture and allied sectors are highly subtle to climatic variability, amid this, the temperature and rainfall directly distress the farm production (Thornton 2014). A midrange projection of climatic change from the period 2020-2039 indicates a crop yield reduction of 4.5 -9% depending on the magnitude and distribution of warming. Temperature drives the hydrological cycle (Smadi, 2006; Tabari and Talaee, 2011) and changes in temperature and radiation balance affects the agricultural productivity. High temperature can cause worsen drought in an area & also a reason for forest fires. High temperature are also responsible for reducing crop yield and crop damage.

In view of the above, a number of studies have attempted to investigate the trend of climatic variables for the country especially the trend of Temperature. The study focuses on the trend analysis of temperature in the city of Mandya, Karnataka, India. In order to detect the trend, a non-parametric Mann-Kendal test and to detect the magnitude of change, Sen' slope estimate has been used for the data collected over the past 30 years. The study will help for the better management and adopting suitable modifications to climate change in the city.

II. STUDY AREA AND DATA USED

The investigation was conducted for the Mandya city but the entire district is often referred as sugar city of Karnataka state. The study region lies between 76° 19' and 77° 20' east longitude and 12° 13' and 13° 04'north latitude which is characterized by an average annual rainfall of 700 mm with moderate temperature of about 35°C maximum and 20°C minimum with high productivity in agriculture.

Mandya district is bounded by Hassan, Tumakuru, Mysuru, and Bengaluru which is comprised by 7 taluks located in the southern dry zone of Karnataka state with a total geographical area of 4982.44 sq. km out of that more than half of the total land area in the district is put to the usage of agriculture. The main crops grown in the district are paddy, sugarcane, jowar, maize, cotton, banana, Vegetable, mulberry, gram, ragi, groundnut, horse gram, coconut etc.

The soil in the district is not known for its original fertile quality. Its water holding quality is low because of its highly bleached red sandy loam interspersed with some red clay loams. The whole of Mandya district is a plateau of heights ranging from 2500 to 3000 feet above sea level. There is a good network of rivers and streams in Mandya district which ensures perennial water supply for the perpetual sustenance of living beings in the district. There are 5 rivers flowing through the district viz., Cauvery, Hemavathi, Lokapavani, Shimsha and Veervasihavani and six streams viz. Nidasaletore, Hebbala, Shima, Handihalla, Amruthur and Bindenahalli. (District Industrial Profile, Mandya, MSME 2016).

For the present analysis, the daily temperature data series were collected from the University of Agricultural Sciences, V C Farm Mandya for about 30 years from the year 1991-2020. The collected daily data was converted into monthly and it is averaged to get Annual, Pre-monsoon (March-May), Monsoon (June–September), Post-monsoon (October and November), and Winter (December, January, and February). The study area was restricted to Mandya city as the data collected were confined to the city limits. Fig. 1 illustrates the location map of the selected study area.

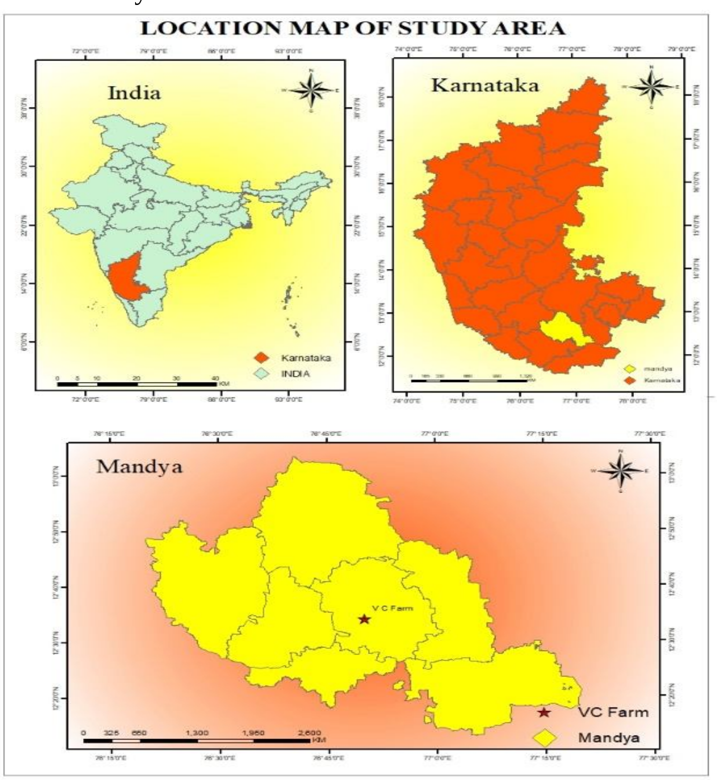

Fig. 1: Location map of the study area

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III. METHODOLOGY

In the present study, the non-parametric test - Mann-Kendall test and Sen's slope estimator test was used to detect the trend and magnitude of the data series respectively. To avoid the accumulation of mistakes, we should verify for randomness in the data series before running the MK test. To achieve this, the serial co-relation effect is adopted to determine the lag- 1 correlation constant. The following equation yields the upper and lower limits for the 95 percent significance threshold. If the Serial correlation is present, then the Pre-whitening method is applied to remove the effect of serial correlation.

$$R = \frac{-1 \pm 1.96\sqrt{n-2}}{n-1} \tag{1}$$

Where n is the number of years.

A. Non-parametric test

Mann-Kendall test is the non-parametric test where there is no assumption necessary for the distribution of data. The S statistics of Mann-Kendall is enumerated as follows:

$$S = \sum_{l=1}^{n-1} \sum_{k=l+1}^{n} sign(X_k - X_l) \tag{2}$$

Where,

$$sgn(x_k - x_l) = \begin{cases} +1, if\ x_k - x_l > 0 \\ 0, if x_k - x_l = 0 \\ -1, if\ x_k - x_l < 0 \end{cases} \tag{3}$$

Where x_k and x_l are the annual time series in the years k and l respectively. for n>10 the variance is enumerated as follows:

$$Var(s) = \frac{[n(n-1)(2n+5) - \sum_{j=1}^{p} t_j(t_j-1)(2t_j+5)]}{18} \tag{4}$$

The Z statistics of Mann Kendall is estimated as follows:

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}, if\ S > 0 \\ 0, if\ S = 0 \\ \frac{S+1}{\sqrt{VarS)}}, if\ S < 0 \end{cases} \tag{5}$$

When the z value is positive, it indicates a positive trend, whereas when it is negative, it indicates a negative trend. The null hypothesis is rejected and the alternative hypothesis is accepted for the significance level 95% when Z>1.965, for significance level 90% when Z>1.645, and for significance level 99% when Z>2.567.

B. Sen's Slope Estimator

The magnitude of the trend detected by the MK test can be found using Sen's slope estimate (Sen 1968). The slope T_i is obtained as follows:

$$T_i = \frac{x_k - x_l}{k-l} for\ i = 1, 2, 3, \dots\dots N \tag{6}$$

Where x_k and x_l are the data at the times k and l.

$$Q = \begin{cases} T_{\frac{N+1}{2}}, N\ is\ odd \\ \frac{1}{2}\left(T_{\frac{N}{2}} + T_{\frac{N+1}{2}}\right), Nis\ Even \end{cases} \tag{7}$$

When Q is positive, it shows the magnitude of a rising trend in the data time series, and when Q is negative, it indicates the downward trend.

IV. RESULTS AND DISCUSSIONS

Statistical characteristics such as mean, standard deviation, skewness, kurtosis, and coefficient of variation of yearly temperature series for the period 1991-2020 were determined using data obtained from V C Farm, Mandya. Form the analysis, it was found that the Maximum and Minimum temperature in Mandya city is 33.124 °C in the year 2016 and 15.923 °C in the year 1993 respectively. The average, maximum, and minimum temperatures are 24.345 °C, 30.701 °C, and 18.411°C, respectively, with standard deviations of 1.095 °C, 1.299 °C, and 1.093 °C for the average annual temperature series data. The skewness of average, maximum and minimum value is -0.939, -0.713 and -0.246 respectively indicating annual temperature in the region is asymmetric and left skewed (it lies to the left of the mean). Kurtosis value of annual average, maximum and minimum temperature 0.355, 0.151 and 0.240 respectively indicating the platykurtic shape. The statistical parameters for annual temperature data series are presented in the Table I.

Table I: Statistical Parameters of Annual temperature data series

Series	Max	Min	Mean	Standard Deviation	Skewness	Kurtosis	Coefficient of Variation
Average	25.958	21.635	24.347	1.095	-0.939	0.355	0.045
T Max	33.124	27.342	30.701	1.299	-0.713	0.151	0.042
T Min	20.842	15.923	18.411	1.093	-0.246	0.240	0.059

Before applying the MK test for the temperature data series, all the series are tested for the serial correlation using lag-1 autocorrelation. The results of lag-1 autocorrelation coefficients for the period from the year 1991 to 2020 at a 95% significance level are shown in the below Table II.

Table III: Lag-1 autocorrelation coefficients of temperature data series

	Average	Maximum	Minimum
Annual	-0.132	0.002	0.124
Pre Monsoon	-0.072	-0.010	0.128
Monsoon	-0.145	-0.046	0.239
Post Monsoon	0.017	-0.100	0.186
Winter	-0.160	0.239	-0.111

The results of Mann-Kendall test and Sen’s slope estimator, the Z and Q value over the period 1991to 2020 has been presented in the below Table III.

TABLE III: Results of Statistical test for temperature series data over the period 1991-2020

	Test	Average	Maximum	Minimum
Annual	MK-Z Value	2.46**	2.8***	0.39
	Sen's Slope Q Value	0.46	0.064	0.009
Premonsoon	MK-Z Value	2.37**	2.21**	0.57
	Sen's Slope Q Value	0.057	0.08	0.02
Monsoon	MK-Z Value	1.36	0.61	0.55
	Sen's Slope Q Value	0.023	0.013	0.009
Post Monsoon	MK-Z Value	1.61	1.87*	-0.39
	Sen's Slope Q Value	0.033	0.04	-0.011
Winter	MK-Z Value	1.71*	2.62***	0.61
	Sen's Slope Q Value	0.033	0.071	0.026

* indicates the significant trend at 90% significance level, **indicates the significant trend at the 95% significance level and ***indicates the significant trend at the 99% significance level.

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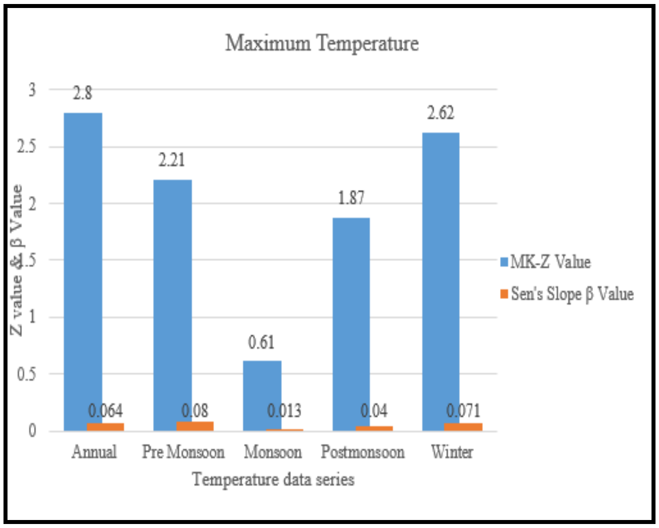
The results shown in the Table III indicates that, the increasing trend can be seen in all the cases considered. The significant increasing trend is seen for the annual series data for the significance level of 95 % and 99%. Similarly, the significant increasing trend is seen for the Pre-monsoon season for average as well as maximum temperature series data. An increasing trend at 90% significance level for the maximum temperature data series can be seen in the post monsoon season. The Mann-Kendall Z value and Sen's slope β value for the different temperature series have been present in the below graphs.



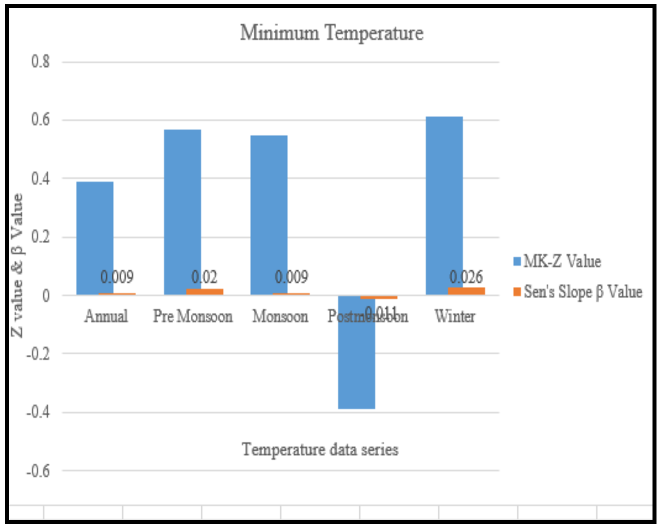


Fig. 2: MK-Z statistics and Sen's slope value for the maximum and minimum temperature data series

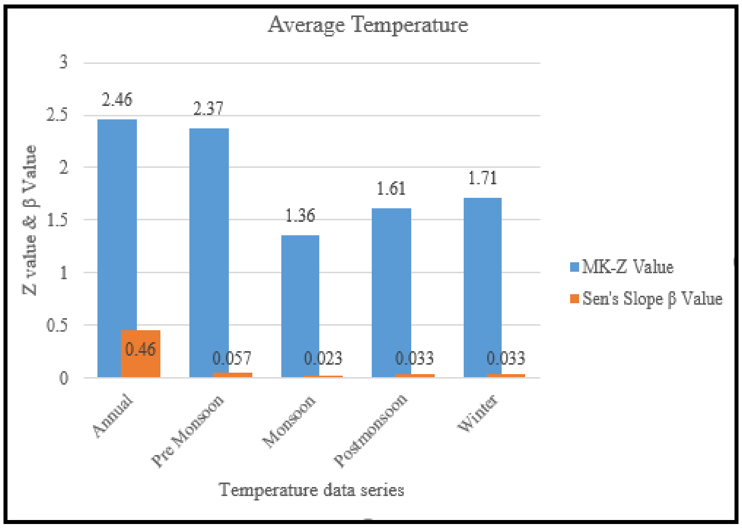


Fig. 3: MK-Z statistics and Sen's slope value for the average temperature data series

V. CONCLUSIONS

Based on the above results it can be concluded that, there is a significant increasing trend at Mandya city and the temperature is expected to increase over the coming years. The magnitude of the increasing trend will be in the range of 0.46 °C/year for the average time series. Also, there will be an average increase of 0.07 °C/year for the various scenarios considered in Mandya city for the Maximum temperature series.

As the selected study area is completely dependent on Agriculture for most of its income, the temperature plays a vital role. From the study it was evident that, the temperature will be increasing for the years to come. The rising tendency in maximum and minimum temperatures over the course of the year may result in a decrease in agricultural output also increases the crop water requirement. To avoid late-season dryness, it is important to change crops to short-duration types, and there is a pressing need for the creation of temperature-tolerant crop kinds that can be cultivated all year.

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REFERENCES

[1] Mahmoud M. Smadi. (2006). "Observed abrupt changes in Minimum and Maximum Temperatures in Jordan in the 20th Century". American Journal of Environmental Sciences, Vol. 2, Issue 3, pp. 114-120.

[2] Tabari H, Marofi S, Hosseinzadeh Talaee P and Mohammadi K (2011). "Trend analysis of reference evapotranspiration in the western half of Iran". Agricultural and Forest Meteorology, Vol. 151, Issue 2, pp. 128–136.

[3] Tan J G, Zheng Y F, Tang X, Guo C Y, Li L P and Song G X (2010). "The urban heat island and its impact on heat waves and human health in Shanghai". International Journal of Biometeorology, Vol. 54, pp. 75–84.

[4] Jonathan A. Patz, Diarmid Campbell-Lendrum, Tracey Holloway & Jonathan A. Foley (2005). "Impact of regional climate change on human health". Nature, Vol. 438, pp. 310–317.

[5] Michael Dioha, Atul Kumar (2020). "Exploring greenhouse gas mitigation strategies for agriculture in Africa: the case of Nigeria". AMBIO: A journal of the Human Environment, Vol. 49, Issue 9, pp. 1549-1566.

[6] Muhammad Aslam Ali, M. Anamul Hoque & Pil Joo Kim (2013). "Mitigating global warming potentials of methane and nitrous oxide gases from rice paddies under different irrigation regimes". AMBIO: A journal of the Human Environment, Vol. 42, Issue 3, pp. 357-368.

[7] Philip K. Thornton, Polly J. Ericksen, Mario Herrero and Andrew J. Challinor. (2014). "Climate variability and vulnerability to climate change: a review." Global Change Biology, Vol. 20, pp. 3313-3328.

[8] Amar Bahadur, Deepak Khare, Prabhash Mishra and Lakhwinder Singh. (2017). "Trend Analysis of Rainfall, Temperature and Runoff Data: A Case Study of Rangoon Watershed in Nepal", International Journal of Students Research in Technology & Management, Vol. 5, Issue 3, pp. 21-38.

[9] Shankarappa Sridhara, Pradeep Gopakkali and R Nandini. (2020). "Trend Analysis of Precipitation and Temperature over Different Districts of Karnataka: An Aid to Climate Change Detection and Cropping System Option". International Journal of Environment and Climate Change, Vol. 10, Issue 3, pp. 15-25.

[10] Anie John S and Brema Jay (2018). "Rainfall trend analysis by Mann-Kendall test for Vamanapuram river basin, Kerala". International Journal of Civil Engineering and Technology, Vol. 9, Issue 13, pp. 1549-1556.

[11] Radhakrishnan Kalidoss, Sivaraman Iyemperumal, Sunil Kumar Jena and Subhas Sarkar. (2017) "A Climate Trend Analysis of Temperature and Rainfall in India". Climate Change and Environmental Sustainability, Vol. 5, Issue 2, pp. 146-153.

[12] Madhusudhan M S, H J Ningaraju and Shashank Patil M R. (2021). "Analysis of Rainfall Trend Series using Mann-Kendall and Sen's Slope Estimator Statistical Test in Mandya District, Karnataka". International Research Journal of Engineering and Technology, Vol. 8, Issue 5, pp. 3387-3393.

[13] Jayashree V Revadekar, D. R. Kothawale, Savita Patwardhan and G. B. Pant. (2012). "About the observed and future changes in temperature extremes over India". Natural Hazards, Vol. 60, Issue 3, pp. 1133-1155.

[14] Manohar Arora, N. K. Goel and Pratap Singh. (2005). "Evaluation of temperature trends over India". Hydrological Sciences Journal, Vol. 50, Issue 1, pp. 81-93.

[15] Med Gedefaw, Hao Wang, Tianling Qin, Abel Girma, Asaminew Abiyu and Dorjsuren Batsuren. (2018). "Innovative Trend Analysis of Annual and Seasonal Rainfall Variability in Amhara Regional State, Ethiopia". Atmosphere, Vol. 9, Issue 326, pp. 1-10.

[16] Arnab Kundu, Siddhartha Chatterjee, Dipanwita K Dutta and Azizur Rahman Siddiqui. (2015). "Meteorological trend analysis in western Rajasthan (India) using Geographical Information System and statistical techniques". Journal of Environment and Earth Science, Vol. 5, Issue 5, pp. 90-99.

[17] Rawshan Ali, Alban Kuriqi, Shadan Abubaker and Ozgur Kisi. (2019). "Long-Term Trends and Seasonality Detection of the Observed Flow in Yangtze River Using Mann-Kendall and Sen's Innovative Trend Method". Water, Vol. 11, Issue 1855, pp. 1-17.

[18] Pranab Kumar Sen. (1968). "Estimates of the Regression Coefficient Based on Kendall's Tau". Journal of the American Statistical Association, Vol. 63, pp. 1379-1389.

[19] Solomon Addisu, Yihenew G. Selassie, Getachew Fissha and Birhanu Gedif. (2015). "Time series trend analysis of temperature and rainfall in lake Tana Sub-basin, Ethiopia". Environmental Systems Research, Vol. 4, Issue 25, pp. 1-12.

[20] District Industrial Profile, Mandya, MSME 2016 assessed on 15th May 2021.

[21] United Nations Framework Convention on Climate Change (UNFCCC). (2007). Climate change: Impacts, vulnerabilities and adaptation in developing countries, Climate Change Secretariat (UNFCCC), Germany, 8-10.

[22] H. M Vinaya Kumar, M. Shivamurthy and M. M. Lunagarla. (2017). "Rainfall Trend Analysis and Adaptation Strategies to manage Climate Induced crisis in Coastal Zone of Karnataka, India". Journal of Scientific Research and Reports, Vol. 3, Issue 5, pp. 1-11.

[23] Darshana Duhan and Ashish Pandey. (2012). "Statistical analysis of long term spatial and temporal trends of precipitation during 1901-2002 at Madhya Pradesh, India". Atmospheric Research, Vol. 122, pp. 136-149.

[24] Brunsell and N. A. (2010). "A multiscale information theory approach to assess spatial–temporal variability of daily precipitation". Journal of Hydrology, Vol. 385, pp. 165–172.

[25] Rituraj Shukla and Deepak Khare. (2013). "Historical Trend Investigation of Temperature Variation in Indira Sagar Canal Command Area in Madhya Pradesh (1901– 2005)". International Journal of Advanced Information Science and Technology (IJAIST), Vol 15, Issue 15, pp. 58-67.

[26] S. Sridhara,Pradeep Gopakkali and R. Nandini.(2020). "Trend Analysis of Precipitation and Temperature over Different Districts of Karnataka: An Aid to Climate Change Detection and Cropping System Option". International Journal of Environment and Climate Change, Vol. 10, Issue 3, pp. 15-25.