

Analysis of Short Term and Long Term Dependence of Stream Flow Phenomenon in Seonath River Basin, Chhattisgarh

Shashikant Verma, Bhupendra Kumar Dhiwar

M.Tech. Scholar, Water Resources Development & Irrigation Engineering, Department Civil Engineering, NIT Raipur, India

Abstract— In this paper to investigate long range phenomena (Hurst effect) of river flows which characterizes hydrological time series is studied, especially in connection with various climate-related factors, is important to improve stochastic models for long-range phenomena and in order to understand the deterministic and stochastic variability in long-range dependence of stream flow. Long range dependence represented by the Hurst coefficient H is estimated for 5 mean monthly discharge time series of Chhattisgarh state for a period of 32 years from 1980-2012. Long memory analyzed for both monthly and seasonally stream flow time series of the Seonath River Basin at Chhattisgarh State by using Hurst exponent and testing specifically the null hypothesis of short-term memory in the monthly and seasonal time series by (Von Neumann ratio test, Kendall's rank correlation test, Median crossing test, Run above and below the median for general randomness, Turning point test, Rank difference test).

Keywords— Hurst Phenomena, Stochastic, Streamflow Processes, Long Memory Time Series.

I. INTRODUCTION

The number of time scale studies have been analyzing for the long-term behaviour of streamflow has increase adequately in the accomplished duration with exceptional quality and data availability with increasing interest of influence of climate change and climate-related factors on stream flow processes (Bloschl and Montanari, 2010), [1] the extent and complexity of such a consideration have increased. The necessity of such research lies in the need for incorporate long-range dependence and to developed speculative models, which can be used for illustration in the management of water resources or reservoir action. Another property characterizing time series from a long-range perspective is the long-term dependence (Hurst phenomenon (Hurst, 1951). [2] The phenomena of long-range persistence have a long history and have been authenticated appropriately in hydrology, meteorology and geophysics. Present day studies have led to reawakening and to add analyze long-term persistence in

temporal time series of hydrologic data and also to developed applicable methods for estimating and modelling the intensity of long-term persistence in time series, as well as providing the reason for the Hurst phenomena. Based on the consideration of long-term persistence, a stationary process x_t processes long memory if there be present in a real number $H \in (0.5, 1)$, called the Hurst exponent (Montanari et al., 2000).[3] The exponent H , in a hydrological time series, is called the devotion of long-term persistence and it can be numerically denoted by the Hurst coefficient H . when $H > 0.5$ higher the intensity of long-term or long-range persistence in the data and when $H < 0.5$ be identical to short-term negative time persistence, which is almost never encountered in the analysis of hydrological data (Montanari et al., 2000).[3] To test for significant statistically long-term memory on a hydrologic time series, a significant difference between short term and long term persistence must be accomplished (Rao and Bhattacharya, 1999).[4] The phenomena of short-term persistence are based on the concept of strong mixing (Rosenblatt, 1956) [5] which measure correlation sequentially among two cases distinct by increasing time lags. Against this background, Towards this end Hurst exponent used for ascertain the appearance of long term persistence in data series and testing specifically the null hypothesis of short term Long range dependence also called long memory or long-range persistence is a phenomenon that may arise in the analysis of spatial and time series data usually considered to have long range dependence if the dependence decays more slowly than an exponential decay and Short range dependence also called short memory or short range persistence a process is said to be short range dependence if the dependence among the observations diminishes fast.

The phenomena of short-term dependence are based on the notion of strong mixing (Rosenblatt, 1956). [5] Which measure correlation successively between two events separated by increasing time lags. Against this background, the primary objective of this study is, (1) to investigate the streamflow time series of Seonath River

for monthly and seasonal time scales are characterised by long-term dependence. If it is present in the given series then it can not a significant serial correlation among the observations which are far apart in time. (2) The purpose of Long-range dependence and short-range dependencies are to determine the magnitude and pattern of variations in streamflow during the study period, which will be helpful to predict the behaviour of streamflow in future over the study area. exponent used for detecting the presence of long-term dependence in data series and testing specifically the null hypothesis of short-term dependence in the monthly and seasonal time series by (Von Neumann ratio test, Kendall’s rank correlation test, Median crossing test, Run above and below the median, Turning point test, Rank difference test).

II. STUDY AREA AND DATA QUALITY APPROACHES

The study area is the seonath river basin of Chhattisgarh state, India. It is a major tributary of Mahanadi river which is situated between 20° 16’N to 22° 41’N Latitude and 80°

25°E to 82° 35’E Longitude it consists a large portion of the upper Mahanadi valley and its traverse length of 380 kilometres. The area of the basin is 30560 square kilometres. The Monthly Discharge data of 5 Meteorological stations for whole Seonath River Basin for a period of 32 years i.e. 1980-2012 is collected from Department of state data centre Water Resources, Raipur (Chhattisgarh). To investigate the long term and short term dependence phenomena in the flow series, the average daily flows are aggregated to mean monthly stream flows by summing the average daily flow over the total number of days in the month. thus, for long-term dependence analysis, the seasonality must be removed. To remove the seasonality in the monthly flow series are log-transformed to normalise the data then deseasonalized; the deseasonalized is done as follows.

$$m_{(j,i)} = \frac{x_{(j,i)} * \bar{x}}{S_{(i)}}$$

Where \bar{x} , is the monthly mean, $S_{(i)}$ the standard deviation and $x_{(j,i)}$ is the flow data matrix.

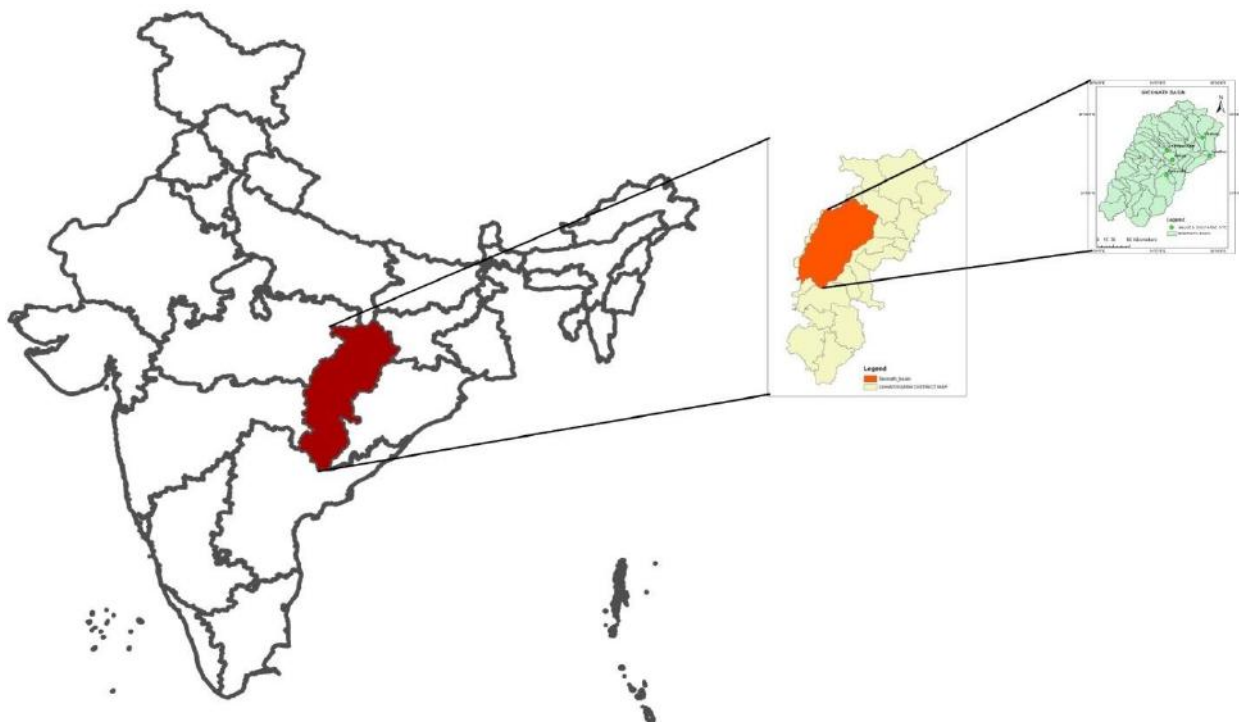


Fig.2.1: An Index of Seonath River Basin

2.1 Test for independence:

The serial correlation coefficient (SCC) was performed to verify the dependency. It is the correlation between adjacent observations in time series data. According to Box and Jenkins the lag_1 serial correlation coefficient, r_1 is computed as follows, for 5% significance level, if $r_1 < 0.5$ then the station is considered as independent, r_1 is given as below.

$$\frac{\sum_{i=1}^{n-1} (x_i - \bar{x}) * (x_{i+1} - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

2.2 Test for randomness:

Test for randomness is performed to identify whether there is any recognised pattern. If the data is non-random it shows that process then generates the event is following a trend. The data should be random for any time series analysis; the run test is carried out for this purpose, for 5% significance level, if $Z > 0.05$ then the station is

considered as random. As per test when randomness is more in given time series it means there is more probability to become trendless in such a time series.

$$Z = \frac{R - R_1}{S_r}$$

$$R_1 = 1 + \frac{(2 * A * B)}{n}$$

$$S_r = \sqrt{\frac{2 * A * B * ((2 * A * B) - (-N))}{n^2 * (n - 1)}}$$

Where R is observed number of runs, R₁ is the expected number of run, n is the number of observation, A is the number of observation above k, B is the number of

observations above k, and k is the mean of the observations

2.3 Test for consistency/Homogeneity:

Consistency test is performed to identify that the behaviour mechanism that generates a part of time series data is considered with the segment of the time series data. For this purpose, standard normal homogeneity test (SNHT) is done with the help of XLSTAT plug in a package for MS-Excel is used. For 5% significance level, if p > 0.05 then the station is considered as consistent.

Table. Results of Data Quality Test Results of G&D Station

S.NO.	G&D STATION NAME	TEST FOR INDEPENDENCE	TEST FOR RANDOMNESS	TEST FOR HOMOGENEITY
		SCC TEST	RUNS TEST	SNH TEST
		P<0.5	P>0.05	P>0.05
1.	ANDHYAKORE	0.35	0.26	0.34
2.	GHATORA	0.43	0.50	0.21
3.	JONDHRA	0.49	0.1	0.125
4.	PATHARDIH	0.43	0.26	0.91
5.	SIMGA	0.48	0.16	0.58

III. METHODOLOGY

3.1 METHODS FOR DETECTING LONG TERM DEPENDENCE:

3.1.1 HURST EXPONENT:

Long range dependence is numerically expressed by the Hurst coefficient H (0 - 1) in general holds H = 0.5, the time series is random noise for H < 0.5, the time series is said to be anti-persistence.

$$\text{Range } (R_n) = \text{Max. } \left| \sum (Z_i - Z) \right| - \text{Min. } \left| \sum (Z_i - Z) \right|$$

$$R_n = d_n^+ - d_n^-$$

Where, d_n⁺ is maximum positive cumulative deviation and d_n⁻ is minimum negative cumulative deviation.

$$H = \frac{\ln(R_n^*)}{\ln\left(\frac{n}{2}\right)}$$

Where n is the no. of data set where,

$$R_n^* = \left\{ \frac{R_n}{\sigma_n} \right\}$$

Where, σ_n is the standard deviation, Long range dependence can be numerically by the Hurst coefficient this is a coefficient ranging between 0 and 1, where H > 0.5 indicates long-range dependence in the data.

3.2 NULL HYPOTHESIS TESTING FOR SHORT TERM DEPENDENCE:

3.2.1 VON NEUMANN RATIO TEST:

The null hypothesis test for short-term dependence is done by using the von Neumann ratio test, (Madansky, 1988).[6] The null hypothesis of no long-term dependence, the following test statistics is computed for

both monthly and seasonal streamflow time series. The null hypothesis in this test is that the time series variable is independently and identically distributed (random). The alternate hypothesis is that the series is not random, The von Neumann ratio (N) is the most widely used test for testing a time series for the absence or presence of homogeneity and also identified the presence of short-term dependence and the null hypothesis of no short-term dependence in given time series.

$$NR = \frac{\sum_{t=2}^n (x_t - x_{t-1})^2}{\sum_{t=1}^n (x_t - \bar{x})^2}$$

Where x_t =hydrologic variable constituting the sequence in time, n = total number of hydrologic records, and x = average of x_t , If data are independent, NR is approximately normally distributed with E (V) = 2 under the null hypothesis, E (NR) = 2. The mean of NR tends to be smaller than 2 for a non-homogeneous series and Var (NR) = $\frac{4 * (n-2)}{(n^2-1)}$, i.e.

$$Z = \frac{V-2}{\left[4 * \frac{(n-2)}{(n^2-1)}\right]^{0.5}}$$

3.2.2 KENDALL'S RANK CORRELATION TEST:

Rank correlation (Kendall, 1948; Abdi, 2007). [7, 8] Can be used to establish whether an apparent trend in a series is significant or not. The number of times p in all pairs of observations x_i, x_j; j > i that x_j > x_i is determined (i.e., for i = 1, N - 1 how many times x_j > x_i is for j = i + 1, i + 2, N).

The test is carried out using the statistic \bar{U} (known as Kendall's \bar{U} and which varies between ± 1) defined as $\bar{U} = \frac{4P}{N*(N-1)-1}$ for a random series, $E(\bar{U}) = 0$, and its variance is given as $Var(\bar{U}) = \frac{2*(2N+5)}{9N*(N-1)}$. As N increases, $\frac{\bar{U}-E(\bar{U})}{\sqrt{Var(\bar{U})}}$ converges to a standard normal distribution. It may also be possible to carry out a test using $E(\bar{U})$ that takes values of -1 and 1 , leading to the inference that there is a rising or falling trend. In this test we have to correlate the two adjacent variables in between -1 to 1 and after adding all the variables we get to chances of no trend in series if the value of 'z' lies within the limits ± 1.96 at the 5% significance level, the null hypothesis of no trend cannot be rejected.

3.2.3 MEDIAN CROSSING TEST:

(Fisz, 1963). [9] x is replaced by zero if $x < \tilde{x}$ (median), and X is replaced by one if $x_i > \tilde{x}$. If the original sequence of x has been generated by a purely random process. In this test we have to compare all variables from a median of the series and after comparing us gets to a number of crossed or not crossed in given time series.

$$m = N \left[\frac{(N-1)}{2} \right], \left[\frac{(N-1)}{4} \right]^{0.5}$$

3.2.4 RUN ABOVE OR BELOW THE MEDIAN TEST FOR GENERAL RANDOMNESS:

(Shiau and Condie, 1980). [10] The necessary condition for applying this test is that the observations in the sample are obtained under similar conditions. Null hypothesis (H_0) is made that the observations in a time series are independent of the order in the sequence, which is tested by the run test on successive differences. From the sequence of observations x_t ($t = 1, 2, \dots, n$), a sequence of successive differences ($x_{t+1} - x_t$) is formed (i.e., each observation has the preceding one subtracted from it). In this test, we have to compare all variables from a median of the series and after comparing us get to a number of run above or run below in given time series. The test-statistic (K) is defined as the number of runs of '+' and '-' signs in the sequence of differences. If M_s represents the total number of runs above and below the median of length s , then for a random process.

$$E(M_s) = \frac{(n+3-s)}{(2^s-1)}$$

$$\frac{\sum_{s=1}^{s'} [M_s - E(M_s)]^2}{E(M_s) \approx x^2 * (s'-1)}$$

where s' is the maximum run length in the sequence.

3.2.5 TURNING POINTS TEST:

Let's assume that a turning point occurs in the series x_t ($t = 1, 2, \dots, n$) at any time t ($t = 2, 3, \dots, n-1$) if x_t is larger than each of x_{t-1} and x_{t+1} or x_t is smaller than x_{t-1} and x_{t+1} this situation has four chances of occurrence in six different possibilities of the occurrence of x_{t-1} and x_{t+1} , assuming that all three elements have different values. In this test, we have to identify the number of turning points in given time series, when number turning point is more it means more chances to randomness or trendless in the dataset. Accordingly, the chance of having a turning point in a sequence of three values is $4/6$ or $2/3$, for all the values of t except for $t = 1$ and $t = n$. In other words, the expected number of turning points (\bar{p}) in the given random series can be expressed as (Kendall and Stuart, 1976). [11].

$$\bar{p} = \frac{2*(n-2)}{3}$$

random series, variance is given by (Kendall, 1973)

$$Var(\bar{p}) = \frac{(16n-29)}{90}$$

The test-statistic is represented by the standard normal variate (z), and is given as:

$$Z = \frac{|p-\bar{p}|}{\sqrt{Var(\bar{p})}}$$

where p is observed number of turning points

It is a very easy to test to apply to a series of randomness observation involves the counting of the number of local maxima and minima, the interval between two turning points is called phase Turning point test reasonable against cyclicity but poor as a test against the trend.

3.2.6 RANK DIFFERENCE TEST:

(Meacham, 1968). [12] Flows are replaced by their relative ranks R_i with the lowest being denoted by Rank 1 (R_i). The U statistic is evaluated by

$$U = \sum_{i=2}^n |R_i - R_{i-1}|$$

For large n ,

$$U = \left\{ \frac{(n+1)*(n-1)}{3}, \left[\frac{(n-2)*(n+1)*(4*n+7)}{90} \right]^{0.5} \right\}$$

IV. RESULTS AND DISCUSSION

The Hurst exponent (K) for different months of the year and seasonal time series is presented in table-1.

Table.1: Values of Hurst exponent (k) for (G&D Stations)

Months	Andhyakore	Ghatora	Jondhra	Pathardih	Simga
January	0.6574	0.6130	0.6832	0.8838	0.8003
February	0.5999	0.5868	0.5327	0.7374	0.5760
March	0.7404	0.7576	0.7901	0.8024	0.8261

Months	Andhyakore	Ghatora	Jondhra	Pathardih	Simga
April	0.7670	0.8010	0.7884	0.8251	0.8321
May	0.8196	0.7276	0.8035	0.7528	0.7945
June	0.6253	0.6292	0.6371	0.6703	0.6006
July	0.7103	0.6049	0.5680	0.7234	0.6088
August	0.6925	0.7240	0.5970	0.8516	0.4956
September	0.6342	0.7382	0.4819	0.7848	0.5770
October	0.5541	0.6545	0.5754	0.7557	0.5317
November	0.7162	0.7102	0.6919	0.7956	0.5977
December	0.6586	0.6435	0.6243	0.8279	0.6900
Annual	0.6872	0.7343	0.5220	0.8730	0.5280
Winter	0.7256	0.7186	0.6925	0.8473	0.7417
Pre-monsoon	0.7812	0.7963	0.8030	0.8043	0.8280
Monsoon	0.6907	0.6936	0.5279	0.8720	0.5298
Post-monsoon	0.7038	0.6890	0.6027	0.7861	0.5198

Where the bold value represents no long-term dependence for the given time series and remaining value shows term persistence.

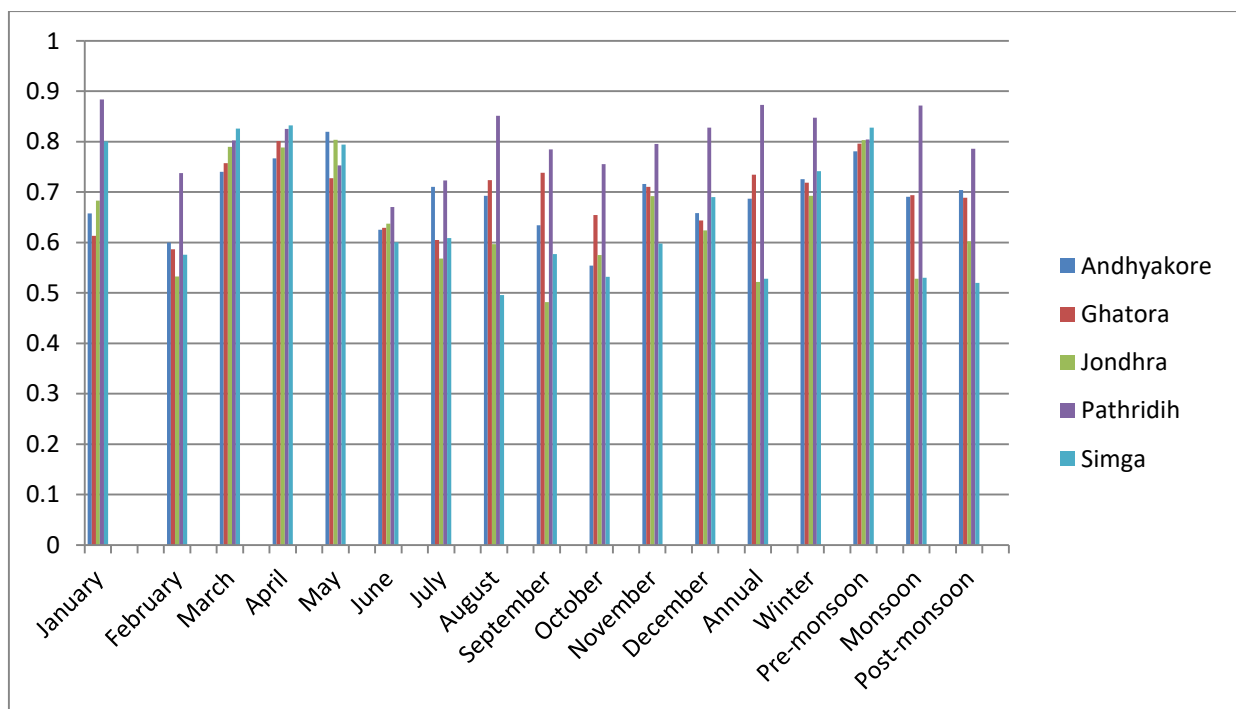


Fig.2: Hurst Exponent (K) For (G&D Stations)

Table.2: Values of Z statistics for short-term dependence by Von Neumann ratio test

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JANUARY	0.0650	0.0052	0.0047	8.0933	0.0197
FEBUARY	0.0508	0.0320	0.0141	1.5799	0.0451
MARCH	0.0731	0.0981	0.0353	9.0117	0.3008
APRIL	0.0919	0.3380	0.3435	9.0288	0.6840
MAY	0.1800	0.2216	0.5737	3.9725	0.7284
JUNE	0.0533	0.0362	0.0680	0.0649	0.0478
JULY	0.0095	0.0070	0.0299	0.1708	0.0029
AUGEST	0.1160	0.0722	0.0348	0.2600	0.0590
SEPTEMBER	0.0171	0.0869	0.1240	0.1140	0.0241
OCTOBER	0.1207	0.0644	0.1114	0.0204	0.1071

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
NOVEMBER	0.0811	0.1801	0.0427	0.0679	0.0016
DECEMBER	0.0937	0.0459	0.0204	3.0213	0.0444
ANNUAL	0.0128	0.0704	0.1081	0.2678	0.0404
WINTER	0.3226	0.2549	0.1944	4.8820	0.0783
PRE-MONSOON	0.1103	0.2598	0.2335	7.5652	0.5561
MONSOON	0.0116	0.0701	0.1050	0.2683	0.0282
POST-MONSOON	0.1613	0.0127	0.1105	0.0368	0.1233

Where, Table -2 represent The Null hypothesis of no short-term dependence in the series is accepted and thus the given series can be assumed to be random at 10%, 5% and 1% significance level.

Table.3: Values of Z statistics for short-term dependence by Kendall's Rank Correlation test

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JANUARY	<u>1.8811</u>	1.2067	2.7024*	0.6969	2.8384*
FEBRUARY	<u>1.7514</u>	2.6344*	<u>1.9206</u>	0.1190	2.5665
MARCH	3.1784*	3.3823*	3.1783*	2.8384*	3.8922*
APRIL	3.6649*	3.7562*	3.5183	3.5183*	3.5183
MAY	3.1784*	3.5523*	3.5183	3.9262*	3.4503
JUNE	0.5189	1.4787	1.3087	0.8668	1.5807
JULY	1.5568	<u>1.7166</u>	0.2210	2.7024*	1.0368
AUGEST	1.1676	1.5462	0.5949	2.1246	0.3909
SEPTEMBER	0.2595	1.0028	0.1870	3.4503*	0.3909
OCTOBER	2.3027	1.1388	1.2407	2.5665	0.4929
NOVEMBER	0.7784	0.5949	0.5269	2.1925	0.7648
DECEMBER	2.1406	2.0226	2.0566	0.0170	2.4645
ANNUAL	0.6811	<u>1.6487</u>	0.4929	2.3285	0.4589
WINTER	1.9784	1.4787	2.1925*	0.7648	2.4305
PRE-MONSOON	2.7892*	3.4843*	3.5523*	2.8044*	3.7562*
MONSOON	0.5838	<u>1.9546</u>	0.5269	2.4305	0.2549
POST-MONSOON	1.1597	0.9688	1.2067	2.2945	0.6969

Where,

- The Bold value represents null hypothesis of **No short-term dependence** in the series is accepted and thus the given series can be assumed to be having **No trend at 1% significance level.**
- Marks represents null hypothesis of **No short-term dependence** in the series is accepted and thus the given series can be assumed to be having **No trend at 5% and 1% significance level.**
- 1.8811 represent represents null hypothesis of **No short-term dependence** in the series is accepted and thus the given series can be assumed to be having **No trend at 10% significance level.**
- (*) marks represents null hypothesis of **No short-term dependence** in the series is accepted and thus the given series can be assumed to be having **No trend**
- The remaining value represents null hypothesis of **No short-term dependence** in the series is accepted and thus the given series can be assumed to be having **No trend at 10%, 5% and 1% significance level.**

Table.4: Values of Z statistics for short-term dependence by Median crossing test

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JANUARY	1.0954	1.0954	0.3651	3.2863	1.0954
FEBUARY	1.8257	1.0954	1.8257	2.5560	1.8257
MARCH	0.3651	0.3651	1.0954	3.2863	2.1908
APRIL	2.5560	2.5560	1.4605	2.5560	1.4605
MAY	1.8257	3.2863	1.8257	-3.2863	2.1908

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JUNE	0.7302	1.4605	0.7302	2.5560	1.4605
JULY	0.000	0.7303	0.3651	1.4605	1.0954
AUGEST	0.7302	0.000	0.000	1.4605	0.3651
SEPTEMBER	0.000	0.000	0.3651	2.1908	0.3651
OCTOBER	1.8257	1.4605	2.1908	2.1908	-0.3651
NOVEMBER	1.4605	0.7303	0.3651	2.9211	0.3651
DECEMBER	0.7302	0.000	0.7303	2.5560	1.8257
ANNUAL	0.000	2.1908	1.8257	2.1908	0.3651
WINTER	2.5560	1.0954	1.0954	3.2863	2.5560
PRE-MONSOON	1.0954	2.5560	1.0954	3.2863	1.4605
MONSOON	0.000	1.4605	0.3651	1.4605	0.3651
POST-MONSOON	1.4605	2.1908	2.5560	2.1908	0.3651

Where,

- The Bold value represents **short-term dependence is observed** in the given series thus the data **cannot be random at 5% significance level**.
- The remaining value represents **No short-term dependence is observed** in the given series thus the data **can be random at 5% significance level**.

Table.5: Values of Z statistics for short-term dependence by Run above and below the median for general randomness

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JANUARY	3.00	8.00	2.00	45.00	2.00
FEBUARY	10.00	8.00	24.00	88.00	26.00
MARCH	3.00	15.00	7.00	178.00	19.00
APRIL	3.00	18.00	19.00	371.00	3.00
MAY	4.00	127.00	103.00	347.00	26.00
JUNE	5.00	4.00	7.00	63.00	3.00
JULY	15.00	7.00	7.00	41.00	3.00
AUGEST	3.00	2.00	6.00	86.00	5.00
SEPTEMBER	2.00	2.00	3.00	88.00	1.00
OCTOBER	5.00	3.00	3.00	85.00	3.00
NOVEMBER	1.00	3.00	11.00	88.00	5.00
DECEMBER	7.00	6.00	6.00	88.00	7.00
ANNUAL	1.00	8.00	1.00	87.00	3.00
WINTER	10.00	5.00	8.00	49.00	20.00
PRE-MONSOON	1.00	8.00	22.00	86.00	19.00
MONSOON	13.00	8.00	1.00	86.00	5.00
POST-MONSOON	2.00	6.00	3.00	93.00	10.00

Where The Bold value represents “No short-term dependence” in the given series and remaining has No dependence at 5% significance level in the given series.

Table.6: Values of Z statistics for Randomness by Turning point test

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JANUARY	0.7317*	0.1463*	0.1463*	1.9023	1.1707*
FEBUARY	0.1463*	1.9023	1.0243*	3.6583	0.7317*
MARCH	1.0243*	1.9023	0.7317*	4.9753	0.2927*
APRIL	1.0243*	3.6583	1.0243*	4.9753	0.2927*
MAY	2.7803	3.6583	<u>2.3413</u>	5.4143	0.1463*

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JUNE	0.2927*	0.7317*	0,2927*	4.5363	0.7317*
JULY	0.5853*	1.0243*	1.1707*	1.9023	0.1463*
AUGEST	1.4633*	0.1463*	1.1707*	<u>2.3413</u>	1.1707*
SEPTEMBER	1.1707*	0.1463*	1.9023	3.2193	1.4633*
OCTOBER	0.7317*	<u>2.0487</u>	1.1707*	1.4633*	1.1707*
NOVEMBER	0.7317*	0.1463*	0.7317*	<u>2.3413</u>	0.1463*
DECEMBER	0.7317*	0.1463*	0.2927*	3.6583	1.1707*
ANNUAL	4.5363	3.6583	4.0973	5.4143	3.6583
WINTER	2.7803	<u>2,3413</u>	1.9023	<u>5.5363</u>	1.4633*
PRE-MONSOON	1.0243*	1.9023	0.7317*	4.9753	0.2927*
MONSOON	1.4633*	1.6097*	0.7317*	<u>2.3413</u>	<u>1.1707</u>
POST-MONSOON	0.7317*	1.1707*	1.6097*	4.9753	1.1707

Where,

- (*) Marks represents null hypothesis of no short-term dependence in the series is accepted and thus the given series can be assumed to be random at 10%, 5% and 1% significance level.
- The Bold value represents null hypothesis of no short-term dependence in the series is accepted and thus the given series can be assumed to be random at 5% and 1% significance level.
- ____ Sign represents null hypothesis of no short-term dependence in the series is accepted and thus the given series can be assumed to be random at 1% significance level.

Table.7: Values of Z statistics for short-term dependence by Rank difference test

Months	Andhyakore	Ghatora	Jondhra	Pathridih	Simga
JANUARY	1.2380	1.5835	0.8349	5.8157	1.5259
FEBUARY	1.9002	2.6200	0.9789	5.8733	1.2092
MARCH	2.2457	2.5912	2.0154	7.4280	2.3896
APRIL	3.0518	5.2111	2.2169	7.7735	2.7351
MAY	3.7140	5.0096	3.2246	7.6008	2.6488
JUNE	0.9213	0.1152	0.6046	4.7793	0.4319
JULY	0.6334	0.6622	0.3743	4.2323	0.2303
AUGEST	1.3532	0.4319	0.5470	4.5490	0.2591
SEPTEMBER	0.5182	0.4607	0.6046	4.8944	0.2303
OCTOBER	0.9789	0.8061	1.1228	3.8004	0.7198
NOVEMBER	0.4607	0.6046	0.4319	4.8657	0.0288
DECEMBER	1.0365	0.7774	0.5470	5.4991	1.8138
ANNUAL	0.5182	0.2303	1.1516	4.5490	0.2591
WINTER	3.742	3.2246	2.8503	6.2476	2.8503
PRE-MONSOON	2.591	4.2035	2.2457	7.2553	2.3896
MONSOON	0.4894	0.4607	1.2092	4.4914	0.2879
POST-MONSOON	0.1152	0.4319	1.0077	3.9443	0.8349

Where,

- At 5% significance level, the value of standard normal variate is “1.95996” below this level show “No short-term dependence observed” thus given series can be random at 5% significance level.
- The Bold value represents Null hypothesis of no short-term dependence in the given series, at 5% significance level.

V. CONCLUSION

The main objective of this study was to detect short-term and long-term dependence of streamflow time series. As a first step, Hurst coefficient was estimated at 5 Gauge and

Discharge stations of daily river discharge time series for Seonath River Basin, Chhattisgarh State. For Hurst phenomena, the Hurst exponent was greater than 0.5. And this Statistical analysis H is estimated greater than 0.7 in

the majority of different time scales and also observed that the null hypothesis of no dependence at 10%, 5% and 1% significance level for all the estimators. The finding of this study has more important implications for hydrological modelling especially in reservoir operation and water resource management for example, in order to estimate the risk of supply from a reservoir the long-term dependence primary incorporated into the model, this study suggests that to identify the main factors associated with the climate variability and storage that affects the long-term dependence of streamflow at a regional scale. Change in climate could have directly and indirectly affected by the various environmental variables including discharge in many countries of the world. Change in discharge regime directly affects the management of water resources, agriculture, hydrology and ecosystems. Hence it is important to identify the changes in the magnitude of the temporal and spatial behaviour of discharge is imperative for suggesting the suitable strategies for sustainable management of water resources, agriculture, environment and ecosystems.

REFERENCES

- Branch, Inland Waters Directorate, Environment Canada, Ottawa, Ont.
- [1] Blöschl, G. and Montanari, A., 2010. Climate change impacts—throwing the dice? *Hydrological Processes*, 24(3), pp.374-381.
- [2] Hurst, H.E., 1951. The long-term storage capacity of reservoirs. *Trans. Amer. Soc. Civil Eng.*, 116, pp.770-808.
- [3] Montanari, A., Rosso, R. and Taqqu, M.S., 2000. A seasonal fractional ARIMA model applied to the Nile River monthly flows at Aswan. *Water Resources Research*, 36(5), pp.1249-1259.
- [4] RAMACHANDRA RAO, A. and BHATTACHARYA, D., 1999. Hypothesis testing for long-term memory in hydrologic series. *Journal of Hydrology*, 216(3-4), pp.183-196.
- [5] Rosenblatt, M., 1956. A central limit theorem and a strong mixing condition. *Proceedings of the National Academy of Sciences*, 42(1), pp.43-47.
- [6] Madansky, A., 1988. Testing for normality. In *Prescriptions for working statisticians* (pp. 14-55). Springer New York.
- [7] Kendall, M.G., 1948. Rank correlation methods.
- [8] Abdi, H., 2007. The Kendall rank correlation coefficient. *Encyclopedia of Measurement and Statistics*. Sage, Thousand Oaks, CA, pp.508-510.
- [9] Fisz, M., 1963. Probability theory and mathematical statistics John Wiley and Sons. Inc., New York.
- [10] Shiau, S.Y. and Condie, R., 1980. Statistical tests for independence, trend, homogeneity and randomness. Hydrologic Applications Division. *Water Resources*
- [11] Kendall, M.G. and Stuart, A., 1968. The Advanced Theory of Statistics, Vol. 3, Charles Griffin & Co. London, 1946 Kendall I The Advanced Theory of Statistics 1946.
- [12] Meacham, I., 1968. Correlation in sequential data three sample indicators. *Civil Eng. Trans. Inst. Eng. Aust*, 10, pp.225-228.
- [13] Koutsoyiannis, D., 2003. Climate change, the Hurst phenomenon, and hydrological statistics. *Hydrological Sciences Journal*, 48(1), pp.3-24.
- [14] Otache, M.Y., Li, Z. and Bakir, M., 2008. Analysis of long-term dependence phenomenon in Benue River flow process and its hypothesis testing. *Chinese Journal of Oceanology and Limnology*, 26(3), pp.313-322.
- [15] Percival, D.B., 1996. Statistics for Long-Memory Processes. *Journal of the American Statistical Association*, 91(435), pp.1379-1381.