

Estimation of Runoff Yield for Nira Deoghar Catchment Using Different Empirical Equations.

¹. D.K.Khopade, ². Prof. R.A. Oak

¹. M.Tech. student of Hydraulics at Bharti Vidyapeeth University's College of Engineering and Technology, Pune. and in charge HOD of Civil Engg. Dept. at Abhinav Education Society's College of Engg.& Tech.(Poly.), Wadwadi, Dist- Satara.

². Professor at Bharti Vidyapeeth University's College of Engg. & Tech. Pune and Ex Research Officer, CWPRS Pune.

ABSTRACT

One of the major problems confronted by the hydrologists for many years is the prediction of runoff from a given basin for a known rainfall. This problem is so complex that its complete solution is practically impossible, as there are numerous factors which affect the runoff process. In this situation, development of a rainfall runoff model is important in Nira Deoghar Dam catchment located at latitudes of northern $18^{\circ}6'18''$ and longitudes of eastern $73^{\circ}43'36''$ in Pune District of Maharashtra. The proposed study on rainfall-runoff modeling over the Nira Deoghar Catchment is essential to explore the spatial and temporal distribution of excess water available in the catchment which has supposed to be harvested and can be utilized for irrigation.

By considering the above said aspect the rainfall-runoff studies were carried out by using various rainfall-runoff empirical formulae. There are only two rain gauge stations located in the catchment namely Shirgaon and Deoghar and data available is only for 18 years (1981-1997). So due to limitations in available data the rainfall data from adjacent Dhom catchment can be taken for analysis with thirty one years of monthly and annual rainfall (1967-1997).

Keywords – Empirical formulae, Nira Deoghar catchment, Rainfall-Runoff relation, Runoff, Yield

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I. INTRODUCTION

Water is the elixir of life and a precious gift of nature to the mankind. Water is a basis necessity for sustaining the life and development of society. It is fast becoming a scarce commodity in most parts of the world. The source of all water on the globe is precipitation. Proper estimation of run-off magnitude is required for efficient design, planning and management of river basin projects that deal with conservation & utilization of water for various purposes. To determine accurate quantity of surface run-off that in any river basin, understanding of the complex relationship between rainfall and run-off processes of particular basin is necessary. Determination of Runoff depends on many geo morphological and climate factors etc.

The basic requirements in designing water projects, is the estimation of runoff resulted from precipitation. In order to achieve this purpose, various methods, empirical equations and rainfall-runoff models can be used. Determination of runoff resulted from precipitation is one of the most important factors in hydrologic problems analysis and water resources management. The relationship between precipitation and runoff is a complicated and non-linear relationship which is depended on several factors.

1.1 Yield

The total quantity of surface water that can be expected in a given period from a stream at the outlet of its catchment is known as yield of the catchment in that period. The annual yield from a catchment is the end product of various processes such as precipitation, infiltration and evapotranspiration operating on the catchment. Due to the inherent nature of the various parameters involved in the processes, the yield is a random variable. A common practice is to assign a dependability value (say 75% dependable yield) to the yield. Thus, 75% dependable annual yield is the value that can be expected to be equaled to or exceeded 75% times (i.e. on

an average 15 times in a span of 20 years). Similarly, 50% dependable yield is the annual yield value that is likely to be equaled or exceeded 50% of times (i.e. on an average 10 times in 20 years).

The calculation of natural runoff volume is of fundamental importance in all surface water resources development studies. The most desirable basis for assessing the yield characteristics of a catchment is to analyze the actual flow records of the stream draining the catchment. However, in general, observed discharge data of sufficient length is unlikely to be available for many catchments. As such, other alternate methods such as the empirical equations and watershed simulations are often adopted.

1.2 Empirical Equations

The importance of estimating the water availability from the available hydrologic data for purposes of planning water-resource projects was recognized by engineers even in the last century. With a keen sense of observation in the region of their activity many engineers of the past have developed empirical runoff estimation formulae. However, these formulae are applicable only to the region in which they were derived. These formulae are essentially rainfall-runoff relations with additional third or fourth parameters to account for climatic or catchment characteristics.

Some of these methods have more expanded domain and can be used for some same regions by applying some corrections and choosing proper coefficients.

1.3 Study Area

Area of the studied region is 44.20 sq. miles located in western ghat area of Sahyadri hills and it is 15 Km. from Bhor City in Dist. - Pune. Geographically, the watershed is located between latitudes of northern $18^{\circ}6'18''$ and longitudes of eastern $73^{\circ}43'36''$. There are small villages within the study area and a large part of watershed slopes is made by forests and Rangeland Topographically, the up-Slope part of watershed including stony and rocky heights with steep slopes and a few branches of water bodies and almost without soil.

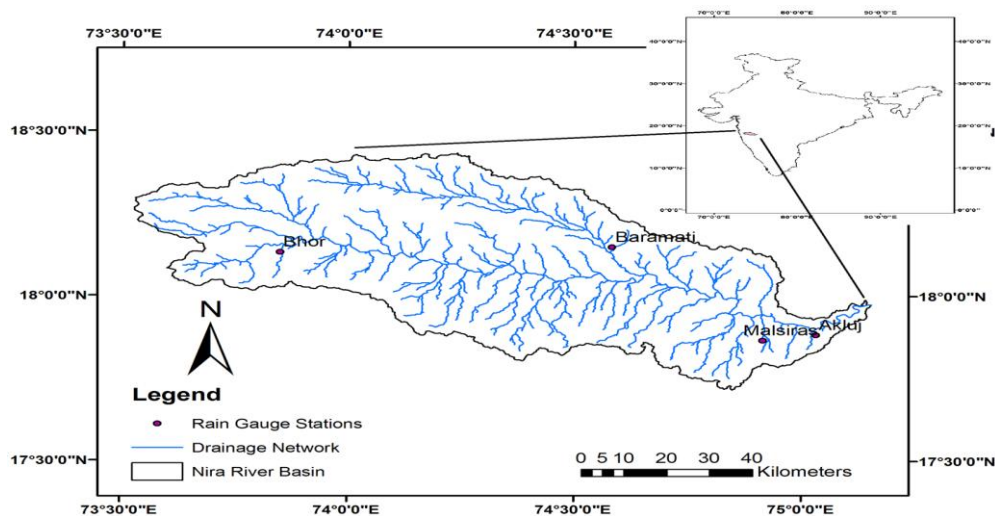


Fig.1 Nira river

The Nira River basin has a tropical climate with a hot summer and a mild winter. Agro-Climatically the area falls under the group of semiarid regions. Nira Deoghar dam is mainly an irrigation earthen dam; receive its main source of water from ghat area of Sahyadri hills. In This paper, the rainfall-runoff process of Nira Deoghar catchment, one of the Sub-basin of Krishna River is considered for the study. The Catchment area was predominantly influenced by North West Monsoon. The month of June to October accounts for major rainfall.

Fig. 2 Nira Deoghar Dam



1.4 METHODOLOGY

The purpose of this study is to apply various empirical methods of runoff estimation and to evaluate them with regard to available results in Nira Deoghar catchment. In this study, various rainfall-runoff models and empirical formulae are considered to estimate the runoff depth of Nira river basin of Nira Deoghar Dam catchment and the results were compared with available data.

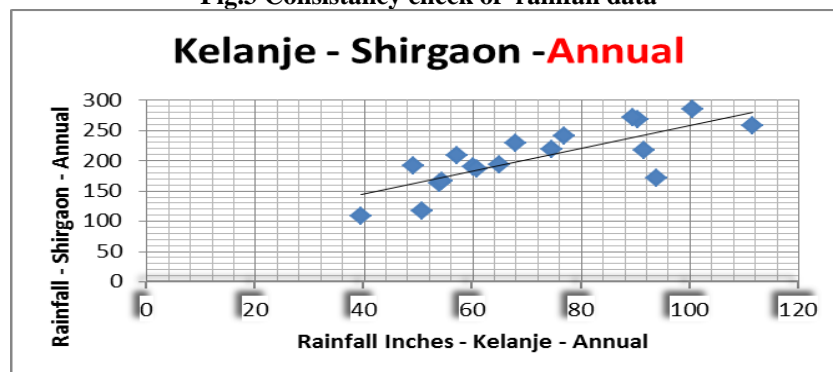
1.4.1 Available Data

The Shirgaon and Deoghar raingauge stations are located inside Nira Deoghar catchment and the monthly rainfall data is available for the period 1980 to 1997 (i.e. 18 years). Whereas Jambhali and Kelanje are the raingauge stations located in adjacent Dhom catchment and monthly rainfall data is available for the period 1967 to 1997 (i.e. 31 years). These four raingauge stations influence the Nira Deoghar catchment and the monthly and annual rainfall data of these stations are used for analysis purpose.

1.4.2 Test for Consistency of Data

Before using the rainfall records of a station, it is necessary to first check the data for continuity and consistency. If the conditions to the relevant to the recording of a raingauge station undergone a significant change during the period of record, inconsistency would arise in the rainfall data of that station. The consistency check of rainfall data has to be done by checking one to one consistency of rainfall data of Jambhali and Kelanje station with Shirgaon and Deoghar station. The consistency is observed in rainfall data.

Fig.3 Consistency check of rainfall data



1.5 Results

The analysis of data is done to estimate the annual runoff of the Nira Deoghar catchment by using different empirical formulae. Now, from these estimated annual runoff values the average yield of the catchment and dependable yield of the catchment are calculated. These yields are then compared with the available yield values of catchment by R-R relations of Dhom dam and Veer dam.

Fig. 4 R-R Relationship using Barlow's Method

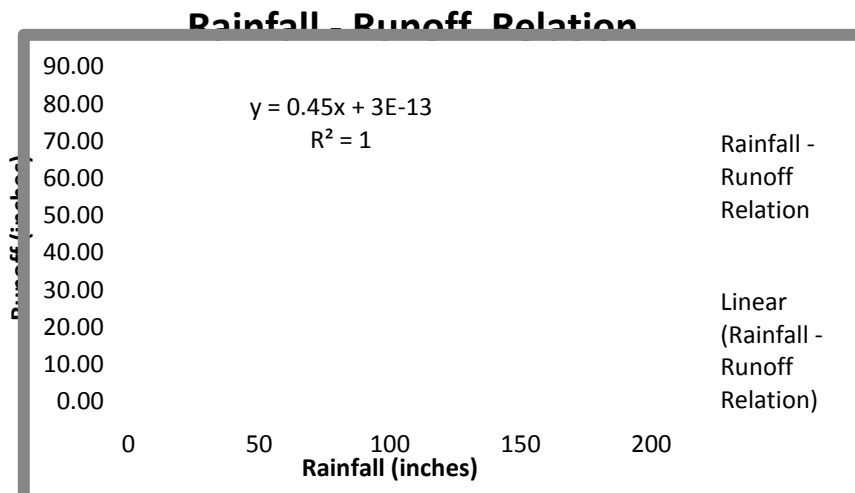


Fig. 5 R-R Relationship using Inglis

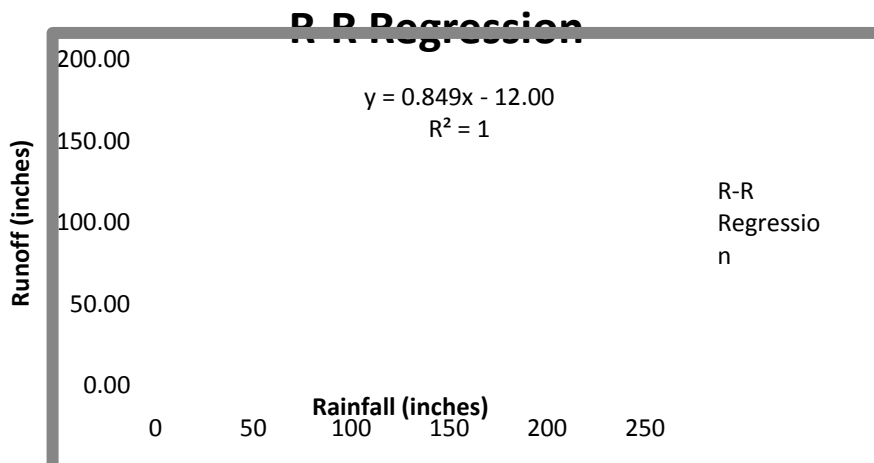


Fig. 6 R-R Relationship using Coutagine Formula

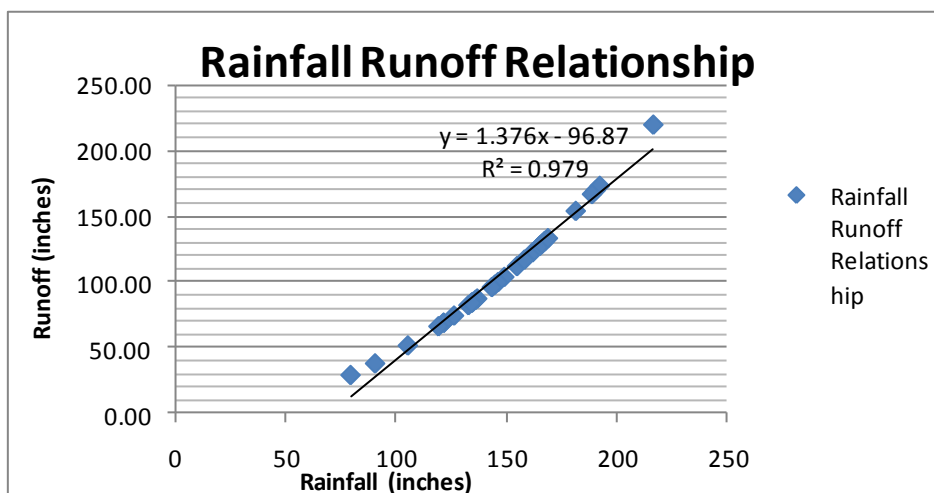


Fig. 7 R-R Relationship using Lacey's Formula

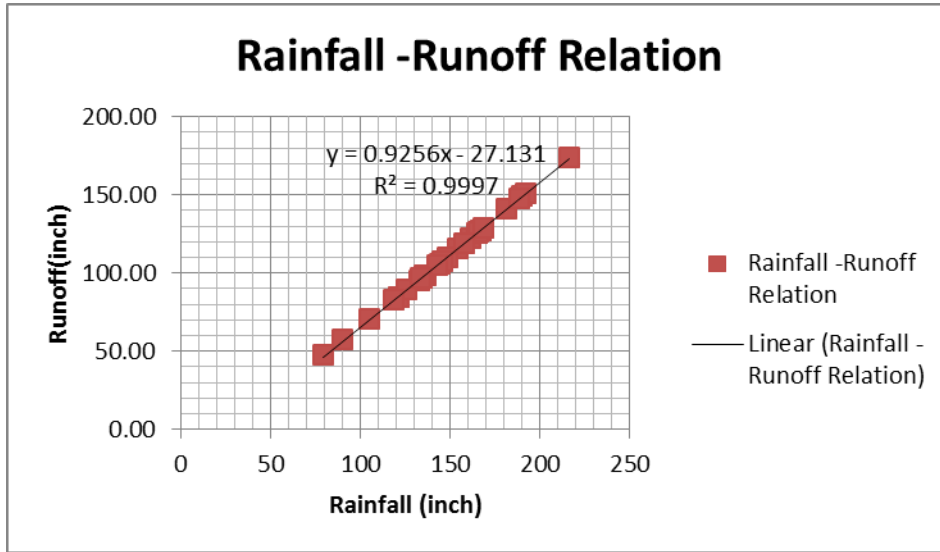
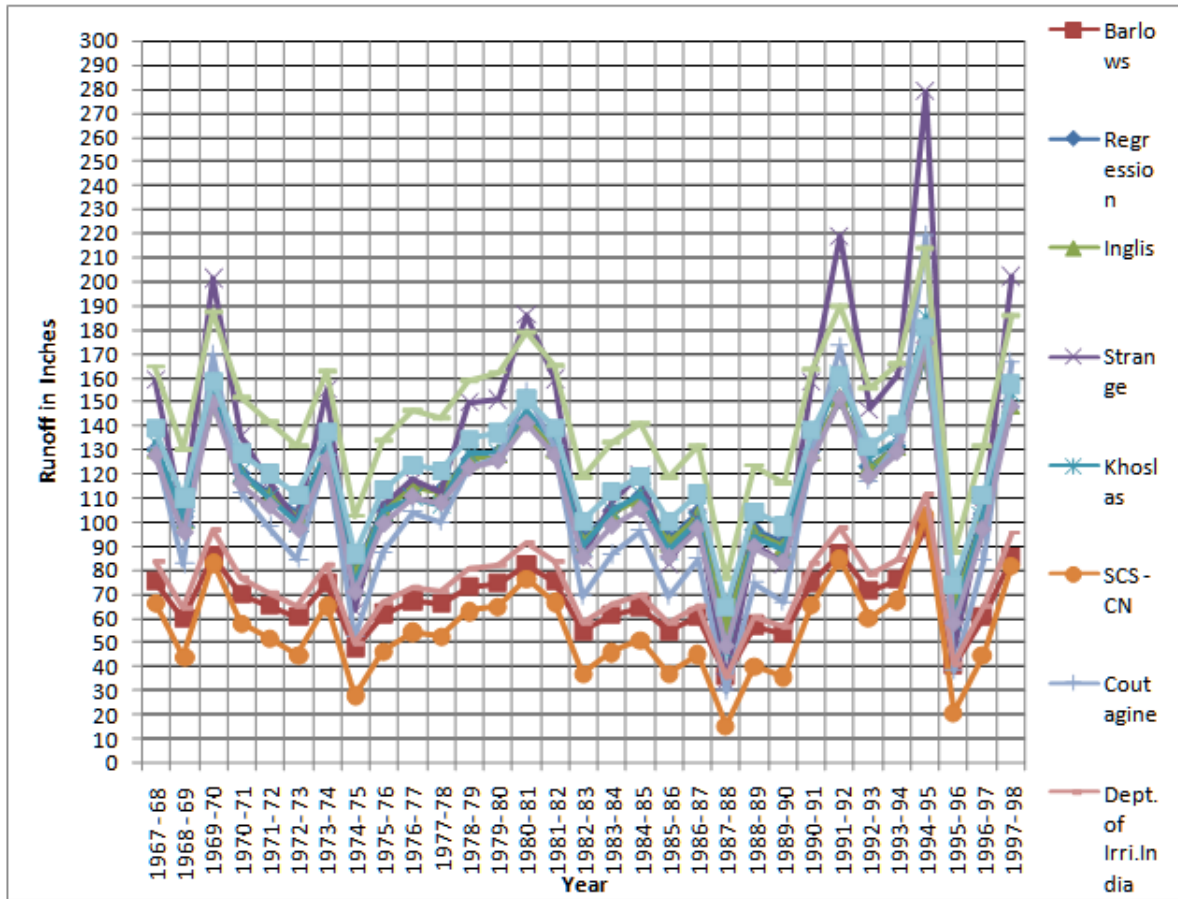


Fig. 8 Comparison of Runoff values of Nira Deoghar catchment



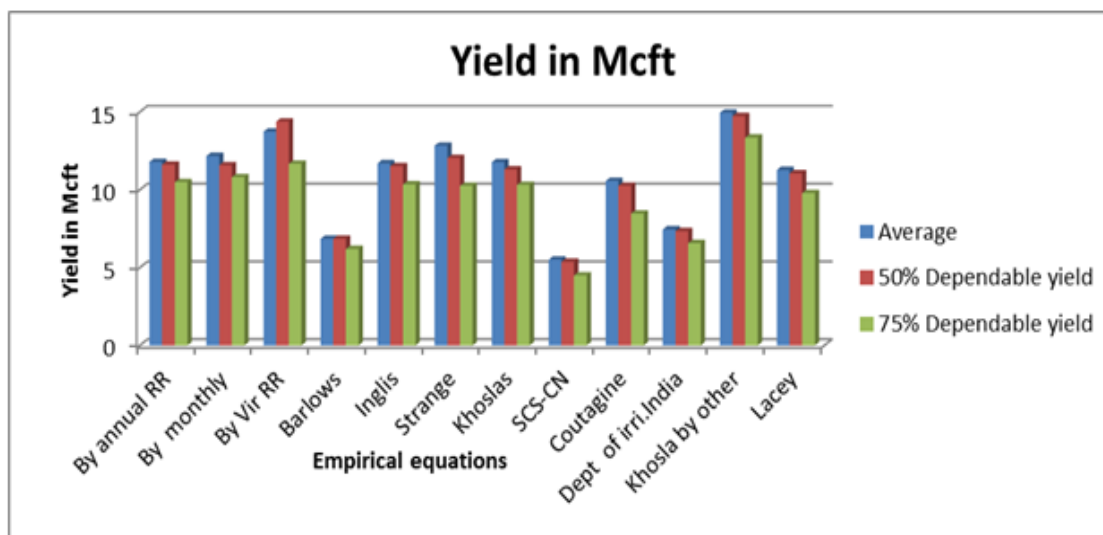
1.5.1 Comparison of Yields

The annual yield values obtained from various empirical equations are then compared with the average yield value, 50% dependable yield and 75% dependable yield as given in Table.

Table 1 – Estimated Yield by using different methods

Yield in Mcft	By annual RR	By monthly	By Veer RR	Barlows	Inglis	Strange	Khoslas	SCS-CN	Coutagine	Dept of irri .India	Khosla by other	Lacey
Average	11.79	12.17	13.73	6.85	11.7	12.83	11.76	5.51	10.56	7.45	14.95	11.26
50% Dependable	11.61	11.57	14.38	6.85	11.5	12.03	11.3	5.37	10.25	7.33	14.72	11.05
75% Dependable	10.48	10.80	11.67	6.18	10.3	10.24	10.30	4.49	8.46	6.56	13.35	9.78

Fig. 9 Comparison of Yield values of Nira Deoghar catchment



CONCLUSION

During the course of the currently proposed research we investigated the appropriateness of 9 runoff estimation methods that are widely used in Indian hydrology were investigated for Nira Deoghar catchment. Also these models were evaluated using available rainfall-runoff relationships of the adjacent Dhom dam and downstream Veer dam. In general we claim that significant deviations were found between the measured and calculated yields for the catchment.

The results plotted in a graph shows that, the runoff yield results obtained from Inglis Formula, Khosla’s Formula, Coutagine relationship, Lacey equation are relatively closer to the available results calculated by using R-R relationship of Dhom dam and Veer dam; whereas, the result of Stranges Table method are slightly higher than the available results. The results obtained from Barlow’s equation, SCS-CN method and equation developed by Dept. of Irrigation, India has very lower values of runoff yield. Also with regard to results from Khosla’s formula, Coutagine relationship and Lacey equation it can be concluded that the assumption made for average temperature of Nira Deoghar catchment (i.e. 33°C) is quite correct. The Barlow’s equation has been derived from the study of small catchment in Uttar Pradesh. Therefore the results obtained by using this equation in Nira Deoghar Catchment are not matching. While using SCS-CN method for Nira Deoghar catchment some assumptions are made regarding soil type to decide CN number, due to this assumptions the yield obtained from the catchment is lower. The equation used by Dept. of Irrigation India is based on the data of river Reihand, hence this relation cannot be directly applicable for our study.

REFERENCES

- [1] M.Rajendran, A. Murugappan, M.Latha and J.Mohamed Ashik Ali, "Comparison of Rainfall-Runoff Models – A Case Study". 5 th Asian Regional Conference, 6-11 December 2009, New Delhi, India.
- [2] Khabat Khosravi , Haidar Mirzai and Iman Saleh, "Assessment of Empirical Methods of Runoff Estimation by Statistical test"(Case study: BanadakSadat Watershed, Yazd Province) International journal of Advanced Biological and Biomedical Research ISSN: 2322 - 4827, Volume 1, Issue 3, 2013: 285-301
- [3] P .Sundar kumar, K.Hanuma.Rishi, "Simulation of Rainfall Runoff Using SCS &RRL (Case Study Tadepalli Mandal)" International Journal of Engineering Research and General Science Volume 1, Issue 1, August 2013
- [4] S.D. Jadhav, D.G. Kanase, R.W. Jawale, M.S. Jadhav, Physico-Chemical Assessment of Nira River,Pune, (Maharashtra), A Case Study.
- [5] Methods for Estimating Stormwater Runoff Chapter 2 Section 2.1 Columbia County Stormwater Management Design Manual 2.1-1
- [6] Ismail Abustan , Ahmad Husaini Sulaiman, Nabsiah Abdul Wahid and Fauzi Baharudin, "Determination of Rainfall-Runoff Characteristics in An UrbanArea: Sungai Kerayong Catchment, Kuala Lumpur" 11th International Conference on Urban Drainage, Edinburgh, Scotland, UK, 2008.
- [7] Ven Te Chow, David R. Maidment, Larry W. Mays, "Applied Hydrology" Mc-Graw Hill Book Comany.
- [8] K Subramanya, "Engineering Hydrology" Third Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi. P-27, 59, 69, 80,148-159.
- [9] Celarity Power Private Ltd.Mumbai, Nira Deoghar Hydro Electric Project "Project Feasibility Report" August 2005.
- [10] Asmita Ramkrishna Murumkar, Dhyan Singh Arya, "Trend and Periodicity Analysis in Rainfall Pattern of Nira Basin,Central India" American Journal of Climate Change, 2014, 3, 60-70
- [11] Md. Eahya Al Huda and Surendra Singh, "Assessment of Runoff in the High Humid Foot-hill Areas of Arunachal Himalayas Using Thornthwaite Equation" Int. Journal of GEOMATE, Dec., 2012, Vol. 3, No. 2 (Sl. No. 6), pp. 397- 401