Rainfall runoff co-relationship using empirical methods for Lower Mahi Basin, India

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RAINFALL RUNOFF CO-RELATIONSHIP USING EMPIRICAL METHODS FOR LOWER MAHI BASIN, INDIA

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ABSTRACT

Rainfall Runoff Co-Relationship done by many approaches such as software, mathematical, empirical, hydrograph. Models of different types provide a means of quantitative extrapolation or prediction that will helpful in decision making. In present paper focused on empirical methods for rainfall runoff co-relationship. Rainfall data for the important rain gauging site was considered for flood years (1991, 1994, 1996, 1997, 1998, 2005, 2006, 2007). INGLIS AND DE SOUZA'S, LACEY'S, PARKER'S BRITISH AND USA, AND TAPI BASIN Formula use for co-relationship. Utilizing all formula, a rainfall runoff co-relationship was obtained using the regression equation.

Key words: Rainfall, Runoff, Empirical Methods.

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1. INTRODUCTION

Rainfall is the result of water vapour condensing and precipitating, forming droplets that fall from clouds due to gravity. It is an important part of the water cycle. Runoff means the draining or flowing off of rainfall from a catchment area through a surface channel. The relationship between rainfall in a period and the corresponding runoff is quite complex and is influenced by a host of factors relating to the catchment and climate. Further, there is the problem of paucity of data which forces one to adopt simple correlations for adequate estimation of runoff. Commonly adopted method is to fit a linear regression line between Runoff and Rainfall and to accept the result if the correlation coefficient is nearer unity.

Several empirical formulae have been developed by various investigations. These formulae the annual precipitation (p). There are generally of two forms:

(I) $R = aP + b$

(II) $R = c\,P^n$

Where a, b, c and n are the catchment constants.

There is large number of empirical formula available in literature. These formulae are applicable for the catchment for which they had been derived. However, these are also used for other catchment with similar characteristics. Some of the most commonly formulae are given below:

- INGLIS AND DE SOUZA'S
- LACEY'S
- PARKER'S BRITISH AND USA
- TAPI BASIN

In this study, an attempt has been made to obtain a rainfall runoff relationship for Lower Mahi Basin, India using Empirical equations. Since the data collection is very expensive and time consuming, the rainfall data was collected only for important rain gauge station for period of 20 years. Using the rainfall data, runoff calculated from empirical methods. Observed and calculated runoff co-relation was obtained using regression question.

2. DIFFERENT EMPERICAL METHODS

2.1. INGLIS and DE SOUZA'S formulae

Inglis and De Souza studies the yield of catchments in Western Ghat mountains and Palins of Maharashtra (India) and gave two separate formulae for the ghat areas and plain areas.

(a) Ghat areas $R = 0.85P - 30.5$

(b) Plain areas $R = \frac{(P - 17.8)\,P}{254}$

Where R is the daily runoff (cm) and P is the daily rainfall (cm) over the entire catchment.

2.2. Lacey's Formulae

Lacey gave the following formula for the catchment in the Indo-Gangetic plains.

$$R = \frac{P}{1 + \frac{304.8F}{PS}}$$

Where F is the monsoon duration factor, whose value is equal to 1.0 for the normal monsoon duration. For very short duration and very long duration, the value of F is, 0.50 and 1.50. S is the catchment factor. The value of S for A, B, C, D and E types of catchments are respectively, 0.25, 0.60, 1.00, 1.70 and 3.45 where types of catchments are as per Barlow's Classification (Table 1). Alternatively, the value of (F/S) for different types of catchments for different monsoon duration factor can be taken from Table 2.

Table 1 Barlow's catchment classification

Class of catchment	Description of catchment
A	Flat, cultivated, absorbent soil
B	Flat, partly cultivated, stiff soil
C	Average catchment
D	Hills and plains with little cultivation
E	Very hilly and steep, with little or no cultivation

Table 2 Value of (F/S) for the catchment of type

Duration of monsoon	Values of (F/S) for the catchment of type				
	A	B	C	D	E
Very short	2	0.83	0.5	0.29	0.14
Standard duration	4	1.67	1	0.58	0.28
Very long	6	2.5	1.5	0.88	0.43

2.3. Parker's formulae

Parker gave the following formulae for different countries.

(a) British Isles $R = 0.94P - 35.6$

(b) Germany $R = 0.94P - 40.6$

(c) U.S.A $R = 0.80P - 41.9$ Where R and P in centimetre.

2.4. Tapi basin (Gujarat)

This formula has been developed for Tapi basin Gujarat, India.

$R = 0.435P - 17.2$ Where R

and P in centimetre.

3. STUDY AREA

Mahi River is one of the major west flowing interstate river of India, draining into the Gulf of Khambhat. The Mahi basin is comprised of two sub-basins: - Mahi upper sub basin of (65.11% of total basin area) consisting of41 watersheds and Mahi lower sub basin (34.89% of total basin area) consisting of 22 watersheds. It lies between720 15‟00” E to 780 15‟00” E and 220 N to 22040‟ 00” N respectively. The basin map is shown in Fig 1.Only the lower Mahi Basin is considered for the present study. Rain gauging stations was considered Table 3 shows the details of the rain gauging station considered for study.

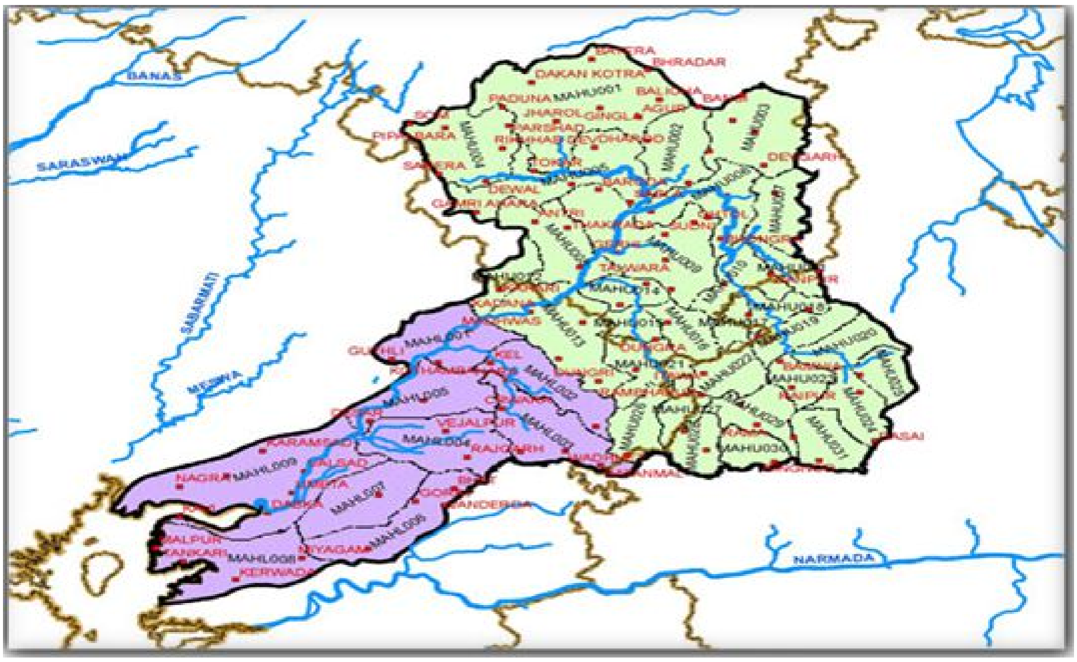

Figure 1 Mahi Basin

Table 3 Details of rainfall gauge station

Station NAME	Latitude	Longitude	Ref. Topo. No
PILOL	22°24'39"	22°24'39"	46F03
SANSOLI	22°24'39"	22°24'39"	46F06
SAVLI	22°24'39"	22°24'39"	00F46
WANAK BORI	22°24'39"	22°24'39"	46F05
KALOL	22°24'39"	22°24'39"	46F06

4. ANALYSIS

4.1. INGLIS and DE SOUZA'S formulae

Table 4 Inglis and De Souza's Formula Analysis

YEAR	CALCULATED	OBSERVED
1991	12476.10	10293
1994	16742.62	14592
1996	8723.64	7403
1997	12695.85	11956
1998	6893.15	5750.6
2005	2158.36	1674.52
2006	24331.42	31061.91
2007	11111.53	9000.16

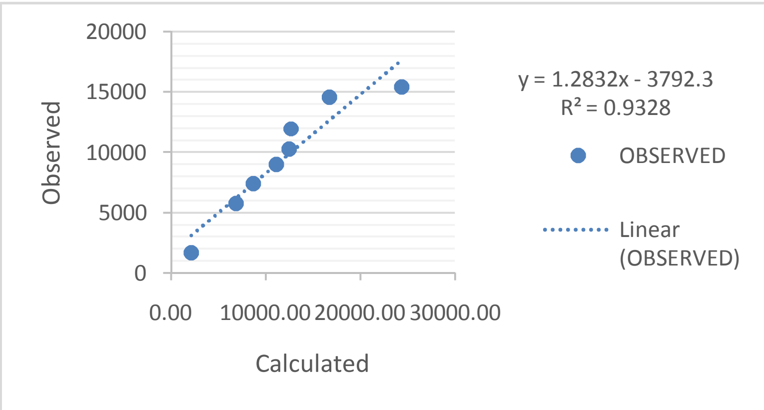

Figure 2 Inglis and De Souza's formula Co-Relation

4.2. Lacey's Formulae

Table 5: Lacey's Formula Analysis

YEAR	CALCULATED	OBSERVED
1991	12442.41	10293
1994	16744.09	14592
1996	8506.82	7403
1997	12547.41	11956
1998	6859.80	5750.6
2005	2160.54	1674.52
2006	24307.82	31061.91
2007	11114.01	9000.16

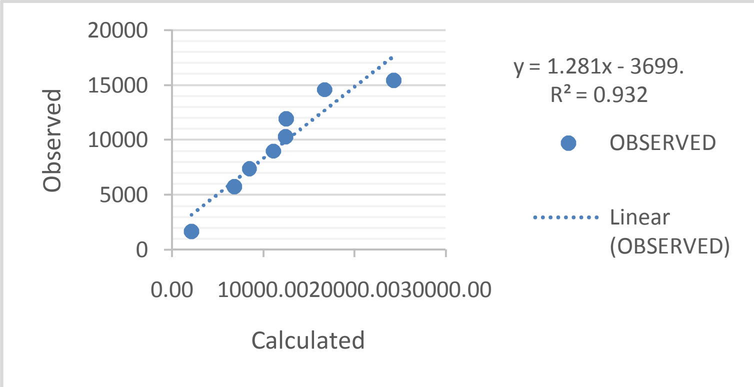

Figure 3 Lacey's formula co-Relation

4.3. Parker's formulae

4.3.1. British Isles

Table 6 Parker's British formula Analysis

YEAR	CALCULATED	OBSERVED
1991	12524.38	10293
1994	16727.51	14592
1996	8679.87	7403
1997	12718.09	11956
1998	6966.78	5750.6
2005	2169.91	1674.52
2006	24408.56	31061.91
2007	11093.82	9000.16

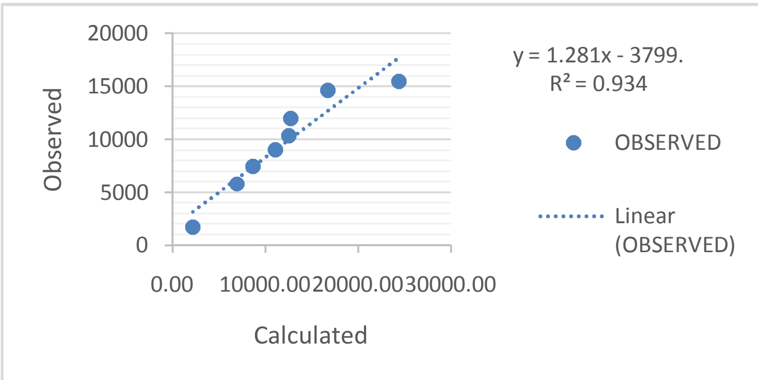

Figure 4 Parker's British formula Co-Relation

4.3.2. U.S.A

Table 7 Parker's USA formula Analisis

YEAR	CALCULATED	OBSERVED
1991	12465.86	10293
1994	16692.93	14592
1996	8587.19	7403
1997	12630.45	11956
1998	6903.50	5750.6
2005	2130.71	1674.52
2006	24347.66	31061.914
2007	11072.82	9000.16

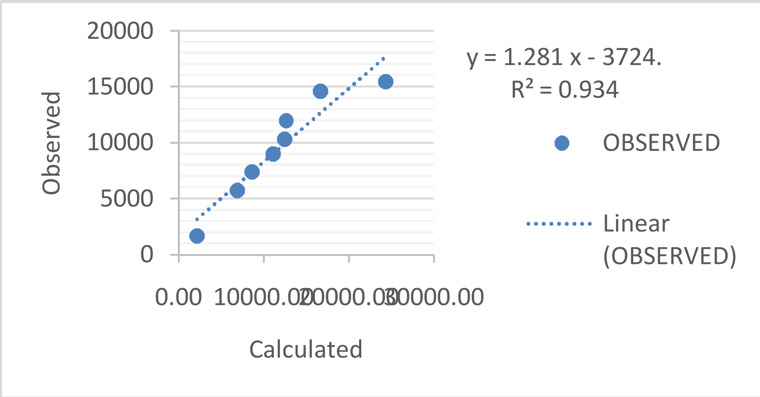

Figure 5 Parker's USA formula Co-Relation

4.4. TAPI BASIN

Table 8 Tapi Basin formula Analisis

YEAR	CALCULATED	OBSERVED
1991	12436.66	10293
1994	16726.15	14592
1996	8468.94	7403
1997	12525.33	11956
1998	6861.90	5750.6
2005	2151.88	1674.52
2006	24312.26	31061.914
2007	11100.32	9000.16

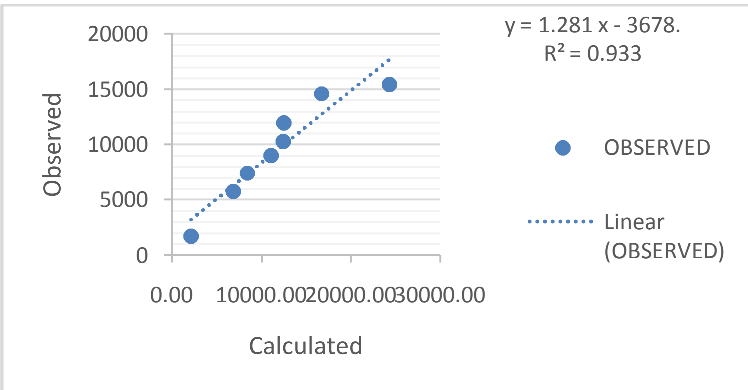

Figure 6 Tapi Basin Formula Co-Relation

5. CONCLUSION

This study is ab attempt to define a Rainfall-Runoff Co-relationship for Lower Mahi Basin, India. Graphical regressions were made relating to rainfall and runoff was determined considering all the important catchment characteristics using the empirical methods. It was found that considerably good results were obtained by correlating rainfall versus run off. The regressions were affected to some extent by the quality of the data from which they were derived. Runoff data was considered fairly well, as it does not take into account the infiltration in the catchment. The infiltration is the start of the event is different when the storm ends and this effects the run off from the catchment. When the "R^2" value approaches to 1, it means the river receives a regular rainfall every year and the flow is actually proportional to it.

The co relation “R” for the basin is nearing the unity and such a correlation is said to be very good, which shows the catchment is more responsive to the rainfall it is receiving. The method presented in this study provides a tool for estimating runoff from a rainfall event.

For all this different empirical equations, the regression value was nearing unity. Parker’s USA analysis gave the value of R2 as 0.934. So, it is most effective method for runoff calculation for lower Mahi Basin.

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