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CLASSIFICATION OF WATERSHED AND RAINFALL-RUNOFF MODELLING USING SOM, LINEAR REGRESSION ANALYSIS AND ANN

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ABSTRACT: - This study presents the homogeneity between various watersheds having similar geomorphological parameters that are significantly responsible for transferring rainfall in to runoff. Geomorphological information of watersheds under consideration has been extracted from USGS website. Based on geomorphological parameters, self organizing map (SOM) is used to classify the watersheds. Rainfall and runoff model is then developed using ANN and Regression model for the catchment of each group. The performance of the developed ANN and regression model are evaluated for the other catchments of their group. In this study MAHARASTRA five rivers GHARNI, LIMBGANESH, NITUR, NALEGAON and YELLAMGHAT and the AMERICAN river MISSISSIPPI's tributaries considered.

(1) KEYWORDS: - watershed, Artificial neural network, Regression analysis

(2) INTRODUCTION:- Runoff data is most important for the effective management of water resources and also for solving many engineering problems such as forecasting stream flow for the purpose of water supply, flood control, irrigation, drainage, water quality, power generation, recreation, etc. again the rainfall to runoff transformation process is one of the most complex hydrologic phenomena to analyze due to the tremendous spatial and temporal variability of watershed characteristics and precipitation patterns, and the number of geomorphological parameter that are involved in the modeling processes.

Various methods have been developed to simulate the rainfall runoff process in the catchment. They can be classified as conceptual model and data driven model. The conceptual models are based on the several assumptions so as to simplify the model as there may be many variables which are difficult to consider all and also to have acceptability along with their assumption. These models require data to evaluate their performance and acceptability, for example unit hydrograph by SHERMAN (1932). On the other hand data driven models are developed and validated completely based only on the length of the data series, for example ANN and regression model.

It has been observed that most of the Indian catchments are ungauged due to high recurring expenditure. As a result, it is difficult to develop conceptual model and data driven model over these catchments. Therefore this study evaluates the performance of the rainfall-runoff model developed for a particular catchment on a geomorphologic similar catchment.

In this study, rainfall runoff model is then developed using ANN and regression model for the catchment of each group. The performance of developed ANN and regression model is evaluated for the other catchment of their group.

(3) REGRESSION ANALYSIS FOR RAINFALL-RUNOFF MODEL:-

(1) YELLAMGHAT river shows following Rainfall-Runoff pattern for regression model, after using several input and output,

Fig (1.1) shows the phenomenon of six days of rainfall and one day runoff and in the equation of fig (1.1) whereas

Q (t+1) is next day's runoff,

X_1R (t), R (t-1), R (t-2), R (t-3) + X_5R (t-4) + X_6R (t-5) is the previous 6 days rainfall,

X_7Q (t) is previous one day runoff,

X_i is the regression coefficient, and C is constant (intercept).

Fig (1.2) shows the regression analysis using artificial neural network tools on mat lab and presents the training, validation results and gives the value of regression 'R'.

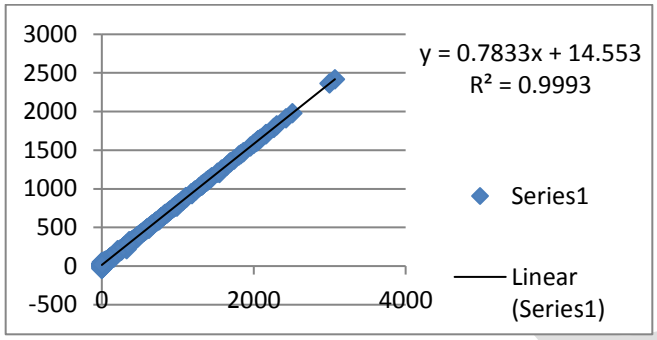

Fig (1.1) for RR Equation Q (t+1) = C = X_1R (t) +X_2R (t-1) + X_3 R (t-2) + X_4R (t-3) + X_5R (t-4) + X_6R (t-5) + X_7Q (t)

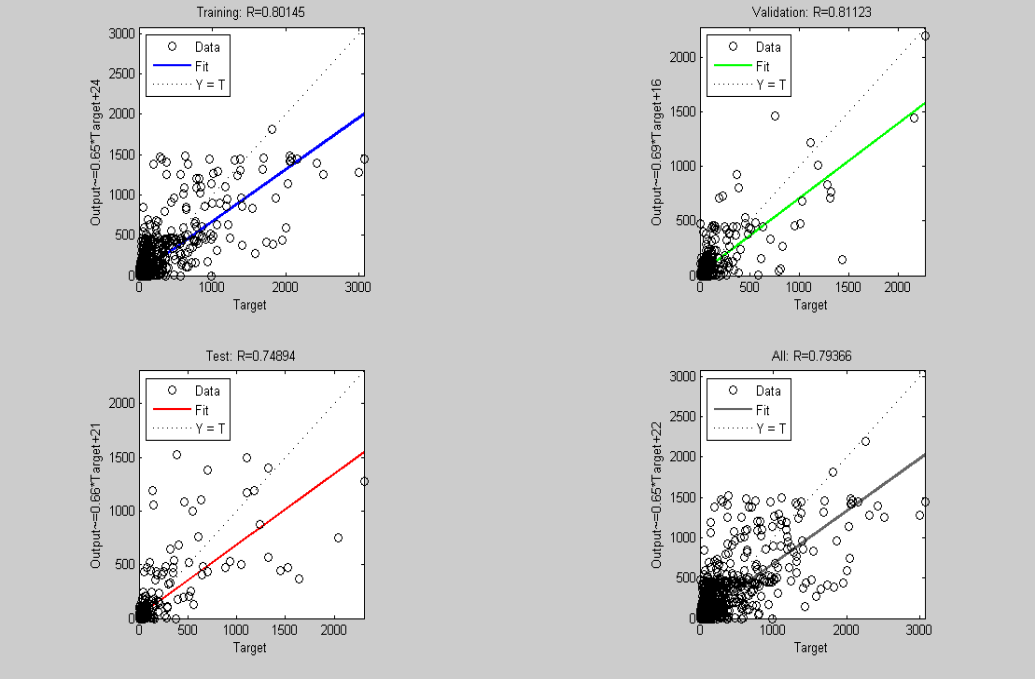

Fig (1.2) Regression by artificial neural network for YELLAMGHAT

(2) NALEGAON river shows following Rainfall-Runoff pattern for regression model, after using several input and output,

Fig (2.1) shows the phenomenon of six days of rainfall and one day runoff of NALEGAON and in the equation of fig (2.1) whereas

Q (t+1) is next day's runoff,

X_1R (t), R (t-1), R (t-2), R (t-3) + X_5R (t-4) + X_6R (t-5) is the previous 6 days rainfall,

X_7Q (t) is previous one day runoff,

X_i is the regression coefficient, and C is constant (intercept).

Fig (2.2) shows the regression analysis using artificial neural network software on mat lab and presents the training, validation results and gives the value of regression 'R'.

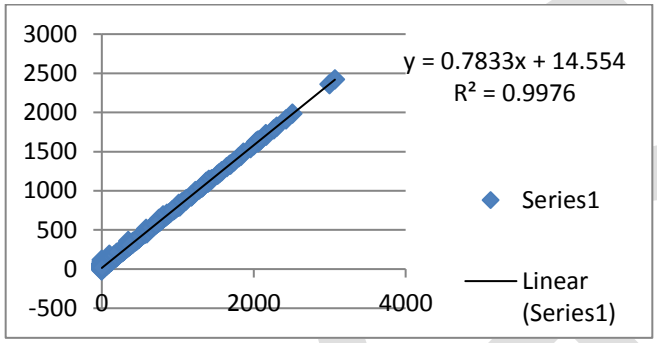

Fig (2.1) for RR Equation Q (t+1) = C = X_1R (t) +X_2R (t-1) + X_3 R (t-2) + X_4R (t-3) + X_5R (t-4) + X_6R (t-5) + X_7Q (t)

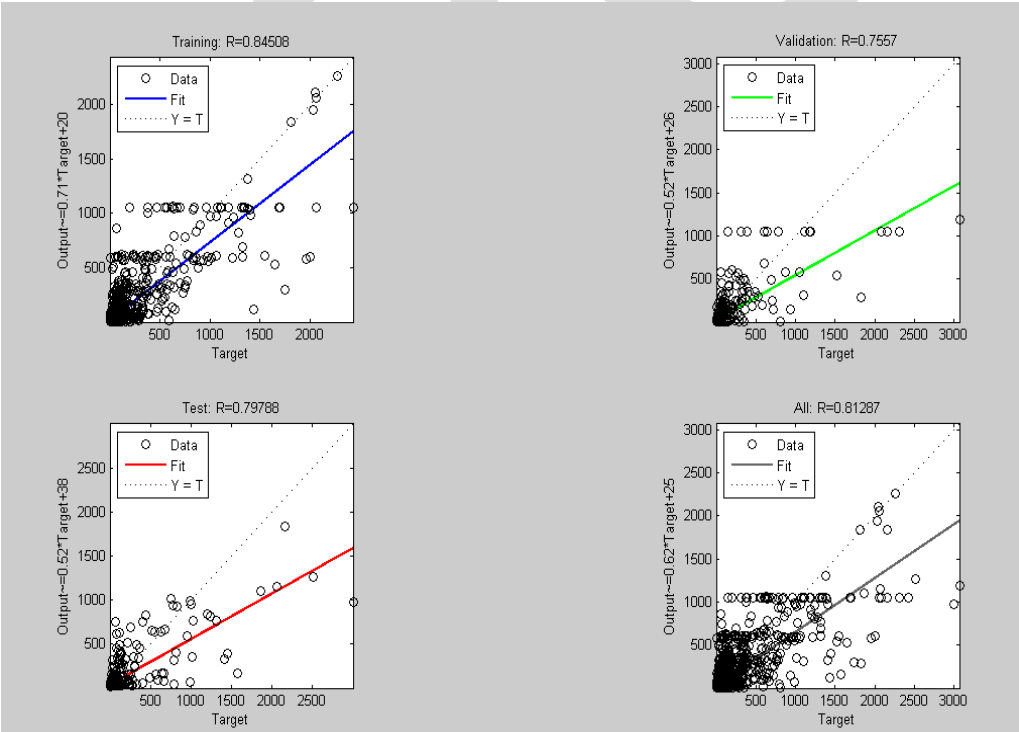

Fig (2.2) Regression by artificial neural network for NALEGAON

TABLE 1 REGRESSION ANALYSIS ON MS EXCEL FOR VARIOUS CATCHMENTS:

This table shows the values by regression analysis on ms excel for various catchments. Input 7(6-1) shows, 6 days of rainfall and 1 day of runoff, same as various inputs are proceeding.

On applying various inputs of rainfall-runoff equations we see that the value of 'R^2' varies. For example if we discuss about the GHARNI catchment we find the best value of 'R^2' for 6 days of rainfall and 1 day of runoff because the value of 'R^2' should be closer to 1 for perfect regression analysis.

Similarly for LIMBGANES, NITUR, NALEGAON and YELLAMGHAT, we use the best value of 'R^2' for analysis.

S.N.	CATCHMENTS	INPUT (Rainfall-Runoff)	LINEAR EQUATION	VALUE OF 'R^2'
1	GHARNI	7 (6-1)	y = 0.785x + 14.45	0.943
2	GHARNI	6 (5-1)	y = 0.785x + 14.45	0.908
3	GHARNI	5 (4-1)	y = 0.785x + 14.45	0.908
4	GHARNI	4 (3-1)	y = 0.785x + 14.45	0.91
5	GHARNI	3 (2-1)	y = 0.785x + 14.45	0.913
6	LIMBGANESH	7 (6-1)	y = 0.783x + 14.55	0.991
7	LIMBGANESH	6 (5-1)	y = 0.783x + 14.55	0.991
8	LIMBGANESH	5 (4-1)	y = 0.783x + 14.55	0.991
9	LIMBGANESH	4 (3-1)	y = 0.783x + 14.55	0.991
10	LIMBGANESH	3 (2-1)	y = 0.783x + 14.55	0.991
11	NALEGAON	7 (6-1)	y = 0.783x + 14.55	0.997
12	NALEGAON	6 (5-1)	y = 0.783x + 14.55	0.997
13	NALEGAON	5 (4-1)	y = 0.783x + 14.55	0.997
14	NALEGAON	4 (3-1)	y = 0.783x + 14.55	0.998
15	NALEGAON	3 (2-1)	y = 0.783x + 14.55	0.999
16	NITUR	7 (6-1)	y = 0.783x + 14.56	0.982

17	NITUR	6 (5-1)	y = 0.783x + 14.56	0.982
18	NITUR	5 (4-1)	y = 0.783x + 14.56	0.982
19	NITUR	4 (3-1)	y = 0.783x + 14.56	0.982
20	NITUR	3 (2-1)	y = 0.783x + 14.56	0.982
21	YELLAMGHAT	7 (6-1)	y = 0.783x + 14.55	0.999
22	YELLAMGHAT	6 (5-1)	y = 0.783x + 14.55	0.999
23	YELLAMGHAT	5 (4-1)	y = 0.783x + 14.55	0.999
24	YELLAMGHAT	4 (3-1)	y = 0.783x + 14.55	0.999
25	YELLAMGHAT	3 (2-1)	y = 0.783x + 14.55	0.999

Table 1

TABLE 2: REGRESSION ANALYSIS ON MATLAB BY ANN TOOLS FOR VARIOUS CATCHMENTS:

This table shows value of 'R' by artificial neural network for validation, test, training and overall regression for 5 catchments of Maharashtra.

S. N.	CATCHMENTS	VALUE OF 'R'			
		TRAINING	VALIDATION	TEST	ALL
1	GHARNI	0.85196	0.80846	0.88913	0.8541
2	LIMBGANESH	0.8008	0.72922	0.777	0.77437
3	NALEGAON	0.84508	0.7557	0.79788	0.81287
4	NITUR	086562	0.72123	0.85452	0.82407
5	YELLAMGHAT	0.80145	0.81123	0.74894	0.70366

Table 2

(4) RESULT:

(4.1) SIMILARITY B/W GHARNI and 07047800 St. Francis River at PARKIN, AR

As we have grouped the catchments of all rivers by self organizing map tool based on their geomorphological parameters as obtained from USGS site, we found river GHARNI and Francis in same group. After applying regression equation of GHARNI river catchment on St. Francis River the validation results were satisfactory with R^2 value as 0.699 as shown below fig. 4.1.

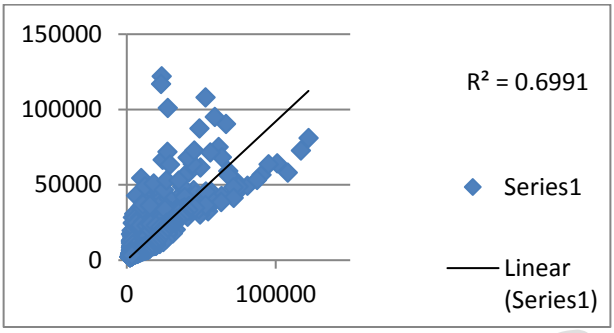

FIG 4.1

(4.2) SIMILARITY B/W LIMBGANESH catchment and07050500 Kings River near Berryville, AR

Similarly 4.1, as we have grouped the catchments of all rivers by self organizing map tool based on their geomorphological parameters as obtained from USGS site, we found river LIMBGANESH and Kings in same group. After applying regression equation of LIMBGANESH river catchment on Kings River the validation results were satisfactory with R^2 value as 0.636 as shown below fig. 4.2.

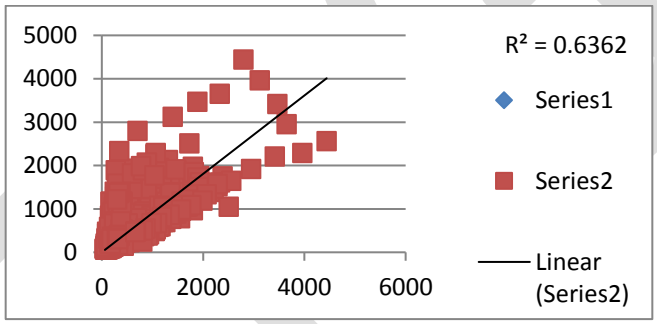

FIG 4.2

(4.3) SIMILARITY B/W NITUR catchment and 07056000 Buffalo River near St. Joe, AR

Similarly 4.1, as we have grouped the catchments of all rivers by self organizing map tool based on their geomorphological parameters as obtained from USGS site, we found river NITUR and Buffalo in same group. After applying regression equation of NITUR river catchment on Buffalo River the validation results were satisfactory with R^2 value as 0.590 as shown below fig. 4.3.

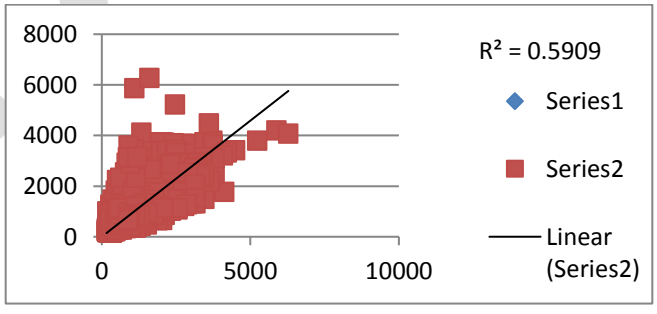

FIG 4.3

(4.4) SIMILARITY B/W YELLAMGHAT catchment and07260640 Petit Jean River near Centerville, AR

Similarly 4.1, as we have grouped the catchments of all rivers by self organizing map tool based on their geomorphological parameters as obtained from USGS site, we found river YELLAMGHAT and Petit Jean in same group. After applying regression equation of YELLAMGHAT river catchment on Petit Jean River the validation results were satisfactory with R^2 value as 0.836 as shown below fig. 4.4.

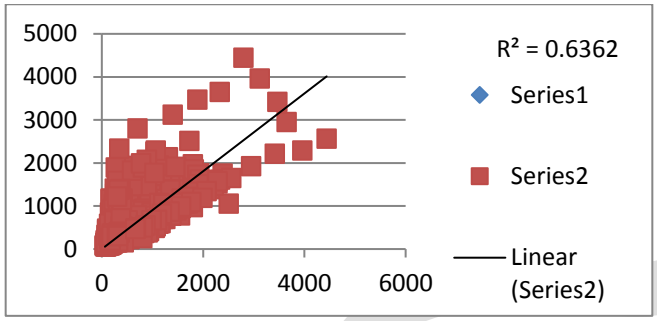

FIG 4.4

(4.5) SIMILARITY B/W NALEGAON catchment and01480870 East Branch Brandywine Creek below Downingtown, PA

Similarly 4.1, as we have grouped the catchments of all rivers by self organizing map tool based on their geomorphological parameters as obtained from USGS site, we found river NALEGAON and East Branch Brandywine Creek in same group. After applying regression equation of NALEGAON river catchment on East Branch Brandywine Creek River the validation results were satisfactory with R^2 value as 0.97 as shown below fig. 4.5.

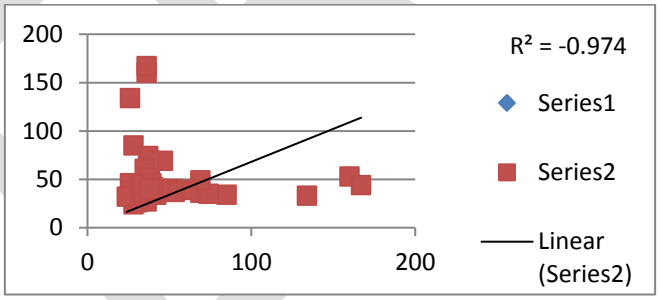

FIG 4.5

(5) CONCLUSION:

This study present a methodology to classify the watershed based on the geomorphological parameters. Self organizing map (SOM) is used to classify the watershed around 16 geomorphological parameter are used in the study. ANN model is then developed to simulate the rainfall runoff model of the catchment. It is also studied the applicability of the ANN and linear regression model on the similar watershed which has been grouped based on the geomorphological parameters. It has been observed that the classification done on the basis of catchment area, is more appropriate and the hydrological models developed using ANN and linear regression are applicable to those catchments.

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