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Estimation of Runoff of Upper Ozat River Basin using Curve Number Technique

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ABSTRACT

The runoff of the Upper Ozat river basin area was determined. The relationships between rainfall and runoff of different sites of Ozat river basin were established. The observed and calculated one day runoff data were correlated. The weighted curve number of the study area was 73. As per the curve number technique, the runoff was calculated for different sites as Ambajal, Zanzesri, Dhrafad and Motagujariya were 38.41 mm, 32.03 mm, 58.77 mm, 58.74 mm respectively. The relationships between one day rainfall and calculated one day runoff were established for different sites of Ozat river basin. The study was under taken for runoff estimation of the watershed area for the Upper Ozat river basin of Junagadh district of Gujarat (India).

Keywords Runoff estimation, Watershed, Curve number technique, Rainfall.

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INTRODUCTION

The Ozat river located at Saurashtra region, Junagadh District, Gujarat, India. The Ozat river originates from Visavadar and meets in Arabian sea. Its length is 64.74 km having catchment area 1409.98 sq km. Ambajal and Popatdi are right bank tributaries and Uben and Utavali are left bank tributaries of this river. The river Ozat provides irrigation facilities to almost 27 villages out of it covers 15 villages of Vanthli taluka, 4 villages of Junagadh taluka, 2 of Mendarda taluka and 6 of Vishavadar taluka.

Remote sensing technology can augment the conventional methods to a great extent in rainfall-runoff studies. The role of remote sensing in runoff calculation is generally to provide a source of input data or as an aid for estimating equation coefficients and model parameters. The information extracted from remote sensing and other sources can be stored as a geo referenced data base in geographical information system. The system provides efficient tools for data input into data base, retrieval of selected data items for further processing and software modules which can analyze/ manipulate the retrieved data in order to generate desired information on specific form.

Dilshad and Peel (1994) evaluated USDA-SCS curve number method using rainfall and runoff data from four catchments at the Douglas-Daly Research Farm, Northern Territory. Optimized curve numbers (CNs) were calculated for each catchment. The curve number method (CNM) was able to describe significant levels of variation in observed rainfall and runoff data. Lewis *et al.* (2000) used the curve number (CN) method by the US Soil Conservation Service for predicting peak runoff from watersheds. Mishra and Singh (2002) presented the hydrologic simulation models based on the Soil Conservation Service Curve Number (SCS-CN) method. Hydrologic simulation included computation of rainfall-runoff volume, infiltration rate and runoff hydrograph. Gaspari *et al.* (2007) developed rainfall-runoff and curve number relationship under different conditions of soil's, Ventania system modal basin, Argentina. The analysis of this rainfall-runoff relationship under different soil uses generated values of CN and runoff coefficient (RC). Zade *et al.* (2006) estimated curve number (CN) for major basins of India using remote sensing. Melesse and Shih (2002) used of geographic information systems (GISs) and remote sensing to estimation of runoff from watershed and agricultural fields. The US Department of Agriculture, Natural Resources Conservation Service Curve Number (USDA-NRCS-CN) method was used in this study for determining the runoff depth.

The studies shows that the Natural Resources Conservation Services Curve Number (NRCS-CN) method have been widely applied to ungauged watershed systems and proved to be a quicker and accurate estimator of surface runoff than other empirical and lumped parameter models (Mishra and Singh 2003). The watershed hydrologic responses leading to generation of surface runoff are governed by the interaction of precipitation with the topological, land use and soil physical properties of the land surface. The estimation process becomes more efficient, interactive and less cumbersome when the Geographic Information System is used for storing, interpreting and displaying the data required in CN based runoff estimation techniques.

The main objective of this study was to determine the runoff estimation and runoff and rainfall-runoff relationship for the upper Ozat river basin of Junagadh district in Saurashtra region of Gujarat (India).

MATERIALS AND METHODS

In this study the satellite data were collected from Bhaskaracharya institute for space Application and Geo-informatics (BISAG), Gandhinagar, Gujarat (India) and the data were utilized for the remote sensing and GIS application for the study. Differerent softwares were used to acquire the hydro-geomorphologic information of the study area like ARC GIS 9.0, ARC VIEW 3.2 and Geometica V 10.0.

Runoff

The values of S and Ia have been put into the below equation to get the runoff (Q) value on one day basis, which calculates the runoff in cm being given precipitation in cm.

$$Q = \frac{(P - l_a)^2}{P - l_a + S}$$

Where,

P = Rainfall depth, cm
Ia = Initial abstraction, cm
S = Potential maximum retention of rainwater at any time, cm

Relationship between rainfall and runoff

The development of relationship between rainfall and runoff is uncertain. There are two types of relationships i.e. linear and non-linear. The linear relationship between rainfall and runoff is found for small watersheds, while non-linear relationships for large watersheds. The non-linear relationships may be in power, logarithmic or exponential form.

Relationship between one day rainfall and calculated/ observed one day runoff :

Relationship is developed by plotting the rainfall (P) and corresponding calculated or observed runoff (R) data and drawing best fit curve. The form of linear

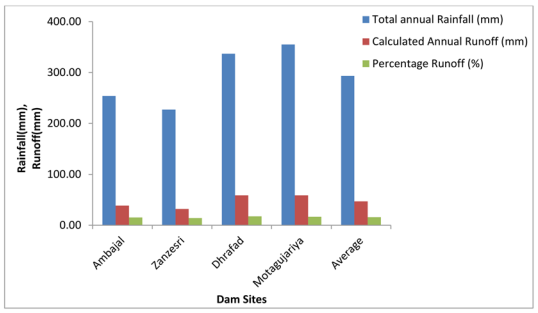

Fig. 1. The annual rainfall, calculated runoff and percentage runoff for different sites of upper Ozat river basin.

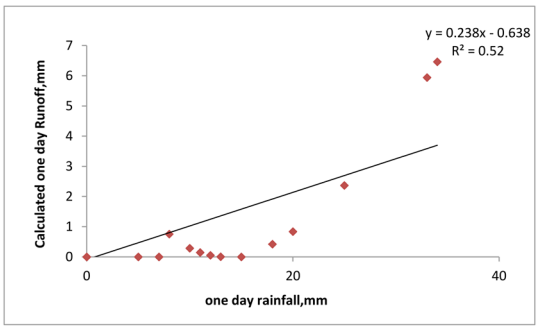

Fig. 2. Relationship between the calculated one day runoff and rainfall for Ambajal dam.

regression equation between R and P is given as,
R = a P + b

Where, a and b are the regression coefficients.

The value of correlation coefficient (r) lying between 0.6< r < 1.0 indicates a good correlation between the variables.

Relationship between calculated and observed one day runoff data:

The calculated one day runoff data and observed one day runoff data were plotted using MS Excel to develop the relationship between them. Different models were used to find the best correlation coefficient of the data.

RESULTS AND DISCUSSION

The total area 1409.98 km^2 was bifurcated in to different land use/ land cover types. The values of curve number of the watershed area was 73 for year 2011 (Chavda and Makvana 2011), which is in the range of 68 to 82 (Zade *et al.* 2006). The weighted curve number of the Vanthli taluka of Junagadh district was 73.77 for year 2009 (Jani *et al.* 2010).

The calculation of runoff for different sites of upper Ozat river basin is presented in Fig. 1. As per the curve number technique, the runoff was calculated for different sites as Ambajal, Zanzesri, Dhrafad and Motagujariya were 38.41 mm, 32.03 mm, 58.77 mm, 58.74 mm respectively. The maximum runoff was calculated as 58.77 mm (17.43 %) of the total rainfall of 337.00 mm in the catchment area of Dharafad dam. The average one day runoff of all four sites was 46.99 mm (15.80 %) for year 2012, due to less rainfall in the year 2012.

Relationship between rainfall and runoff

The relationship between the one day rainfall and calculated and observed one day runoff for different sites of Ozat river basin are as follow :

Relationship between one day rainfall and calculated one day runoff

The one day rainfall data and one day calculated runoff data were plotted on graph paper using MS Excel to develop the relationship between the one day rainfall and one day calculated runoff. The model was

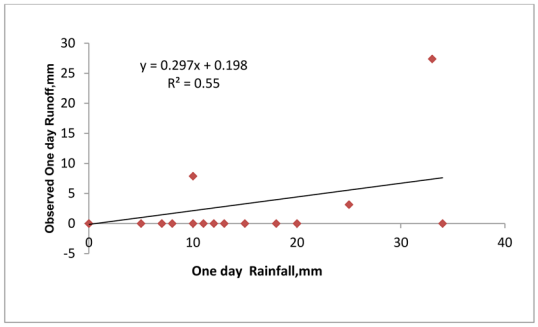

Fig. 3. Relationship between the observed one day runoff and rainfall for Ambajal dam.

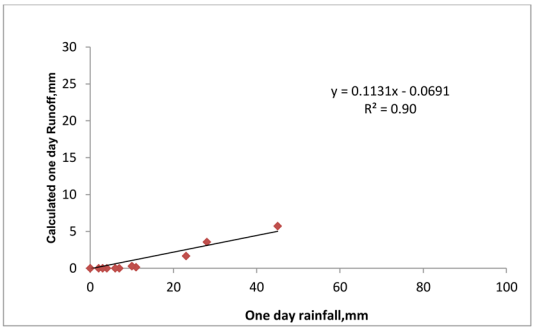

Fig. 4. Relationship between the calculated one day runoff and rainfall for Zanzeshri dam.

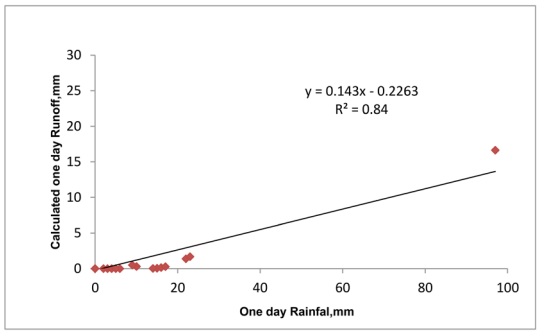

Fig. 5. Relationship between the calculated one day runoff and rainfall for Dhrafad dam.

developed for each site. The correlation coefficient was found out to know the best fit of the data.

Relationship between one day rainfall and observed one day runoff

The observed one day runoff data were collected from Irrigation Department-Junagadh and the data were plotted with one day rainfall to develop the relationship between them. The model was developed for different sites and the correlation coefficient was calculated to know the best fit of the data.

Relationship between calculated and observed One day runoff data

The calculated one day runoff data and observed one day runoff data were plotted using MS Excel to develop the relationship between them. Different models were used to find the best correlation coefficient of the data.

The relationship between one day rainfall and calculated one day runoff, relationship between one day rainfall and observed one day runoff and the relationship between calculated and observed one day runoff data for different sites of Ozar river basin are discussed as below :

Ambajal dam

The catchment area of Ambajal dam is 80.35 km². The graphical relationship of one day rainfall with calculated and observed one day runoff during year 2012 are shown in Figs. 2 – 3, the correlation coefficients were 0.52 and 0.55 respectively. The linear model was not found best fit for the one day rainfall runoff data of the Ambajal dam of Ozat river basin. The observed one day runoff data and calculated one day runoff data were seen that the correlation coefficient for the regression between calculated and observed one day runoff data was found as 0.42 during year 2012.

Zanzeshri dam

The catchment area of Zanzeshri dam is 70.30 km². The graphical relationship of one day rainfall with calculated and observed one day runoff during year 2012 is shown in Fig. 4. Its correlation coefficients were 0.9. The relationships were not established between the observed one day runoff data and rainfall and also for the observed one day runoff with the calculated one day runoff data for the Zanzeshri dam, due to very less data and rainfall.

Dhrafad dam

The catchment area of Dhrafad dam is 181.70 km². The graphical relationship of one day rainfall with calculated and observed one day runoff during year 2012 is shown in Fig. 5. Its correlation coefficients were 0.84. The relationships were not established between the observed one day runoff data and rainfall and also for the observed one day runoff with the calculated one day runoff data for the Dhrafad dam, due to less rainfall.

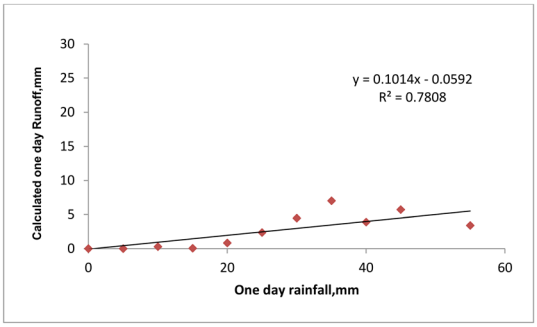

Fig. 6. Relationship between the calculated one day runoff and rainfall for Motagujariya dam.

Motagujariya dam

The catchment area of Motagujariya dam is 69.29 km². The graphical relationship of one day rainfall with calculated and observed one day runoff during year 2012 is shown in Fig. 6. Its correlation coefficients were 0.78. The relationships were not established between the observed one day runoff data and rainfall and also for the observed one day runoff with the calculated one day runoff data for the Motagujariya dam.

CONCLUSION

In this study it was observed that, the relationships between rainfall and runoff of different sites of Ozat river basin were established. The observed and calculated one day runoff data were correlated. The weighted curve number of the study area was 73. As per the curve number technique, the runoff was calculated for different sites as Ambajal, Zanzesri, Dhrafad and Motagujariya were 38.41 mm, 32.03 mm, 58.77 mm, 58.74 mm respectively. The maximum runoff was calculated as 58.77 mm (17.43 %) of the total rainfall of 337.00 mm in the catchment area of Dharafad dam. The average one day runoff of all four sites was 46.99 mm (15.80 %) for year 2012.

The relationships between one day rainfall and calculated one day runoff were established for different sites of Ozat river basin. The relationship between one day rainfall and observed one day runoff was established for only Ambajal dam, the relationships for other sites were not established due to limited data availability. The relationship between one day observed runoff and one day calculated runoff data was established for Ambajal dam only for year 2012. For other dam sites, the relationships were not established due to less runoff generation.

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