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"Watershed Management – Estimation of Runoff and Geomorphological Analysis of composite watershed: RS and GIS Approach"

Mr. Vanve Devidas B.[1] Dr.S.K.Ukarande[2]
Dept. of Civil Engineering Yadavrao Tasgaonkar college of Engineering and Management Karjat, Dist- Raigad, Maharashtra, India.

Abstract: ***An accurate understanding of the hydrological behaviour of a watershed is important for effective management. Runoff is the most basic and important data needed when planning water control strategies/ practices, such as, waterways, storage facilities or erosion control structures. The most popular method used for runoff estimation is NRCS-CN method. The Runoff curve number is a key factor in determining Runoff in the NRCS based hydrological modelling method. Now a days GIS and RS is being used with NRCS-CN method highly, most of the researchers found that use of NRCS-CN with help of GIS very accurate results in determination of Runoff. Kinhi watershed covers an area of near 1485 ha. And is consist of two revenue villages Kinhi and Bhairobawadi. The study was carried out in the hot and dry climatic condition; area lies between Longitude19° 04′27″ to 19°08′00″ N and Latitude 74°24′51″ to 74° 27′32″E. Remote sensing provided a powerful tool for estimating curve number values in Kinhi watershed and eventually values of runoff. Also RS and GIS technologies used in Geomorphological investigations give incredible advantages. The SRTM DEM data collected base on spectral reflectance properties of land and Harmonised soil data, Global land cover data base used in the morphometric analysis and also Watershed Modelling System software were used.***

Keywords: Remote Sensing, Geographical Information System, Natural Resources Conservation Services, Shuttle Radar Topography Mission (SRTM), Digital Elevation Model, Watershed Modelling System.

I. INTRODUCTION

A watershed is the hydrological unit which drains the Runoff to a common outlet point by the stream system. It is topographical delinated area, which composed of interrelated parts and functions. In India, the availability of accurate information on runoff is scarcely available in few selected sites. However, quickening of the watershed management programme for conservation and development of natural resources management has necessitated the runoff information. Advances in computational power and the growing availability of spatial data have made it possible to accurately predict the runoff. The possibility of rapidly combining data of different types in a GIS and using RS has led to significant increase in its use in hydrological applications. The NRCS-CN method also known as the hydrologic soil cover complex method is a versatile and widely used procedure for runoff estimation. This method includes severalImportant Geomorphological properties and the various physical, hydraulic properties of soil, of the watershed. In the present study, the runoff from NRCS-CN model modified for Indian conditions has been used by using conventional database and GIS for Estimation of runoff for Kinhi watershed.

Remote sensing Techniques are more reliable, up-to-date, and faster than conventional techniques. It plays a vital role in acquisition of data in the different aspects of land use and soil cover, which are essential parameters in the field of watershed runoff estimation. GIS is capable of handling spatial and a spatial data when compared to conventional information system. It also identifies the spatial relationships between map features. The use of GIS technology as a spatial data management and an analysis tool provides an effective mechanism for hydrologic studies. Thus the remote sensing along with GIS application aid to collect, analyse and interpret the data rapidly is very much helpful for watershed planning and management.

II. LITERATURE SURVEY

Arun W. Dhawale Jan 2013 Studied and published paper entitled "Runoff Estimation for Darewadi Watershed using RS and bGIS"The study was conducted for the Darewadi Watershed having area of 3569 hector in ahmednagar district. Surindar G

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Wawale July –Aug. 2012 Carried out research work and published paper entitled as "Geomorphologic Analysis of Pravara River using Topographical and Remote Sensing Database: A Case Study of Pravara River in Ahemadnagar District of Maharashtra"

A. Study Area

The Project area "Kinhi watershed" is subwatershed of GV-115 which is of Kalu River, sub tributary of Mula River. It is located in Parner tahasil in the district of Ahmednagar of Maharashtra State about 50 Km. from district headquarters. This area lies in the South-West of Ahmednagar district, and bounded with Longitude19° 04′27″ to
19°08′00″ N and Latitude 74°24′51″ to 74°
27′32″E.It consist of 2 revenue villages namely Kinhi and Bhairobawadi**.**The nearest town is Parner which is about 21 Km from project area and is well connected by all-weather road. Project area is located nearer to Nagar- Kalyan Highway.

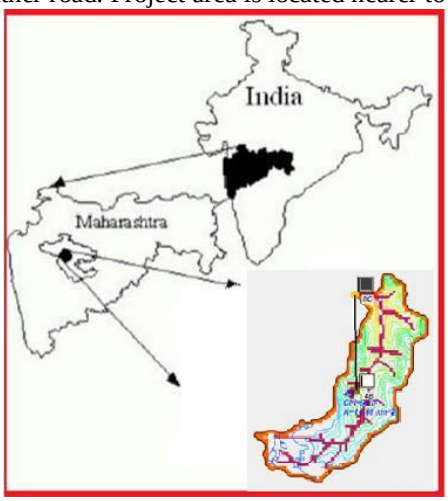

Fig 1: Location Map

The net geographical area of Kinhi watershed is about 1485 ha out of which 86.86 % is under agriculture which is completely rain-fed; mainly a *Kharif* crop is taken. About 11.82 % of the land is waste land,0.47% land is under habitation and 0.82% land is covered by water bodies.

1) *Physiography***:** Area is located about 800 m above the MSL. The watershed is ferned shape. The drainage pattern having 3 and 4 number of stream orders, the area having average elevation 851.72m.
2) *Climate & Rainfall:* The Climate of this region is hot and dry except during south-west monsoon season. The average annual rainfall in the project area is 533.80 mm for last 5 years (2009-2014) which is recorded at Takali Dhokeshwar Raingauge Station of Parner Tahasil. However the occurrence and time of the rain is unpredictable. Hence there is uncertainty of cropping pattern as well as harvest. The area receives its annual precipitation from the South West monsoon. Since the area falls under drought prone region, the area suffering from frequent draughts every alternate year. In general there is Scarcity of water in the month of April to June. In this area temperature ranges from 7^0C to 42^0 C Average relative humidity for last 5 years ranges from 36 to 80.80 %. Wind Velocity in the area recorded for year 2012 is 4.4 km/hr. The Avg. Bright Sunshine hours for the year 2012 are 5.4hrs per day.

B. Geomorphology and Geology

This area falls under Deccan plateau, hot semi-arid Eco-region at western plateau and hilly agro-climatic region in scarcity agro-climatic zone of Maharashtra State.

C. Soil Characteristics

The soil types of the project area are broadly divided into three categories namely coarse shallow soil; medium black soil; and greyish soil. The existing farming systems being adopted by majority of farmers in rain fed area of district are characterizes by existence of food grain crops including mostly Bajra, Jowar as cereals and Mung, Udid, and Tur as pulse crops in combination with dairy and animal husbandry.

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D. Data used

Type of Data	Details of Data	Source of Data
Toposheet	47(I/8) at 1:50,000 scale	Survey of India Dept. (SOI)
Satellite Data	SRTM DEM Data, 90m resolution	NASA Satellite Data
Harmonised Soil Data	Global type	NASA Satellite Data
Land Cover Data	Global type	NASA Satellite Data
Soil Texture Data	1:60,000 scale	District Soil Laboratory
Rainfall Data	Daily (2011-12)	Takli Dhokeshwar weather station

Table 1: Various Data Used

III. METHODOLOGY

The Curve Number method (NRCS-CN) also known as the Hydrologic Soil Cover Complex Method, is a versatile and widely used procedure for runoff estimation. In this method, runoff producing capability is expressed by a numerical value varying between 0 - 100.

In general, the rainfall-runoff equation of the NRSC Curve Number Method relates a land area's runoff depth (precipitation excess) to the precipitation it receives and to its natural storage capacity. The amount of runoff from a given watershed is solved with the following equations. The NRCS curve number equation is shown below in Equation 5-1, and the NRCS rainfall excess equation is shown below in Equation below.

$$S=\frac{1000}{CN}10$$

$$Q=\frac{P-0\,2S\;2}{(P+0.8S)}$$

Q= 0 for P < 0.2S

Where; S = maximum storage volume of water on and within soil (inch).

CN = curve number

Q = Runoff depth (in) multiply by drainage area to determine runoff volume

P = precipitation (in)

0.2S =initial abstraction as intercepted or absorbed by soil.

The curve number is a function of the watershed antecedent moisture conditions, hydrologic soil group and land use/landcover.Give the runoff curve number for urban and agricultural areas *for an antecedent moisture condition of II (AMC II, average condition).*

Formulas for converting from AMC II (average condition) to AMC I (dry condition) and from AMC II to AMC III (saturated condition) are given below:

$$CNI=\frac{4.2CNII}{10-0.058CNII}$$

$$CNIII=\frac{23CNII}{10+0.13CNII}$$

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A. Weighting CNs

When the watershed varies in soil type, antecedent moisture condition, or land cover a composite curve number is used, which is computed as the weighted areal average of the curve number for each region of the watershed. Alternatively, the runoff can be computed for each region individually and then added.

$$CN = \frac{\sum_{i=1}^{N} A_i CN_i}{\sum_{i=1}^{N} A_i}$$

N=number of regions, i= region index ,Ai= area for region I ,CN i= curve number for region I,CN= composite curve number for the watershed.

Sr No	Land use	Runoff curve numbers for hydrologic soil group			
		A	B	C	D
1.	Agricultural land	59	69	76	79
2	Barren land	71	80	85	88
3	Built-up area	77	86	91	93
4	Canal	100	100	100	100
5	Forest	26	40	58	61
6	Plantation	41	55	69	73
7	River	100	100	100	100
8	Scrub land	33	47	64	67
9	Tanks	100	100	100	100

Table 2 Runoff Curve Number

B. Hydrologic soil group classification

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. Good hydrologic condition indicates that the soil usually has a low runoff potential for the specific hydrologic soil group, cover type, and treatment .some factor to consider in estimating the effect of cover on infiltration and runoff are canopy or density of lawn, crops, or other vegetative areas,amount of round cover ,amount of grass or close seeded legumes in rotations ,per cent of residue cover and degree of surface roughness.

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Antecedent moisture condition AMC class	5-day total antecedent rainfall (cm)	
	Dormant season	Growing season
1. Optimum soil condition from about lower plastic limit to wilting point.	Less than 1.25	Less than 3.5
2. Average value for annual floods.	1.25 to 2.75	3.5 to 5.25
3. Heavy rainfall or light rainfall and low temperature during 5 days preceding the given storm.	Over 2.75	Over 5.25

Table 3 Antecedent Moisture Condition

Soil group	Description
A	Lowest rainfall potential- includes sand with very little clay and silt, deep, rapidly permeable Loss.
B	Moderately low runoff potential- sandy soil less deep than A, and loess less deep than A, the group Has average infiltration.
C	Moderately high runoff potential- Shallow soil with Clay and colloids, though less those of group D.
D	Highest runoff potential- clay of high swelling percentage and some shallow soil with impermeable Horizon near the surface.

Table 4 Soil Group Classification

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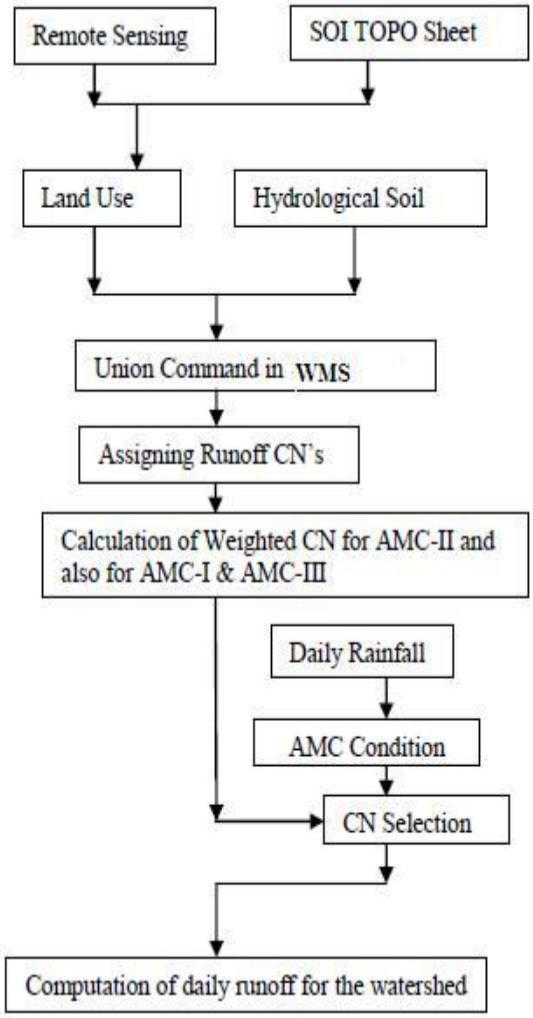
Flow chart for above method is as follow:



IV. RESULT

Following table shows the geomorphic properties of the watershed which is calculated by the watershed modelling system.

Type of Geomorphic Properties	Analysis
Basin ID	3
Basin Name	3B
Basin CN	91
Basin Area	1485 ha
Basin Slope	0.0506 m/m
Basin Length	6600.89 m
Perimeter	29789.8 m

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Shape Factor	2.86
Mean Basin Elevation	851.72 m
Maximum Flow Distance	9996.62 m
Maximum Flow Slope	0.0124 m/m
Maximum Stream Length	9864.27 m
Maximum Stream Slope	0.0124 m/m
Average Overflow Distance	110.78 m

Table 5 Geomorphic Properties

For the present study NRCS-CN procedure has been used for estimating surface runoff depth with the aid of satellite remote sensing data base. Runoff varies spatially due to changes in soils, land use slope and temporarily due to changes in soil water content. As runoff has spatial variability, each and every portion of earth surface produces different volume of runoff base on their geo-hydrological environment. The surface runoff is varied time to time and place to place. It is estimated using the CN = 91.

Rainfall period 2011	Runoff Volume by NRCS-CN method, (m3)	Runoff Volume by watershed modelling system. (m3)	Acceptability (%)
Jan-March	00	00	100
April-June	18696	24928.6	75
July-Sept.	64865.2	76312	85
Oct-Dec.	26359	43933	60

Table 6 Computed Runoff

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V. CONCLUSION

For ungauged watersheds accurate estimation of the surface runoff from the land in to rivers and streams requires very much time and efforts but remote sensing technology can aggument the conventional method to a great extent in rainfall runoff studies. In this study NRCS-CN for Indian condition has been used for generation of the watershed. An integrated RS and GIS based methodology has successfully demonstrated for estimation of runoff in Kinhi watershed. The manual calculation of CN's for large areas or many drainage basins can be laborious and time consuming their fore GIS is an appropriate to used for such an application. Using NRCS-CN model for Kinhi watershed the average CN obtained for treatment is 91.

This runoff potential can be used for the artificial recharge by constructing the Nala Bundies and Farm ponds at suitable sites of these sub watersheds. Also, constructing the structures like check dams water can be stored it will be helpful for the dry summer days to be used as a drinking purpose as well as agricultural purpose.

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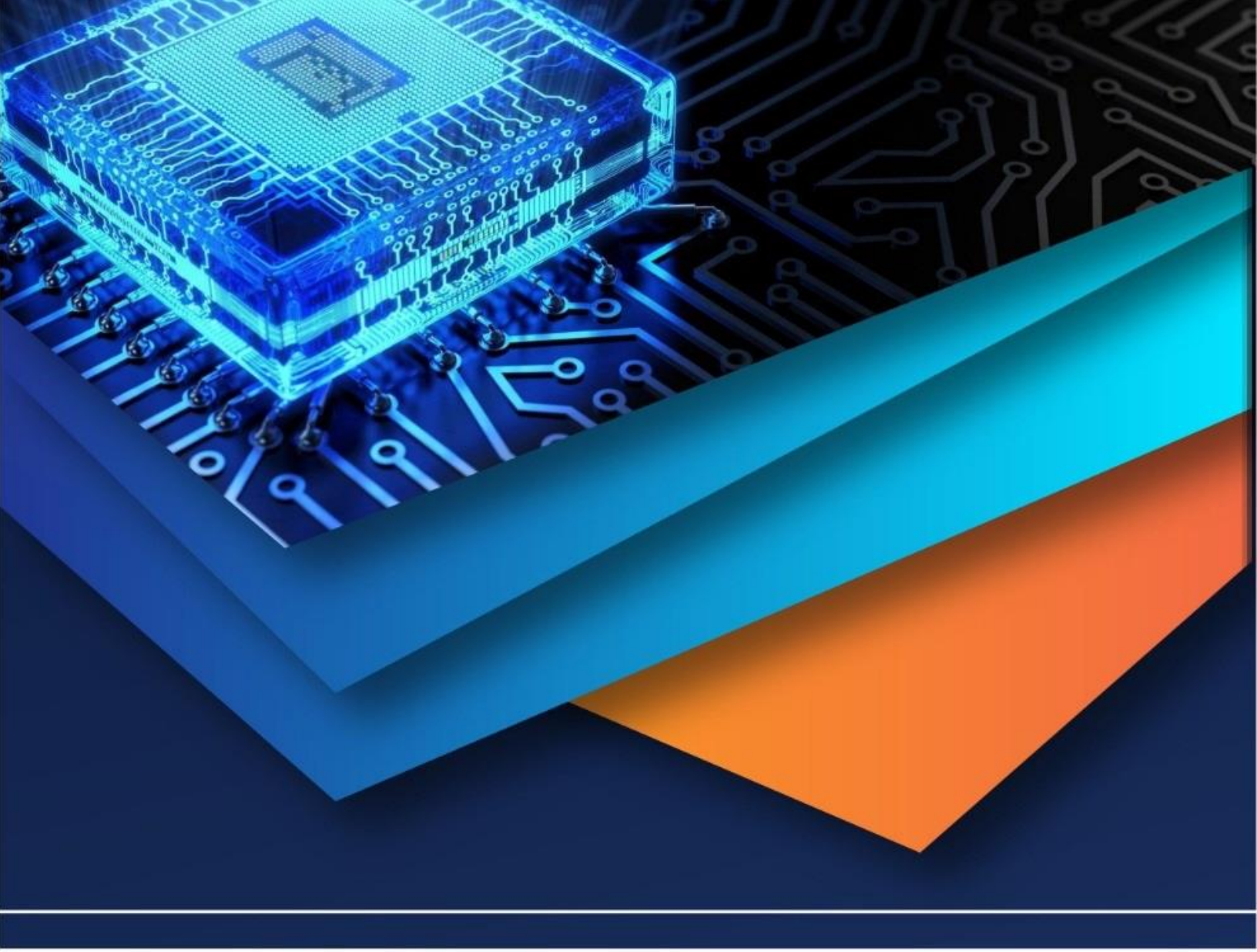

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