ABSTRACT:
Nowadays in water resources engineering watershed management plays a vital role. Water harvesting structure based on management of water resources is essential to plan and protect the existing resources. Geographic Information System (GIS) and Remote Sensing (RS) techniques are mostly useful to achieve spatial and non-spatial database that signify the hydrologic features of the watershed use as accurately as possible. In this study area of Agrani river basin, Upper Krishna basin, Western Maharashtra, India. The yearly rain fall data of 7 rain gauge stations (1998–2015) together used to calculate the yearly run off from the watershed using Soil Conservation Service – Curve Number (SCS – CN) method and Arc GIS tool. From the collected annually rainfall data for the years of 1998 to 2015 in the study area annual run off has been calculated. The average rainfall is 466.63 mm respectively and typical runoff for the year of 1998 to 2015 is 20.75 mm respectively. The developed rainfall–runoff model is used to understand the watershed and its runoff flow characteristics.

INTRODUCTION:
Water is the most important requirements for fiscal and social development. In India Human population is always increasing thereby water demand for domestic, agricultural and industrial use also increasing. However, the significant of rain and ground water availability has resulting in over-utilization of surface water, decreasing water table levels and water quality deterioration. To improve watershed at micro level it is required to reduce the runoff, increase the groundwater level and quality. Making variations in land management or constructing suitable structures can be achieving decrease of surface runoff. Detailed understanding and investigation of several rainfall-runoff model such as hydraulic properties of the soil, land use, rainfall intensity, slope soil moisture, and lithology is required to study micro-watershed development approach. Every single watershed has certain features such as shape, size, drainage, slope, geology, vegetation, geomorphology, soil, land use and climate. Water shed management indicates proper utilization of water for natural resources and land in a watershed forvaluation of runoff helps for developing, planning and managing the irrigation scheduling and water resources. In the management planning and water resources applications runoff is very important hydrologic variables used. Valuation of runoff requires much time and effort on land surface and rivers for gauged watershed accuracy. In this study to produce rainfall runoff model by integrating spatial difference of the various physiographic features like as geology, geomorphology, land use/land cover, structures, soil and drainage pattern using SCS-CN technique with the help of RS data and GIS techniques.

OBJECTIVE:
To generate a Rainfall-Runoff-Model (RR Model) by incorporating spatial variation of various physiographic characteristics of the study area such as slope, land use/land cover, soil and drainage pattern integrated with the help of Geospatial techniques.
MATERIALS AND METHODS:

STUDY AREA:

This study was carried out in Agrani River which is a tributary of Krishna River in Sangli and Belgavi district of Maharashtra (Fig. 1). The basin length is about 97 km and perimeter is 249 km. It originates from the rain shadow region near to Western Ghats at an altitude 885 m and confluence point is Hulga Bali at Altitude 549 m. Agrani river basin lies between 16° 39' 24" N to 17°19' 25" N Latitude and 74° 40' 16" E to 75° 13' 20" E longitude. The watershed experiences humid monsoon climate with normal temperature, evaporation and humidity throughout the year. The monsoon season in this study area is from June to September. The rainfall occurrence during July and August is comparatively more than rest of the year and significant amount of runoff occurs in the river basin. The rainfall stations are Kavthe Mahankal, Vita, Miraj, Tasgaon, Jat, Madabhavi, and Atpadi. The annual rainfall is about 466.63 mm for a period 1998-2015. The Agrani basin has 7th order drainage basin (Fig. 2).

METHODOLOGY:

In this study, Survey of India topographical sheet no. E43U10, E43V1, E43U9, E43016, E43U19, E43U13, E43P4, 47P/2 on the scale 1:50,000 were used to delineate the watershed boundary, drainage and contour. Remote sensing data of IRS P6 - LISS III sensor, on a scale of 1:50,000 for outlining land use/land cover map (Fig. 3) and hydrological soil map (Fig. 4). Hydrologic soil group was prepared according to soil characteristics and type of land use/land cover for the assessment of runoff by river basin. Yearly rainfall data from 7 rain gauge stations for the year of 1998 to 2015 (18 years) data were used to calculate the runoff using SCS-CN method.

SCS CURVE NUMBER METHOD:

Soil Conservation Service Curve Number (SCS-CN) is the greatest method to evaluate the direct runoff from a watershed (USDA, 1972). The SCS-CN method explaining the water balance equation can be expressed as below (Mishra and Singh 2003).

\[
P = I_a + F + Q \tag{1}
\]

\[
\frac{Q}{P - I_a} = \frac{F}{S} \tag{2}
\]

\[
I_a = \lambda S \tag{3}
\]

Where,
- \( P \) denoted as total precipitation (mm);
- \( Q \) is the direct runoff (mm),
- \( F \) indicates the cumulative infiltration (mm),
- \( I_a \) denoted as initial abstraction (mm);
- \( S \) is the potential maximum retention (mm) and \( \lambda \)the initial abstraction coefficient (0.3) and consist of surface storage, infiltration and interception prior to runoff in the watershed and empirical relation was developed for the term \( I_a \) and it is given by,

\[
Q = \frac{(P - I_a)^2}{(P - I_a + S)} \tag{4}
\]

Which is valid for \( P \geq I_a \). Otherwise, \( Q = 0 \). For a constant value of \( I_a \) (0.3S), P-Q data can be useful to determine \( S \). In practice mapping equation is used to derive \( S \) expresses in terms of the curve number (CN)

\[
S = \frac{25400}{CN} - 254 \tag{5}
\]
The CN (dimensionless number ranging from 0 to 100) is determined from a table, based on land-cover, HSG and AMC. HSG is expressed in terms of four groups (A, B, C and D), according to the soil after prolonged wetting. AMC is expressed in three levels (1, 2 and 3), according to rainfall limits dormant and growing seasons.

\[ CN_w = \frac{\sum (CN_i \cdot A_i)}{A} \]  

Where, \( CN_w \) is the weighted curve number; \( CN_i \) is the curve number from 1 to any number \( N \); \( A_i \) is the area with curve number \( CN_i \); and \( A \) the total area of the micro-watershed.

HSG AND ANTECEDENT SOIL MOISTURE CONDITION (AMC):

According lowest infiltration rate of the soil, after continued wetting which is gained fora bare soil (Table 1) HSG is stated as four groups. Soil conservation service (SCS) had established three antecedent soil moisture conditions such as AMC 1, AMC 2 & AMC 3 and significant effect on rainfall runoff. Prior to estimate rainfall runoff for event, depend on the spell and antecedent precipitation the curve numbers are adjusted. At three levels AMC is stated, according to rainfall restrictions for inert and growing seasons. Even if originally intended for use on river basin of 1930 km², it has been amended by various operators for significance to greater watersheds, predominantly bland-cover created area weighting of curve numbers (Jackson et al., 1976; Rawls et al., 1981; Still and Shih, 1984, 1985, 1991).

2.2.3 AREA WEIGHTED CURVE NUMBER:

One by one the different layers of HSG, soil and land use/landcover were superimposed using Arc GIS 9.3 and the original PAT (polygon attribute table) was found. PAT was used to calculate the entire area weighted curve number of the study area to calculate the AMC 2 and the result obtained refer (Table 2).

ESTIMATION OF RAIN FALL – RUNOFF:

Area weighted curve number and yearly rainfall database from 1998 to 2015 (for 18 years) of Agrani basin were filled into the SCS formula and the results are found from the yearly runoff results are found. The detailed annual rainfall and runoff values for the 18 years are given below in Table 3.

RESULTS AND DISCUSSION:

Every year due to high runoff, minimum average yearly rainfall, and evapo-transpiration in Agrani river basin like scarcity of water situation overcomes because of lack of proper management surface and sub-surface water resources. Discontinuities (fractures/joints) in the rigid rock zones play important role in groundwater restore movement and discharge in Agrani watershed. The basin creates different landuse/land cover of about 26.67% of the area is occupied by agricultural land, 20.37% area occupied by forest land, 27.06% area of fallow land, 7.98% area covers open scrub land and remaining 17.89% of the area is covers by others such as water body and rocky land. In general, the fallow land among the different landcover types acts the main role for the direct surface runoff.
Table 1 Yearly Runoff for Agrani River Basin

<table>
<thead>
<tr>
<th>Hydrologic Soil Group</th>
<th>Type of Soil</th>
<th>Runoff potential</th>
<th>Final infiltration rate mm/hr</th>
<th>Distribution (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Deep, well drained sands and gravels</td>
<td>Low</td>
<td>&gt;7.5</td>
<td>4.73</td>
<td>High rate of water transmission</td>
</tr>
<tr>
<td>Group B</td>
<td>Moderately Deep, well drained with moderately fine to coarse textures</td>
<td>Moderate</td>
<td>3.8-7.5</td>
<td>25.54</td>
<td>Moderate rate of water transmission</td>
</tr>
<tr>
<td>Group C</td>
<td>Clay loams, shallow sandy loam, soils with moderately fine to fine textures</td>
<td>Moderate</td>
<td>1.3-3.8</td>
<td>52.04</td>
<td>Moderate rate of water transmission</td>
</tr>
<tr>
<td>Group D</td>
<td>Clay soils that swell significantly when wet, heavy plastic and soils with a permanent high water table</td>
<td>High</td>
<td>&lt;1.3</td>
<td>18.69</td>
<td>Moderate rate of water transmission</td>
</tr>
</tbody>
</table>

Table 2 Weighted Curve Number for Agrani River Basin (For AMC 2)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Land use</th>
<th>Soil Type</th>
<th>Area in km²</th>
<th>CN</th>
<th>% area</th>
<th>% area * CN</th>
<th>Weighted Curve Number (WCN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agricultural</td>
<td>B</td>
<td>40.14</td>
<td>75</td>
<td>2.08</td>
<td>155.984</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>200.72</td>
<td>81</td>
<td>10.40</td>
<td>842.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>257.93</td>
<td>86</td>
<td>13.36</td>
<td>1149.33</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Natural Vegetation</td>
<td>C</td>
<td>218.42</td>
<td>81</td>
<td>11.32</td>
<td>916.685</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>164.73</td>
<td>86</td>
<td>8.54</td>
<td>734.03</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Open scrub land</td>
<td>C</td>
<td>39.68</td>
<td>71</td>
<td>2.06</td>
<td>145.973</td>
<td>AMC 1 =77.93 AMC 2 = 83.06 AMC 3=88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>54.00</td>
<td>81</td>
<td>2.83</td>
<td>229.57</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fallow Land</td>
<td>C</td>
<td>282.38</td>
<td>81</td>
<td>14.63</td>
<td>1185.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>240.02</td>
<td>85</td>
<td>12.44</td>
<td>1057.08</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rocky Land</td>
<td>C</td>
<td>276.81</td>
<td>84</td>
<td>14.34</td>
<td>1204.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>17.3</td>
<td>81</td>
<td>0.90</td>
<td>72.6062</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Water bodies</td>
<td>-</td>
<td>6.17</td>
<td>100</td>
<td>0.32</td>
<td>31.9689</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Yearly runoff for Agrani river basin

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall (mm)</th>
<th>Runoff (mm)</th>
<th>Runoff (mm²)</th>
<th>Year</th>
<th>Rainfall (mm)</th>
<th>Runoff (mm)</th>
<th>Runoff (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>561.33</td>
<td>497.36</td>
<td>103.19</td>
<td>2007</td>
<td>570.00</td>
<td>505.95</td>
<td>104.97</td>
</tr>
<tr>
<td>1999</td>
<td>505.85</td>
<td>442.43</td>
<td>91.79</td>
<td>2008</td>
<td>420.14</td>
<td>357.84</td>
<td>74.24</td>
</tr>
<tr>
<td>2000</td>
<td>527.67</td>
<td>464.02</td>
<td>96.27</td>
<td>2009</td>
<td>582.59</td>
<td>518.43</td>
<td>107.56</td>
</tr>
<tr>
<td>2001</td>
<td>480.57</td>
<td>417.44</td>
<td>86.61</td>
<td>2010</td>
<td>618.51</td>
<td>554.07</td>
<td>114.95</td>
</tr>
<tr>
<td>2002</td>
<td>328.19</td>
<td>267.65</td>
<td>55.53</td>
<td>2011</td>
<td>345.64</td>
<td>284.7</td>
<td>59.07</td>
</tr>
<tr>
<td>2003</td>
<td>235.13</td>
<td>177.53</td>
<td>36.83</td>
<td>2012</td>
<td>351.49</td>
<td>290.66</td>
<td>60.30</td>
</tr>
</tbody>
</table>
The hydrologic soil group which signifies the soil type, characteristics, and its infiltration capacity acts important role while measuring the runoff potential. The hydrologic soil category of ‘B’, ‘C’ and ‘D’ were explained with reference to remote sensing data and other secondary data in this study area. Throughout the study region that ‘C’ category of HSG mostly covered which is predominantly included of crop and agricultural land and then followed by ‘B’ and ‘D’ category. By intersecting the hydrologic soil group and land use the curve number was allotted according to Scand resulting the antecedent moisture conditions values are AMC 1, AMC 2 and AMC 3. The yearly runoff evaluated in both mm and mm and has decreased from the year 1998 to 2003 and suddenly increased between the years of 2004 to 2010 and gradually decreases and increases from the year 1998 to 2015. The trend line for the average rainfall is in the straight line for indicates that rainfall has decreased from the year 1998 to 2015. The result of the rainfall runoff trend line indicates that there is high runoff taking place comparatively. It is reasonably more runoff in this area and further it can be controlled by converting fallow land into agricultural land since it occupies 53.73% of the total land area.

CONCLUSION:

The conventional hydrological data are insufficient for determination of design and process of water resources schemes. The great use of RS data for the evaluation of important hydrological parameters, such as soils, land use/land cover, drainage, geomorphology etc. The estimation of runoff value using combination of SCS model and remote sensing gives the great accuracy within time. GIS is an effective tool provides the adequate input data for the preparation of the SCS curve number model in watershed management. The analysis can be extended further to evaluate the effect of land use variations, after Progresses in the watershed, on the rainfall-runoff relationship. Water irrigation can be done to the related agricultural land and other utility purposes by evaluating the difference in annual runoff.
ACKNOWLEDGMENT:

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REFERENCES