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Rainfall Runoff Modelling of Machhu II basin, Morbi, using Soil and Water Assessment Tool

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Abstract—"The ***objective of this study is to estimate the runoff on Machhu II basin by applying the SWAT (Soil and Water Assessment Tools). The present Watershed covers an area of 427.34sq km. To perform the study at regional scale, an effort is made to combine the geospatial data with the available hydrological and meteorological data. The Soil and Water Assessment Tool (SWAT) was designated to spot its applicability in developing urban basins. This work provides a case study for simulating hydrologic processes on small Watershed, which is experiencing the rapid urbanization, by adapting SWAT modelling tools on ArcGIS platform. Simulation of SWAT for daily, monthly as well as yearly basis is done by using 35 years of daily precipitation as well as daily maximum and minimum temperature, to obtain the runoff for corresponding precipitation. The coefficient of correlation (r) obtained for rainfall and corresponding to runoff is found to be 0.9657.***

Keyword: Runoff, SWAT, Rainfall, ArcGIS, Urbanization.

I. INTRODUCTION

In water resources studies, for identifying any characteristic of a watershed, runoff is most important hydrological parameter used. However, estimation of direct runoff for any basins is difficult and time intense. The standard models for predicting runoff needs wide range of hydrological and meteorologic data. Many models have been evolved for watershed hydrology; however unavailability of the temporal and spatial data was the main hindrance for its application. But, with the major development in the field of remote sensing and Geographic Information System (GIS), there has been rapid increase in use of these models worldwide. The model allows forecasting as well predicting the runoff of any given episode of precipitation and the required duration. The present study uses ArcGIS 10.3 and SWAT2012 Model. In the present study an attempt has been made for estimating runoff with the help of SWAT tool utilizing ArcGIS.

II. DESCRIPTION OF SWAT MODEL

The Soil & Water Assessment Tool (SWAT) is a tool which works in conjunction with ArcGIS with an extension ArcSWAT to estimate the quality and quantity of surface as well as sub-surface water, so as to predict the impact of the land management practices as well as climate change for identifying the best management practice on the desired watershed . SWAT was developed by Arnold of the United States Department of Agriculture (USDA) in the 1990s [1], to provide a consistent basis for estimating runoff, erosion, sediment and nutrient transport from the watersheds under different management practices. The calculation of the hydrological cycle which is simulated by SWAT is based on the water balance equation as follows [3]:

$$SW_t = SW + \square(R_{day}\text{-}Q_i\text{-}E_a\text{-}P_i\text{-}QR_i$$

i.e. SWt is the final groundwater content,SW0 represents the initial groundwater content on day i, t is time (day), Rday is the amount of rainfall on day i, Qsurf is the amount of surface flow on day i, Ea describes the amount of evapotranspiration on day i, Wseep represents the amount of water entering the unsaturated zone of the soil profile on day i, and Qgw is the total flow of groundwater on day i. SCS Curve Number Procedure is used to get the runoff. Here, the runoff volume is estimated by using the Soil Conservation Service (SCS) curve number technique (USDA, 1972). For simulating a watershed, first, the watershed is divided into sub basins. The impact of the of use of the sub basin in simulation is profound when different areas of the basins have distinct land uses or soil property unique enough to have impact on hydrological properties. However, the total runoff relies on the actual hydrologic condition for each land use cover, soil class and slope existing in the basin. Therefore, it is important to identify the impact for each type of land cover in order to calculate runoff of the basin. After overlaying land-cover, soil maps and slope, the sub-basin is further categorised into HRUs (Hydrological Response Units) having identical land use, soil and slope. Runoff and peak discharge is predicted individually for each single HRU and then summed up to predict the total runoff of the entire watershed.

III. STUDY AREA

The present study area lies in Machhu II basin in Morbi district. Machhu River is one of the major North flowing river which rises in hills of Jasdan near village Khokhara in Chotila taluk of Surendranagar district of Gujarat at an elevation of 220 m above m.s.l and outfalls into the little Rann of Katchch is 114.75 km. The Present study area falls under Survey of India sheet number 41J16 which extends from longitude 70° 50' to 71° 05' and latitude 22 °33' to 22° 50' with elevation

52m and 93m. The Study Area lies between Morbi and Wakaner which has become the nerve_center of the India's ceramic tiles and sanitary ware industry. Over the years, this industry has grown into the one of largest contributors to ceramic ware worldwide after China. With industrialization, changes in the land cover can be observed which has affected the behaviour of the watershed.

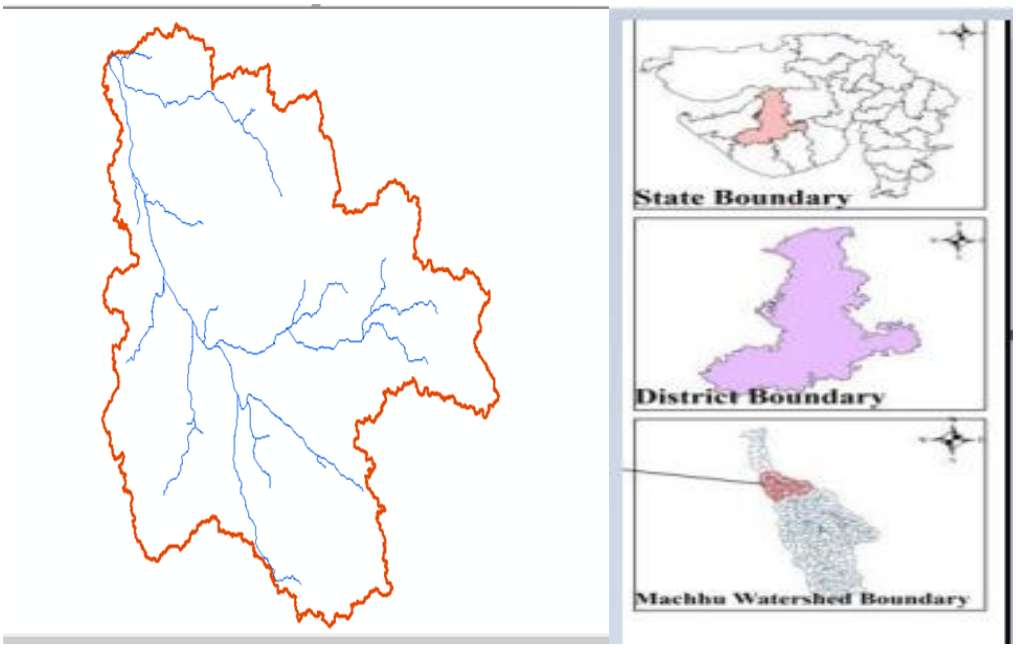


Fig. 1 Study Area Map

IV. METHODOLOGY

SWAT requires spatial and temporal data of the required area. Being semi-distributed model, this tool has to process, combine and analyse the input data with the help of GIS. The methodology for the generation of runoff for the desired outlet with the help of SWAT is shown in flow diagram:

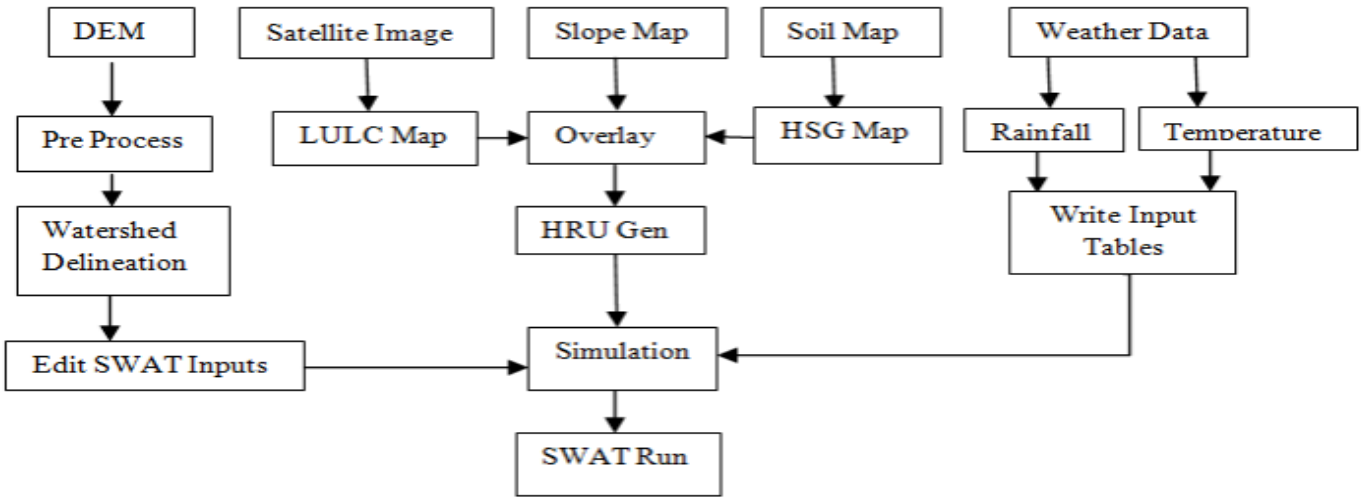


Fig: 2 Proposed Methodology

V. DATA PREPROCESSING

5.1 Digital elevation model (DEM) DEM (Figure 3.1) is obtained from the USGS website. It delineates the watershed and sub-watersheds as channel network along with longest reaches. The topographic parameters such as terrain slope, channel slope or reach length were also derived from the DEM.

5.2 Land use map (Figure 3.1) for the proposed area is prepared using satellite Resourcesat-1 LISS-III image (year: 2014).The unsupervised classification technique is used to identify the most present land use classes in the Machhu basin. Here, four major classes were identified as agriculture (57%), waste land (33.33%), water (4.851%) and urbanized areas (4.0625%).

5.3 Soil map (figure 3.2): The soil map used was obtained from the Harmonized World Soil Database (HWSD) raster world soil map. Four types of textural classes are identified in the study area. The complete soil map is shown in Figure 3.2

5.4 Hydro meteorological data: SWAT requires daily data of rainfall, maximum and minimum temperature, relative humidity, wind speed and solar radiation for modelling of various physical processes. Rainfall data and Temperature data of Machhu basin catchment has been downloaded from site http://swat.tamu.edu . Here 35 years of precipitation as well as maximum and minimum temperature data is used from the year 1979 to 2014 in this study area.

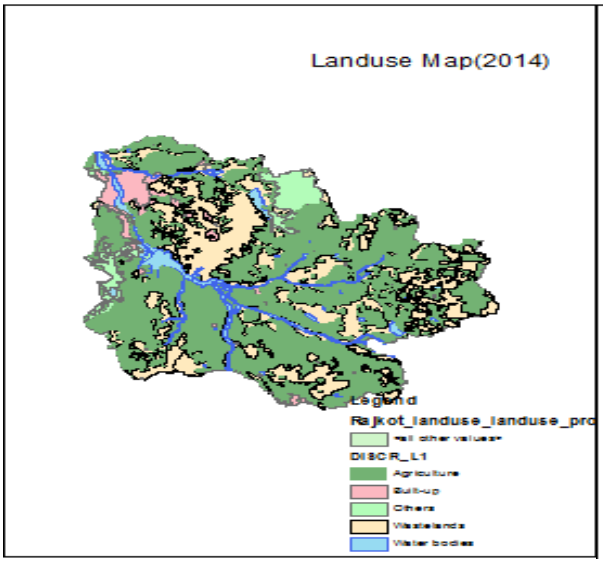


Fig. 3.1 Land –Use Map

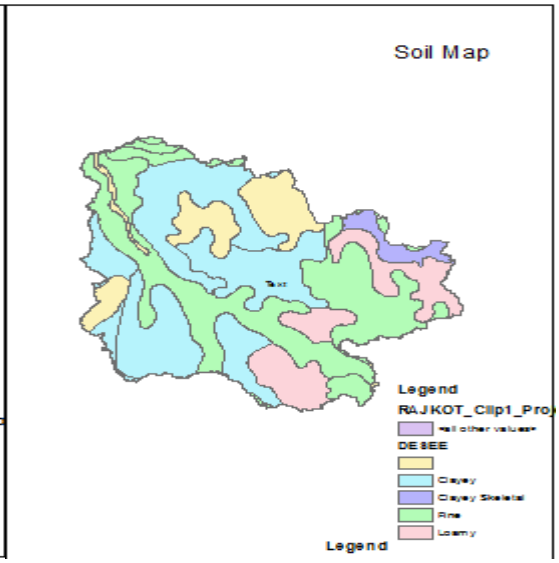
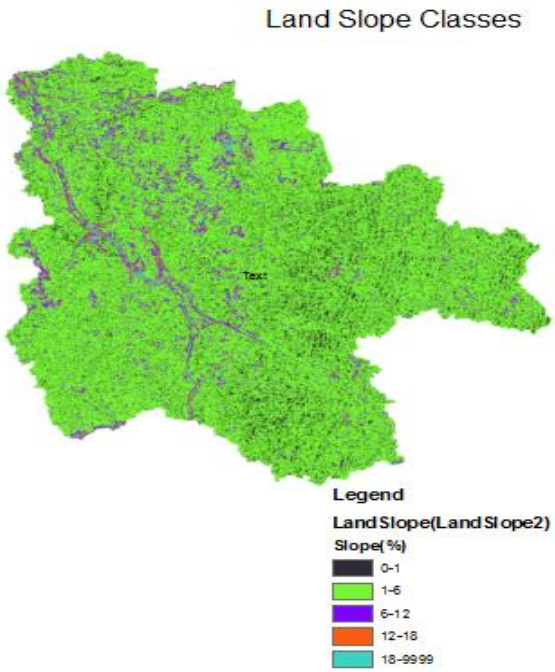


Fig. 3.2 Soil Map



VI. MODEL SETUP

The model was setup for the study area along with the entire dataset required by the SWAT model. In ArcSWAT, basin is delineated into sub-basins, based on the automatic procedure with the help of DEM. The outlet point is defined for basin area and watershed was delineated for the present study (Figure 4.) and all the parameters are calculated for each sub basins. The entire basin is divided into 41 sub-basins.

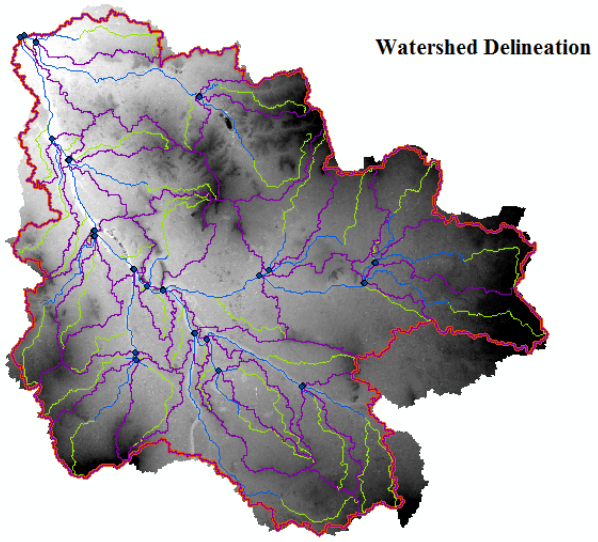


Fig. 4 Watershed Delineation

SWAT imports land use and soil map along with the slope characteristics to examine and determine the land HRU (Hydrological Response Unit) for each sub basins. Land use category is used to classify the land use layer and soil look up table is used for specifying the type of soil to be modelled for each category. The LULC map is reclassified into 4 different groups whereas the soil map is classified into 2 hydrological categories The slope map is reclassified in 5 classes i.e. 0-1%, 1-6%, 6-12%, 12-18% and above 18%. Next the land use, soil and slope maps were overlaid. The distribution of hydrologic response units (HRUs) within the catchment has been determined. A total of 41 HRUs were generated for the proposed basin

VII. RESULT AND DISCUSSION

The present study describes the SWAT-based model for determining the runoff of the given basin. SWAT simulation is done for the daily, monthly and yearly basis. Yearly runoff and average yearly rainfall for past 35 years is shown in Figure 5 .The rainfall runoff correlation has also been done for 35 years data and a good correlation is found with r2 value 0.9657.

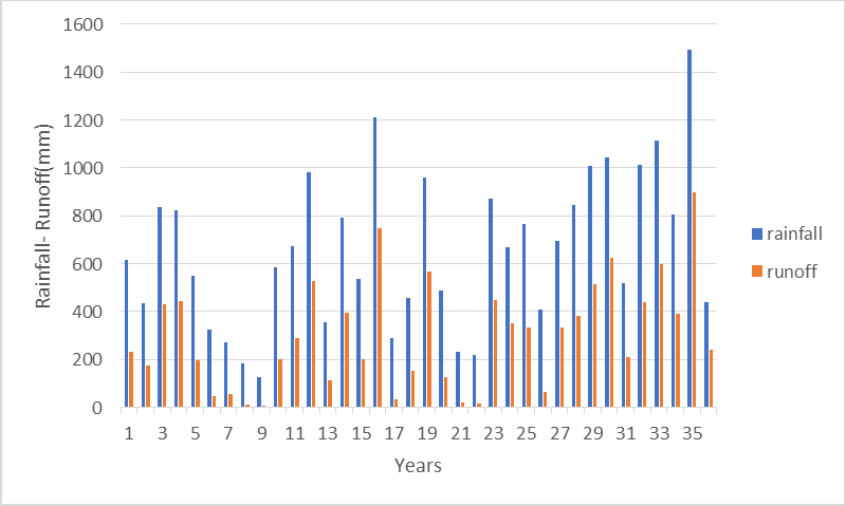


Fig. 5 Yearly Average Rainfall- Runoff

REFERENCES

[1] Arnold J G and Fohrer N 2005 Hydrol. Process. 19 563–572 V. S. Malunjkar, M. G. Shinde, S. S. Ghotekar, A. A. Atre "Estimation of Surface Runoff using SWAT Model" IJSTE - International Journal of Science Technology & Engineering | Volume 3 | Issue 4 | March 2015.

[2] A S Jasrotia , S D Dhiman And S P Aggarwal "Rainfall-Runoff And Soil Erosion Modeling Usingremote Sensing And Gis Technique-A Case Study Of Tons Watershed" Journal of the Indian Society of Remote Sensing, Vol. 30, No. 3, 2002".

[3] Singh V P and Woolhiser D A 2002 Journal of Hydrologic Engineering 7(4) 270-292

[4] Asmita K. Mistry, Bankim R. Joshi "Rainfall Runoff Modelling of Shakkar River using SWAT Model" IJSTE - International Journal of Science Technology & Engineering | Volume 4 | Issue 10 | April 2018.
[5] Subhadip Kangsabanik, Sneha Murmu "Rainfall-runoff modelling of Ajay river catchment using SWAT model" 7th International Conference on Environment and Industrial Innovation.
[6] AhirP.B., Prof.B.M.Vadher, Prof P.P.Lodha,Dr.Indraprakash,(2016). "Discharge modelling in part of Ambika River Basin using SWAT model". International Journal of Advance Research in Engineering, science and Technology. E-ISSN: 2393-9877, p-ISSN: 2394- 2444, Vol.03, Issue.05 (May 2016), pp.527-532.
[7] Madhusudhan M.S., Shivapur.A.V, (2016). "Application of SWAT model in generating surface runoff for Bennihalla River basin". International research journal of engineering and Technology (IRJET), e-ISSN: 2395-0056 p-ISSN: 2395- 0072, Vol.03, Issue.06 (may-June 2016), pp.364-369.
[8] V. S. Malunjkar, M. G. Shinde, S. S. Ghotekar, A. A. Atre "Estimation of Surface Runoff using SWAT Model" IJSTE - International Journal of Science Technology & Engineering | Volume 3 | Issue 4 | March 2015.
[9] A. W. Jayawardena, N. Muttil And J. H. W. Lee "Comparative Analysis Of Data-Driven And Gis-Based Conceptual Rainfall-Runoff" Journal Of Hydrologic Engineering © Asce / January/February 2006".
[10] Mohammed, R. 2010. The impact of the man activity in duhok dam watershed on the future of Duhok Dam Lake North-Iraq. 1st International Applied Geological Congress, Department of Geology, Islamic Azad University—Mashad Branch, Iran, 26–28 April, 2010.

WEBSITES:
https://earthexplorer.usgs.gov/
https://swat.tamu.edu/software/india-dataset/
https://bhuvan.nrsc.gov.in/bhuvan_links.php