Research Article

RIVER BASIN DELINEATION AND HYDROLOGICAL RESPONSE UNITS (HRUs) ANALYSIS USING SWAT MODEL

Jalgaonkar B.R.*, Mahesh Kothari, H.K. Mittal and P.K. Singh
Department of Soil and Water Engineering, CTAE (MPUAT), Udaipur, Rajasthan, INDIA
*Corresponding author's E-mail: bhagyashrijalgaonkar93@gmail.com

KEYWORDS:

ArcGIS, Delineation, HRUs, Land use map, River basin, SWAT model

ARTICLE INFO

Received on:
09.08.2020
Revised on:
16.11.2020
Accepted on:
20.11.2020

ABSTRACT

The present study analyses the River Basin Delineation and Hydrological Response Units (HRUs) Analysis using Soil and Water Assessment Tool (SWAT) Model. Delineation of Rajasthan, India considering delineation of the River Basin plays a significant role in watercourse planning. The study focused to demonstrate the applicability of SWAT (Soil and Water Assessment Tool) - a model of residential scale to forecast the effect over a period of land, soil and water changes. Since hydrological models are essential tools for understanding the hydrological activity of river basins, hence are used for the management of the river basin. These models are capable of simulating the effect of various systems for soil and water conservation. Under this study the delineations of river basin was carried out by ArcGIS 10.2.1. Post delineation the land use map, the soil class map and the slope class map were superimposed to complete the river basin HRUs analysis on the delineated river basin map. The output of the study may help in water resource planning in the basin and to undertake appropriate preventive actions in areas that are vulnerable to erosion.

INTRODUCTION

A river basin is the portion of ground drained by a river and its tributaries. This includes all the earth's surface, dissected and drained by many streams and creeks that flow through each other downhill. Climate change has manifold impacts on coastal ecosystems and hydrological processes. The imperative of the river basin is to engage people actively in conversational techniques involving proper management and execution of basin capital. River basin planning and management is undertaken to fulfill the mission related to the overall development of the river basin, which could be related to water quality and quantity enhancement, ecosystem management, enrichment of the socio-economic status of the inhabitants of the river basin, improvement of job opportunities for people and the selection of the most appropriate cropping patterns etc (Anonymous, 2018).

The Soil & Water Assessment Tool is a small river basin-scale watershed model used to simulate the quality and quantity of surface and ground water and to predict the effect on the environment of land use, land management activities, and climate change. SWAT is commonly used in evaluating the prevention and regulation of soil erosion, the control of non-point source emissions and regional management in watersheds (Srinivasan and Arnold, 1994). The input data for the SWAT model can be extracted with the use of GIS mainly from the map layers as well as land use / land cover, DEM, soil, slope, river basin and sub-basin boundaries. Mengistu and McCray (2008) had done his study to see the effects of variation of spatial resolution of soil data on stream flow using SWAT model. Bhatta *et al.* (2019) evaluated and implemented the SWAT model for evaluating the effect of climate change on the hydrology of the Himalayan River Basin has been. The purpose of this study was to assess the output uncertainty of the SWAT model correlated with the number of sub-basins, HRUs and elevation bands and measure the effect of climate change of the River Basin stream flows. Prasad (2005) investigated the delineation of hydrologic response units (HRUs) using remote sensing and GIS in the Nagwan basin in India. In this study, the HRUs were delineated using basin characteristics such as physiography, land use, soil, elevation and slope in a geographic information system. The hydrological activity of these HRUs was also discussed based on basin characteristics that can be used to simulate runoff in a physically dependent or conceptual hydrological model. The West Banas River Basin area was selected for the study because of not much work has been carried out in hilly region. The present study analyses the river basin delineation and hydrological response units (HRUs) analysis using SWAT model.

MATERIALS AND METHODS

The West Banas River Basin is selected for the present study, which is situated at southwest part of Rajasthan. The field of research is about 24°19'55" to 24°54'51" North latitude and 72°35'22" to 73°10'03" East longitudes. It originates from the southern Aravalli range, at an altitude of 372.5 m above mean sea level, in the Sirohi district of the state of Rajasthan. It runs south, draining the valley to the west between Mount Abu and the eastern ridge of the Aravallis. The total catchment area of this study is 2,152 sq km. The area's location is shown in figure 1.

The data required for this study is topographic map, soil map and land use / land cover map and details are as depicted through table 1.

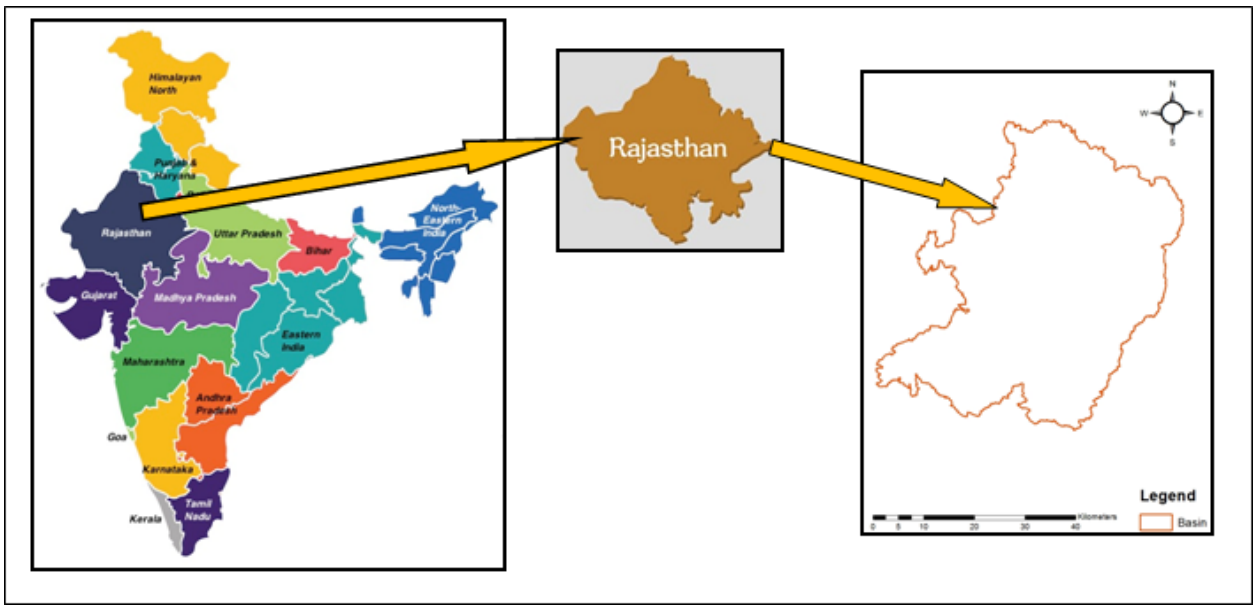

Figure 1: Map of the study area

Table 1: Details about the data required for the study

Sl. No.	Data Type	Source	Resolution	Data Parameters
1.	Topography Map	Unites State Geological Survey (Earth Explorer)	90 m	Digital Elevation Model (DEM)
2.	Soil Map	FAO (Digital Soil Map of the World)	1:500000	Soil Classification
3.	Land Use/ Land Cover Map	BHUVAN Land Cover Database	30 m	Land Use Classification

The step by step procedure followed in delineating river basin is described in further sections.

Delineation of the Study Area

In watercourse management, delineation of the River Basin plays a significant role and done under ArcGIS 10.2.1. The Digital Elevation Model (DEM) was used for the delineation of the West Banas River Basin. Toposheets were used for identifying the location, drainage network and contour details. The delineation is performed in ArcSWAT project. The output file is copied to the source folder for the project and translated to the GeoTIFF format if necessary.

Stream Networks Creation

For stream network, the threshold size for sub-basin formation is set by deeting the area unit in hectares or sq km, or by number of cells. By selecting the Draw Inlets/Outlets option the outlets, reservoirs, inlets, and point sources can be added. Points need to be positioned on the stream network precisely position. The points within a stream range's snap threshold will be recorded as points.

Adding Inlets/Outlets

To add inlet and outlets subset in the inlets/outlets file are used by selecting inlet or outlet. On selection it turns in yellow and the count is displayed at the bottom left of the main window. The snapped inlets/outlets are shown by clicking Review Snapped, i.e. those within the specified threshold distance. The river basins are formed after a few minutes by clicking on Create Watershed.

Merging Sub-basins

In the SWAT model, sub-basins can be selected and combined. This is particularly important when avoiding small sub-basins. Sub-basins that are identified will turn yellow after completing the step and will be saved. Further, it is merged and output is saved after merging the Sub-basins. This creates the numbering of the Sub-basins. This step completes the delineation of the river basin.

RESULTS AND DISCUSSION

Delineation of the River Basin

The West Banas River Basin is delineated using the Digital Elevation Model and the Soil and Water Assessment Tool. In the River Basin, number of areas of sub-basins and sub-basins was established was found 1,596 as shown in figure 2. The threshold size should be set before creating streams when creating stream networks; it can be set by area, in different units, such as sq km or hectares, or the number of cells. The figure 2 shows delineation of the West Banas River Basin, river basin streamlines, and sub-basins.

Hydrological Response Units (HRUs) Analysis

The Hydrological Response Units (HRUs) analysis was done by SWAT model; the input data requirements for the HRUs analysis was land use/ land cover map, soil map and slope map are discussed further:

1. Land Use/ Land Cover Map

Importing the LULC data defines the physical land type of the study area. The required area was extracted and imported as a raster file using the sub-basin boundary within the land use specification. Figure 3 illustrates the imported raster data with the values and their equivalent definition according to the LULC USGS (SWAT-land use classes) classes after the reclassification of the land use/ land cover raster. The LULC lookup table for the West Banas River Basin is summarized in table 1.

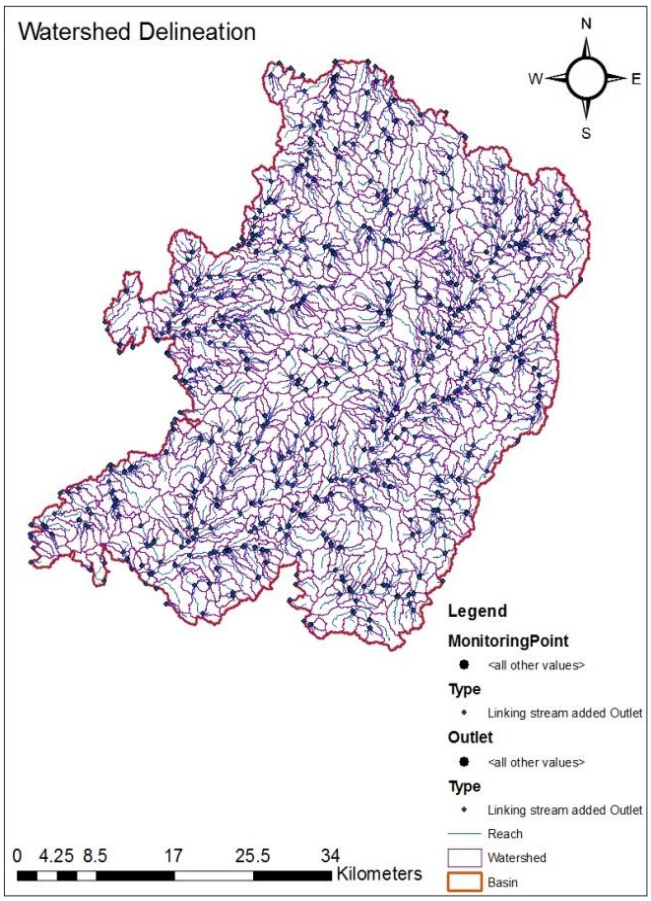

Figure 2: Delineation of the study area

Table 1: USGS, LULC Map Classification

Sl. No.	Land Use	SWAT Code
1	Forest-Mixed	FRST
2	Agriculture	AGRL
3	Wetlands-Forested	WETF
4	Barren	BARR
5	Urban	URBN
6	Range-Grasses	RNGE
7	Pasture	PAST
8	Mines	SWRN
9	Water	WATR
10	Wetland-Non-Forest	WETN

Figure 3 showed that, the most of the area covered under agriculture class was found 898.97 sq km and low area found under wetland-non-forest having area of 1.57 sq km in the total area of the River Basin. Rest of the study area is

covered by forest-mixed, wetlands-forested, barren, urban, range-grasses, pasture, mines and water.

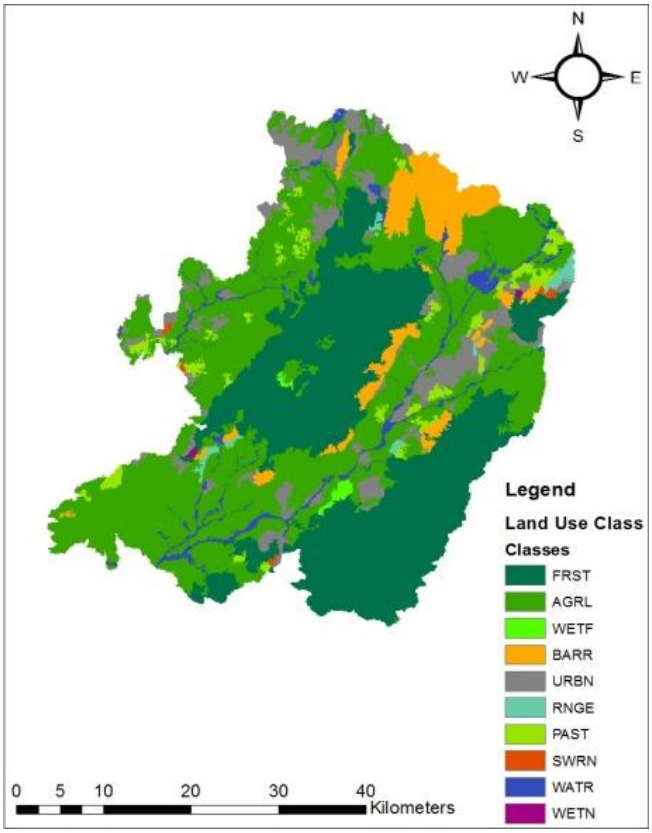

Figure 3: LULC map classes by SWAT model

2. Soil Map

Initially, the FAO soil type was collected and converted to raster format as a layer file to provide the data for defining the soil cover shown in figure 4. The soil cover data was finally reclassified, as shown in table 2, based on the user-identified FAO soil type (SWAT-Soil Class).

Table 2: FAO Soil Classification

Sl. No.	**Soil**	**SWAT Code**	**SWAT Soil Classes**
1.	Silt Loam	6673	Xh12-2a-6673
2.	Loam	3716	I-Be-Lc-b-3716
3.	Loam	3674	Be74-2a-3674

The soil map in Figure 4 showed that the most of the area covered by the silt loam soil with covered area of 1475.12 sq km and less area found under loam soil with covered area of 677.35 sq km of the total area of the study area.

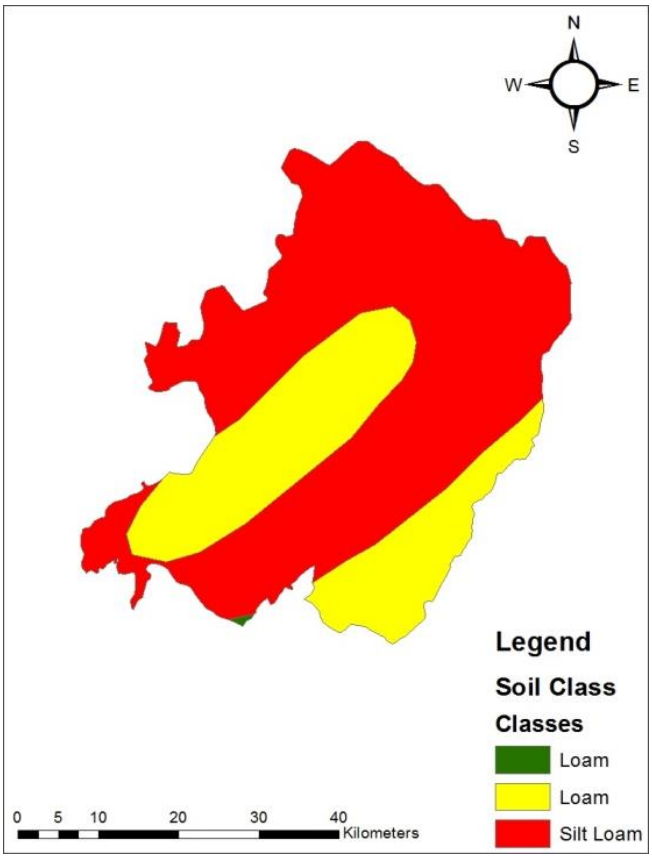

Figure 4: Soil map classes by SWAT model

3. Slope Map

The topographical features of the region had their own significance in interrupting the drainage, recharging and relation of surface water. One of the most important developmental behavioral parameters is slope, which is categorized by the SWAT model and shown in figure 5 and table 3.

Table 3: Slope Mop Classification by SWAT Model

Sl. No.	Land Slope (%)	Class
1	0-10 %	Gentle
2	10-20 %	Moderately Gentle
3	20-30 %	Steep
4	30-40 %	Moderately Steep
5	> 50 %	Very Steep

From Figure 5, revealed that the gentle category slope *i.e.*, 0-10% having covered area of 1281.15 sq km was found large area and moderately steep category slope *i.e.*, 30-40%

having covered area of 6.49 sq km was low area covered under the total area of the West Banas River Basin. Rest of the area fall under moderately gentle, steep as well as very steep slope.

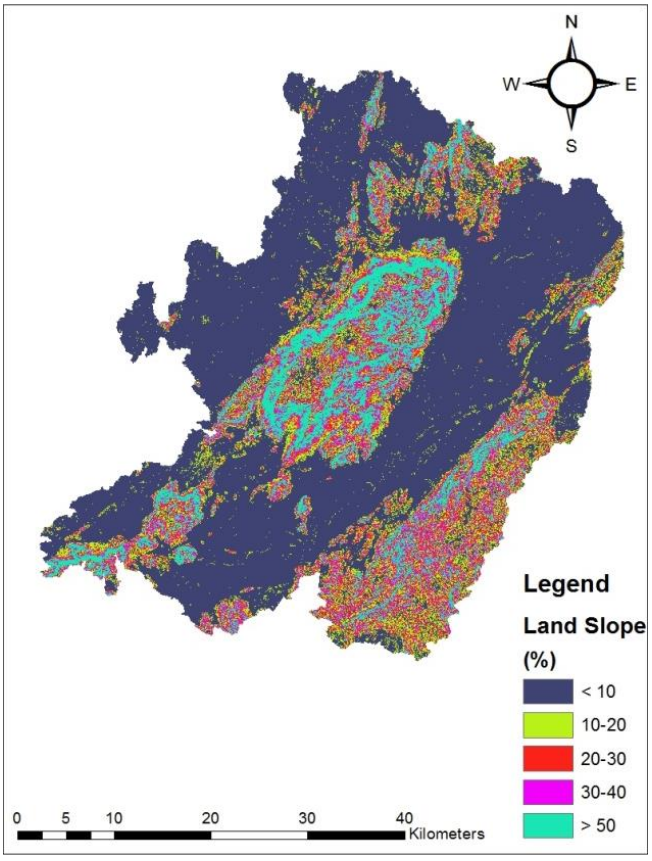

Figure 5: Soil Map Classes by SWAT Model

4. HRUs Analysis

The land use map, soil map and slope map were superimposed after the river basin delineation to complete the river basin HRUs analysis on the delineated river basin. The West Banas River Basin was split into 1,596 HRUs. Figure 6 illustrates the hydrologic response unit of the study area.

CONCLUSION

The methodology described in this paper allows efficient and consistent delineation, and HRUs analysis of the river basin. The analysis demonstrates the finest delineation of the specific area's river basin. Catchment delineation was accomplished by cunning sub-basin parameters. The sub-basin parameters premeditated were geomorphic parameters for each sub-basin and virtual stream reach. The study demonstrated the method for soil and water evaluation that

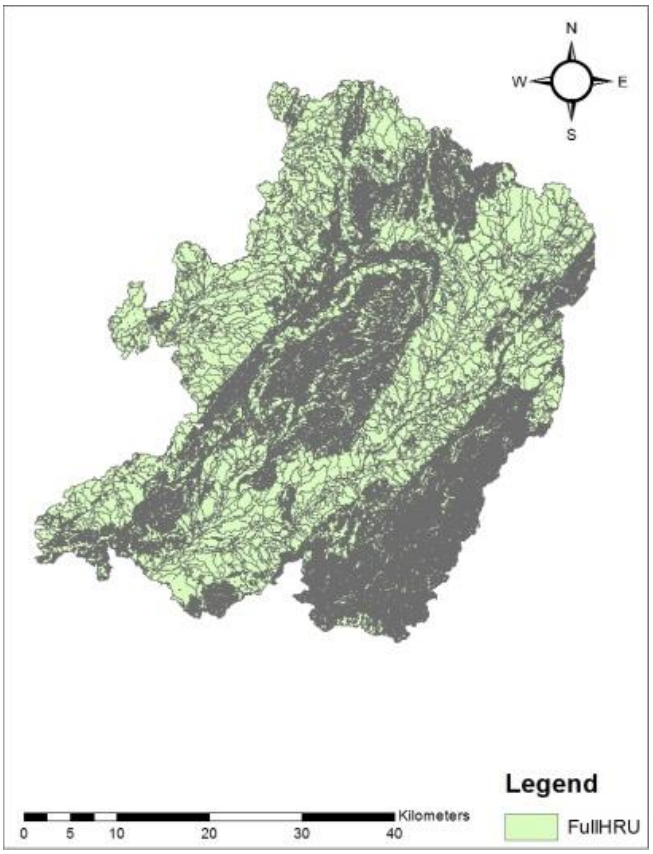

Figure 6: Hydrologic Response Unit (HRUs) of the study area

can easily provide us with productive data on elevations, stream flows, sub-basins. The Hydrologic Response Units can be generated further from the created river basin using land use, soil data and slope data. The West Banas River Basin area was divided into 1596 HRUs. This report provided a detailed explanation of the distribution of land use, soil and slope classes in the river basin and sub basin. The output of the study may help in water resource planning in the basin and to undertake appropriate preventive actions in areas that are vulnerable to erosion.

Acknowledgments

The authors declare that there is no conflict of interests regarding the publication of this paper. The authors would like to express their gratefully to provided all data and helped regarding research work.

REFERENCES

Anonymous. 2018. A Source Book for Soil and Water Conservation Measures. *Foundation for Ecological Security*, Anand, Gujarat. pp. 1-239.

Arnold, J. G., Williams, J. R., Srinivasan, R. and King, K. W. 1996. Soil and Water Assessment Tool, Use's Manual. USDA, Agriculture Research Service, Grassland, Soil and Water Research Laboratory, 808 East Blackland Road Temple, TX 76502, variously paged.

Bhatta, B., Shrestha, S., Shrestha, P.K. and Talchabhadel, R. 2019. Evaluation and application of a SWAT model to assess the climate change impact on the hydrology of the Himalayan River Basin. *Catena*, 181: 104082.

Kalcic, M.M., Chaubey, I. and Frankenberger, J. 2015. Defining Soil and Water Assessment Tool (SWAT) hydrologic response units (HRUs) by field boundaries. *International Journal of Agricultural and Biological Engineering*. 8: 69-80.

Mengistu, G., and Mccray, J. E. 2008. Effects of Soil Data Resolution on SWAT Model Streamflow and Water Quality Predictions. *Journal of Environmental Management*, 88: 393-406.

Prasad, V.H. 2005. Delineation of Hydrologic Response Units (HRUs) using Remote Sensing and GIS. *Water and Energy Abstracts*, 15.

Srinivasan, R. and Arnold, J. G. 1994. Integration of a basin scale water quality model with GIS. *Water Resour. Bull., A WRA*, 30: 453-462.

How to cite this article?

Jalgaonkar, B.R., Kothari, M., Mittal, H.K., Singh, P.K., 2020. River basin delineation and Hydrological Response Units (HRUs) analysis using SWAT model. *Innovative Farming* 5(4): 149-154.