ISSN 0974-5904, Volume 10, No. 02

DOI:10.21276/ijee.2017.10.0211

International Journal of Earth Sciences and Engineering

www.cafetinnova.org

April 2017, P.P. 207-213

# Application of SWAT Model to Investigate Soil Loss in Kaneri Watershed

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**Abstract:** *Watershed as an entry point acts as a beginning to address the issues of sustainable rainwater management for improving livelihoods. To deal with water management issues, one must analyse and quantify the different elements of hydrologic processes taking place within the area of interest. For this, in present study, SWAT (Soil and Water Assessment Tool) model is selected to model hydrological processes and compute runoff and sediment yield from the Kaneri watershed. Application of the SWAT model showed a relationship between watershed characteristics and their effects on runoff and sediment yield The distributed nature of the model output helped in identifying the sub basins and even HRUs within the watershed that were more prone to soil erosion and, hence, need to be given priority while implementing soil conservation measures. Its application proved that the model is a very flexible and robust tool that can be used to simulate a variety of watershed problems.*

***Keywords:*** *SWAT model, Surface runoff, Sediment Yield, Water Balance, Kaneri Watershed*

## 1. Introduction

The monsoon water and groundwater being supplementary, their management is a continuous process. The ridge to valley approach for executing soil and water conservation measures could be successfully handled only through the watershed concept. Soil and water conservation measures are necessary to reduce the kinetic energy of falling raindrop to reduce surface runoff which increases the opportunity time to water to infiltrate down and recharge the ground water. (Vidula Swami and Kulkarni, 2011). To deal with water management issues, one must analyse and quantify the different elements of hydrologic processes taking place within the area of interest. This analysis must be carried out on a watershed basis because all these processes are taking place within individual watersheds. Only after understanding the spatial and temporal variation and the interaction of these hydrologic components, one can scientifically formulate strategies for water and soil conservation. To achieve this goal the choice and use of an appropriate watershed model is a must.(Sathian and Shyamala, 2009). Soil and Water Assessment Tool (SWAT) is found to be suitable for watershed modelling. In SWAT, GIS and other interface tools can be used to support the input of topographic, land use and soil data. SWAT is a public domain hydrologic model, which was developed with a view to assist water resources managers in assessing the effect of land management practices and climate on water flow and sediment yields in ungauged rural watersheds and larger river basins. SWAT model could find applications in India in some of the watersheds and river basins. This new advanced concept has been used to predict the surface flow and soil loss in watersheds and river basins. For Kaneri watershed, it was decided to determine the total runoff which is responsible for the soil loss in the area. That is why it was decided to use the SWAT model for prediction of the runoff and the soil loss. Use of geospatial technology for this purpose has made the model making easier.

## 2. Literature Review

SWAT assumes that there is unlimited capacity for water to infiltrate into aquifer, but this cannot be applicable for hard rock areas. (Garg et al., 2012). Many of the water harvesting structures are represented in the model through the adjustment of the same parameters which makes it impossible to determine the effectiveness of individual structures (Garg et al., 2012). SWAT model is not able to give spatial representation of Hydrological Response Units (HRUs) and therefore the spatial heterogeneity within the sub-basins increases with the increase in the size of the sub-basin.(Phillip Gassman et al., 2007).The SWAT input interface automatically delineates a watershed, extracts the input data from geographical map layers and creates the associated relational databases for each subbasin (Amold et al., 2012). Soils, land-use, weather, management, topographic, and groundwater data are developed and written to appropriate model input files (Neitsch et aI., 2005). In SWAT, the HRU (Hydrologic Response Unit) is the smallest unit to spatial disaggregation. As a watershed is divided into HRUs based on elevation, soil and land use, the distributed parameter such as hydraulic conductivity can be defined for each HRU, thus resulting in a large number of input parameters.

Received: December 02, 2016; Accepted: February 17, 2017; Published: April 26, 2017
International Journal of Earth Sciences and Engineering, 10(02), 207-213, 2017, DOI:10.21276/ijee.2017.10.0211

SWAT tool having an interface with Arc View GIS software (AVSWAT 2000) used for runoff and sediment yield from area of Suni to Kasol, watersheds of satluj river, western Himalaya, performed well for runoff prediction (Jain S. K. et al. 2010). Mishra et. al. (2007) used SWAT model to assess sediment transport from 17 $km^2$ Banha watershed located in Northern India. Watershed has mixed land use and check dams are provided for on stream sediment control. Model is run with and without check dams to test its capability to evaluate their impact on sediment control. Model estimates shows that sediment loss from water shed can be reduced more than 64% due to provision of check dams on stream as barriers. Sediments transport from specific sub watershed also can be assessed due to which prioritization of specific sites for provision of check dams can be possible. It is found that SWAT model is applicable to small rain–fed watersheds with mixed land use. For modelling mountainous catchments specifically Cisadane watershed in Indonesia, SWAT tool was used for predicting surface runoff and water yield from the catchment. Study showed that SWAT model can be a potential monitoring tool especially for watershed management in Cisadane catchment area or in the tropical region. (Iwan Ridwansyah et al., 2014). Taleghan mountainous watershed (800.5 $km^2$ area) Iran was modelled using SWAT for prediction of daily runoff. Model was provided with input including digital elevation model (DEM), land use land cover, soil type and soil properties and hydro-climatological data. Model results proved that SWAT can provide reasonable predictions of daily stream flow (Hamzeh Noor et al., 2014).

## 3. Related work

This paper applies SWAT model to Kaneri watershed to model the hydrological processes and compute runoff, water yield and sediment yield. SWAT is a semi physically based, semi distributed model and runs on continuous records of weather for short or long term predictions. The semi distributed approach allows simulation of spatial detail by dividing the watershed into a large number of sub-watersheds to account for spatial differences in soils, land use, crops, topography, channel morphology and weather conditions. Water balance equation for SWAT model is

$$SWt = SWo + \sum (Pday) - Qsurt - AET - Qseep - Qgw$$

Where SWt is the final water content in millimeters, SWo is the initial soil water content on day i (mm), Pday is precipitation on day i (mm), Qsurt is surface runoff on day i (mm), AET is the actual evapo-transpiration on day i (mm), Qseep is the water flowing into the unsaturated zone form the soil profile on day i (mm) and Qgw is the return flow from the shallow aquifer and lateral flow on day i and t is time in days.(Neistch et al.2005).

In the present study, SWAT model is used for prediction of runoff and sediment yield in the micro watershed Kaneri. Soil loss for Kaneri watershed has been estimated to be 17.67 Tonnes / Ha /Year, (Santosh Kumbhar, 2012), which is beyond the acceptable limits. Permissible soil loss given by Mannering (1981), is from 4.5 to 11.2 tonnes/ha/year. NBSS LUP, Nagpur has published the soil erosion map according to the classes of soil loss (t/ha/year). Accordingly, Kaneri watershed falls in a class with moderately severe soil erosion. GIS is interfaced with hydrological modelling for computation of hydrological processes. The distributed rainfall-runoff-sediment yield models have the capability to account for the spatial variability of watershed characteristics and predict the spatial distribution of runoff and sediment over the land surface in addition to total runoff and soil loss. SWAT model is interfaced with Arc GIS to account for the spatial variability in the catchment characteristics.

### 3.1 Input data

The data required for the model are DEM (Digital Elevation Model), soil data, land use data, precipitation and other weather data. To delineate the watershed and sub basins and to determine drainage networks SWAT uses the digital representation of the topographic surface i.e. DEM. A 30 m by 30 m resolution ASTERDEM was derived and re sampled to 15m X 15m for ease in data acquisition. The soil map used in this research was taken from soil map of Maharashtra prepared by NBSS & LUP (National Bureau of Soil Survey and Land Use Planning), Nagpur, Maharashtra and geo-referenced with Kaneri watershed and digitized. LULC map was acquired from LISS III (Linear Imaging and Self Scanning Sensors). SWAT requires daily or sub-daily meteorological data. Daily weather data from January 1979 – July 2014 were obtained from the website www.swattamu.edu.

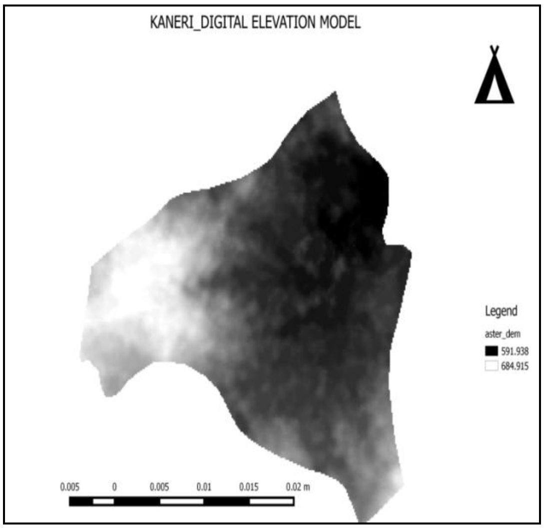


***Fig.1*** *Digital Elevation Model of Kaneri village*

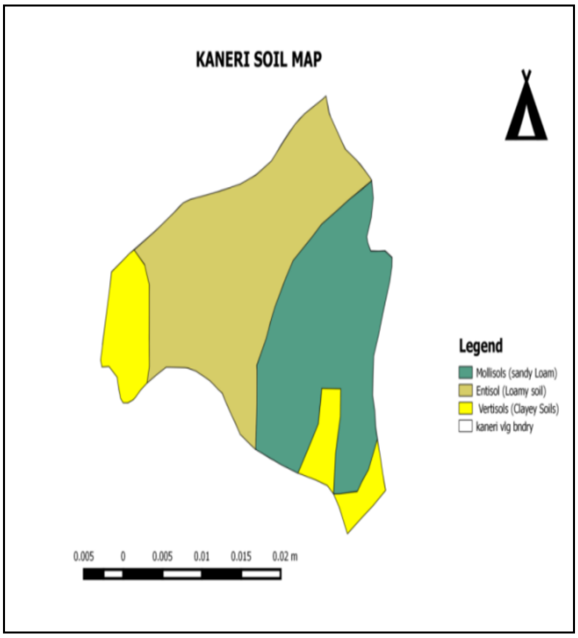


*Fig.2 Soil Map of Kaneri Village*

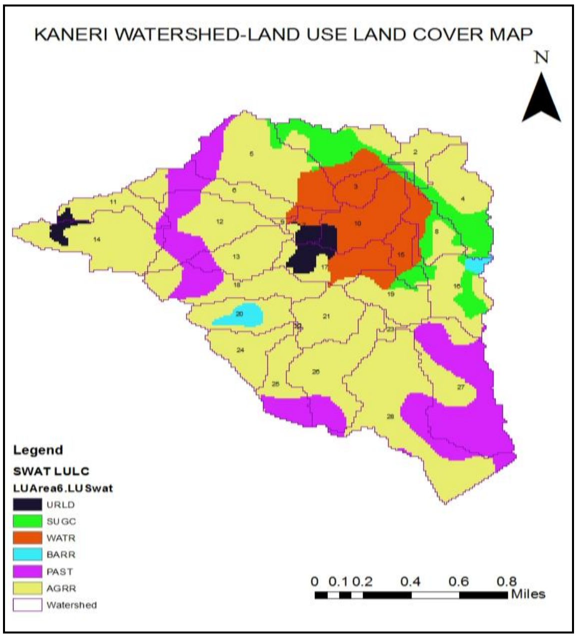


***Fig.3** Land Use Land Cover Map of Kaneri Watershed*

***Table 1.** HRU (Hydrologic Response Unit) wise Input (Base Scenario for 2012-13)*

| HRU | SUBBASIN | ARSUB | LANDUSE | ARLU | SOIL | ARSO | SLP | ARSLP | SLOPE |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 24.1572 | SUGC | 12.2719 | Ao47-3bc-4619 | 7.1264 | 1-9999 | 7.1264 | 5.9775 |
| 2 | 1 | 24.1572 | SUGC | 12.2719 | Zo16-3a-3327 | 5.1455 | 1-9999 | 5.1455 | 6.6485 |
| 3 | 1 | 24.1572 | WATR | 5.1455 | Ao47-3bc-4619 | 5.1455 | 1-9999 | 5.1455 | 10.4034 |
| 4 | 1 | 24.1572 | AGRR | 6.7399 | Ao47-3bc-4619 | 4.6623 | 1-9999 | 4.6623 | 7.5976 |
| 5 | 1 | 24.1572 | AGRR | 6.7399 | Zo16-3a-3327 | 2.0775 | 1-9999 | 2.0775 | 5.3203 |
| 6 | 2 | 8.9865 | AGRR | 8.9865 | Ao47-3bc-4619 | 8.9865 | 1-9999 | 8.9865 | 7.6932 |
| 7 | 3 | 8.3101 | SUGC | 0.9569 | Ao47-3bc-4619 | 0.9569 | 0-1 | 0.6547 | 0.0000 |
| 8 | 3 | 8.3101 | SUGC | 0.9569 | Ao47-3bc-4619 | 0.9569 | 1-9999 | 0.3022 | 3.7695 |
| 9 | 3 | 8.3101 | WATR | 7.3532 | Ao47-3bc-4619 | 7.3532 | 0-1 | 1.5865 | 0.0000 |
| 10 | 3 | 8.3101 | WATR | 7.3532 | Ao47-3bc-4619 | 7.3532 | 1-9999 | 5.7667 | 9.9559 |
| 11 | 4 | 24.8820 | SUGC | 9.7872 | Ao47-3bc-4619 | 4.2606 | 1-9999 | 4.2606 | 6.7649 |
| 12 | 4 | 24.8820 | SUGC | 9.7872 | Dd4-2c-4318 | 5.5266 | 1-9999 | 5.5266 | 6.9142 |
| 13 | 4 | 24.8820 | AGRR | 15.0947 | Ao47-3bc-4619 | 15.0947 | 1-9999 | 15.0947 | 7.6319 |
| 14 | 5 | 41.1881 | WATR | 7.2877 | Ao47-3bc-4619 | 7.2877 | 0-1 | 1.4827 | 0.0000 |
| 15 | 5 | 41.1881 | WATR | 7.2877 | Ao47-3bc-4619 | 7.2877 | 1-9999 | 5.8050 | 7.7242 |
| 16 | 5 | 41.1881 | PAST | 6.5841 | Zo16-3a-3327 | 6.5841 | 1-9999 | 6.5841 | 13.4791 |
| 17 | 5 | 41.1881 | AGRR | 27.3163 | Ao47-3bc-4619 | 7.5641 | 1-9999 | 7.5641 | 6.6594 |
| 18 | 5 | 41.1881 | AGRR | 27.3163 | Zo16-3a-3327 | 19.7522 | 1-9999 | 19.7522 | 9.1384 |
| 19 | 6 | 17.9972 | PAST | 4.6982 | Zo16-3a-3327 | 4.6982 | 1-9999 | 4.6982 | 10.6669 |
| 20 | 6 | 17.9972 | AGRR | 13.2990 | Ao47-3bc-4619 | 4.6484 | 1-9999 | 4.6484 | 6.1535 |
| 21 | 6 | 17.9972 | AGRR | 13.2990 | Zo16-3a-3327 | 8.6506 | 1-9999 | 8.6506 | 10.0221 |
| 22 | 7 | 5.2904 | URLD | 2.1983 | Ao47-3bc-4619 | 2.1983 | 1-9999 | 2.1983 | 7.4750 |
| 23 | 7 | 5.2904 | WATR | 2.3916 | Ao47-3bc-4619 | 2.3916 | 1-9999 | 2.3916 | 5.3901 |
| 24 | 7 | 5.2904 | AGRR | 0.7006 | Ao47-3bc-4619 | 0.7006 | 1-9999 | 0.7006 | 8.3194 |
| 25 | 8 | 13.2382 | SUGC | 4.0826 | Ao47-3bc-4619 | 4.0826 | 1-9999 | 4.0826 | 6.8772 |
| 26 | 8 | 13.2382 | WATR | 4.8556 | Ao47-3bc-4619 | 4.8556 | 1-9999 | 4.8556 | 12.3351 |
| 27 | 8 | 13.2382 | AGRR | 4.3000 | Ao47-3bc-4619 | 4.3000 | 1-9999 | 4.3000 | 5.8040 |
| 28 | 9 | 1.0146 | WATR | 0.2657 | Ao47-3bc-4619 | 0.2657 | 1-9999 | 0.1933 | 4.4661 |
| 29 | 9 | 1.0146 | WATR | 0.2657 | Ao47-3bc-4619 | 0.2657 | 0-1 | 0.0725 | 0.0000 |
| 30 | 9 | 1.0146 | AGRR | 0.7489 | Ao47-3bc-4619 | 0.7489 | 1-9999 | 0.7489 | 6.0897 |
| 31 | 10 | 20.7511 | URLD | 2.1651 | Ao47-3bc-4619 | 2.1651 | 1-9999 | 2.1651 | 6.8270 |
| 32 | 10 | 20.7511 | WATR | 18.5860 | Ao47-3bc-4619 | 18.5860 | 1-9999 | 18.5860 | 9.9419 |
| 33 | 11 | 10.9915 | AGRR | 10.9915 | Zo16-3a-3327 | 10.9915 | 1-9999 | 10.9915 | 9.1555 |
| 34 | 12 | 28.4814 | PAST | 9.7595 | Zo16-3a-3327 | 9.7595 | 1-9999 | 9.7595 | 16.0164 |
| 35 | 12 | 28.4814 | AGRR | 18.7219 | Ao47-3bc-4619 | 7.2472 | 1-9999 | 7.2472 | 9.1044 |
| 36 | 12 | 28.4814 | AGRR | 18.7219 | Zo16-3a-3327 | 11.4747 | 1-9999 | 11.4747 | 12.3326 |
| 37 | 13 | 15.8955 | PAST | 2.1742 | Ao47-3bc-4619 | 1.6185 | 1-9999 | 1.6185 | 11.4100 |
| 38 | 13 | 15.8955 | PAST | 2.1742 | Zo16-3a-3327 | 0.5556 | 1-9999 | 0.5556 | 6.4337 |
| 39 | 13 | 15.8955 | AGRR | 13.7213 | Ao47-3bc-4619 | 13.7213 | 1-9999 | 13.7213 | 9.5468 |
| 40 | 14 | 30.9213 | AGRR | 30.9213 | Zo16-3a-3327 | 30.9213 | 1-9999 | 30.9213 | 10.0615 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 41 | 15 | 8.0927 | SUGC | 2.0232 | Ao47-3bc-4619 | 2.0232 | 1-9999 | 2.0232 | 5.6093 |
| 42 | 15 | 8.0927 | WATR | 6.0695 | Ao47-3bc-4619 | 6.0695 | 0-1 | 2.0981 | 0.0000 |
| 43 | 15 | 8.0927 | WATR | 6.0695 | Ao47-3bc-4619 | 6.0695 | 1-9999 | 3.9714 | 7.4266 |
| 44 | 16 | 21.9589 | SUGC | 6.4372 | Ao47-3bc-4619 | 1.5884 | 1-9999 | 1.5884 | 4.9011 |
| 45 | 16 | 21.9589 | SUGC | 6.4372 | Dd4-2c-4318 | 4.8488 | 1-9999 | 4.8488 | 7.4723 |
| 46 | 16 | 21.9589 | AGRR | 15.5217 | Ao47-3bc-4619 | 10.3664 | 1-9999 | 10.3664 | 6.6124 |
| 47 | 16 | 21.9589 | AGRR | 15.5217 | Dd4-2c-4318 | 5.1553 | 1-9999 | 5.1553 | 6.9389 |
| 48 | 17 | 18.7943 | URLD | 4.5174 | Ao47-3bc-4619 | 4.5174 | 1-9999 | 4.5174 | 7.5621 |
| 49 | 17 | 18.7943 | WATR | 8.8174 | Ao47-3bc-4619 | 8.8174 | 1-9999 | 8.8174 | 9.4828 |
| 50 | 17 | 18.7943 | AGRR | 5.4595 | Ao47-3bc-4619 | 5.4595 | 1-9999 | 5.4595 | 6.0117 |
| 51 | 18 | 24.6646 | PAST | 6.2809 | Ao47-3bc-4619 | 3.7444 | 1-9999 | 3.7444 | 7.6603 |
| 52 | 18 | 24.6646 | PAST | 6.2809 | Zo16-3a-3327 | 2.5365 | 1-9999 | 2.5365 | 10.0460 |
| 53 | 18 | 24.6646 | AGRR | 18.3837 | Ao47-3bc-4619 | 13.8421 | 1-9999 | 13.8421 | 8.1226 |
| 54 | 18 | 24.6646 | AGRR | 18.3837 | Zo16-3a-3327 | 4.5416 | 1-9999 | 4.5416 | 12.0431 |
| 55 | 19 | 15.5090 | WATR | 2.5848 | Ao47-3bc-4619 | 2.5848 | 1-9999 | 1.8171 | 7.1333 |
| 56 | 19 | 15.5090 | WATR | 2.5848 | Ao47-3bc-4619 | 2.5848 | 0-1 | 0.7678 | 0.0000 |
| 57 | 19 | 15.5090 | AGRR | 12.9241 | Ao47-3bc-4619 | 12.9241 | 1-9999 | 12.9241 | 4.9257 |
| 58 | 20 | 15.8713 | BARR | 4.1067 | Ao47-3bc-4619 | 4.1067 | 1-9999 | 4.1067 | 9.3812 |
| 59 | 20 | 15.8713 | AGRR | 11.7646 | Ao47-3bc-4619 | 11.7646 | 1-9999 | 11.7646 | 7.5733 |
| 60 | 21 | 16.3545 | AGRR | 16.3545 | Ao47-3bc-4619 | 16.3545 | 1-9999 | 16.3545 | 5.3449 |
| 61 | 22 | 0.1691 | AGRR | 0.1691 | Ao47-3bc-4619 | 0.1691 | 1-9999 | 0.1691 | 3.7666 |
| 62 | 23 | 1.8118 | AGRR | 1.8118 | Ao47-3bc-4619 | 1.8118 | 1-9999 | 1.8118 | 5.2385 |
| 63 | 24 | 14.3252 | AGRR | 14.3252 | Ao47-3bc-4619 | 14.3252 | 1-9999 | 14.3252 | 8.1455 |
| 64 | 25 | 14.7601 | PAST | 5.4837 | Ao47-3bc-4619 | 3.4786 | 1-9999 | 3.4786 | 7.1046 |
| 65 | 25 | 14.7601 | PAST | 5.4837 | Dd4-2c-4318 | 2.0051 | 1-9999 | 2.0051 | 8.7869 |
| 66 | 25 | 14.7601 | AGRR | 9.2764 | Ao47-3bc-4619 | 9.2764 | 1-9999 | 9.2764 | 6.8645 |
| 67 | 26 | 29.6651 | PAST | 5.1697 | Dd4-2c-4318 | 5.1697 | 1-9999 | 5.1697 | 12.0974 |
| 68 | 26 | 29.6651 | AGRR | 24.4954 | Ao47-3bc-4619 | 13.7696 | 1-9999 | 13.7696 | 7.4516 |
| 69 | 26 | 29.6651 | AGRR | 24.4954 | Dd4-2c-4318 | 10.7258 | 1-9999 | 10.7258 | 7.5608 |
| 70 | 27 | 45.7780 | PAST | 33.0230 | Dd4-2c-4318 | 33.0230 | 1-9999 | 33.0230 | 10.0218 |
| 71 | 27 | 45.7780 | AGRR | 12.7550 | Ao47-3bc-4619 | 5.4112 | 1-9999 | 5.4112 | 7.0292 |
| 72 | 27 | 45.7780 | AGRR | 12.7550 | Dd4-2c-4318 | 7.3438 | 1-9999 | 7.3438 | 9.7600 |
| 73 | 28 | 55.6583 | PAST | 10.8224 | Ao47-3bc-4619 | 4.7590 | 1-9999 | 4.7590 | 9.1889 |
| 74 | 28 | 55.6583 | PAST | 10.8224 | Dd4-2c-4318 | 6.0635 | 1-9999 | 6.0635 | 10.5137 |
| 75 | 28 | 55.6583 | AGRR | 44.8359 | Ao47-3bc-4619 | 28.7471 | 1-9999 | 28.7471 | 7.8973 |
| 76 | 28 | 55.6583 | AGRR | 44.8359 | Dd4-2c-4318 | 16.0887 | 1-9999 | 16.0887 | 9.5269 |

*(ARSUB-Area of sub basin, ARLU-Area of Land Use, ARSO-Area under soil, ARSLP-Area with slope)*

Before running the model the land use classes are to be reclassified according to the land uses in boundary. Kaneri watershed has been re-classified in six land use classes. Figure 3 shows reclassified LULC map of Kaneri watershed. Watershed has been delineated and divided into 28 sub-basins and 76 HRUs. Similarly according to land-uses, soil types slopes the sub-basins are classified in Hydrological Response Units which have uniform characteristics.

### 3.2 Model Processing

Figure 4 gives the flow chart of SWAT modelling process, explaining step by step procedure of modelling.

The weather data needed for SWAT model is precipitation, minimum and maximum temperature, relative humidity, solar radiation and wind speed. The model was set to run from 1st January 1979 to 31st July 2014 with a monthly printout interval. Multiple gauges were read for watershed and daily rainfall data was used for model to run. The Multiple gauges simulated for watershed for the temperature data. SWAT allows the user to delineate the watershed and sub basins using the Digital Elevation Model (DEM). Drainage network is also prepared which can be useful for delineation. Original LULC map is used for preparation of input LULC file. Once LULC of village input has been provided to SWAT model, the model according to watershed delineation, develops the number of classes coming inside watershed boundary.

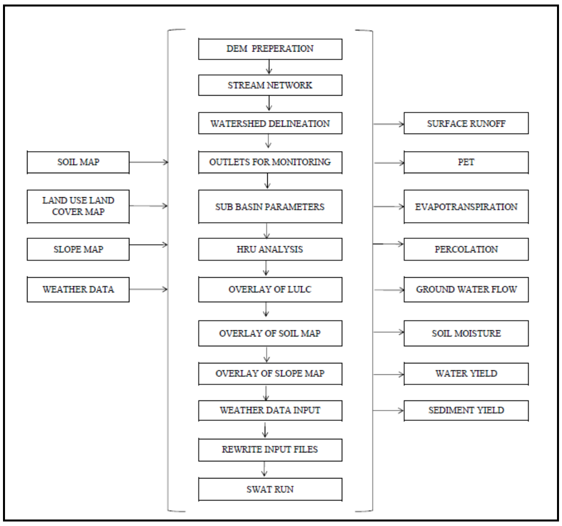


***Fig.4*** *SWAT Modelling - Flow Chart*

Before running the model the land use classes are to be reclassified according to the land uses in boundary. Kaneri watershed has been reclassified in six land use classes. Before defining the stream network, the model processes the DEM map grid to remove all the non-draining zones (sinks). To define the origin of streams a threshold area was defined. The threshold area or critical source area defines the minimum drainage area required to form the origin of a stream. The size and number of sub basins and details of stream network depends on this threshold area. By considering the drainage lines the stream network is prepared. The watershed outlet is manually added and selected for finalizing the watershed boundary. With this information the model automatically delineates a watershed of 536 ha and 28 sub basins were produced.

### 3.3 Output of the Model

In SWAT model the Kaneri watershed was represented by twenty eight distinct sub-watersheds. The weighted CN, Manning's roughness coefficients and geographical parameters were estimated for each sub-watershed with the use of GIS and RS data which provided the necessary input to the model.

***Table 2.*** *HRU (Hydrologic Response Unit) wise Output (Base Scenario for 2012-13)*

| HRU | SUB-BASIN | SOIL | AREA $km^2$ | CN | AWC mm | USLE_LS | GWQ mm | ET mm | SED Ton/Ha | SURQ mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Ao47-3bc-4619 | 7.13E-02 | 83 | 80 | 0.98 | 260.57 | 1.86 | 1.12 | 89.73 |
| 2 | 1 | Zo16-3a-3337 | 5.15E-02 | 87 | 100 | 1.13 | 173.81 | 6.09 | 1.08 | 145.87 |
| 3 | 1 | Ao47-3bc-4619 | 5.15E-02 | 92 | 80 | 2.24 | 0 | 0.32 | 0 | 0 |
| 4 | 1 | Ao47-3bc-4619 | 4.66E-02 | 85 | 80 | 1.39 | 238.83 | 2.1 | 17.42 | 111.03 |
| 5 | 1 | Zo16-3a-3337 | 2.08E-02 | 89 | 100 | 0.82 | 148.64 | 6.48 | 13.54 | 171.69 |
| 6 | 2 | Ao47-3bc-4619 | 8.99E-02 | 85 | 80 | 1.42 | 238.84 | 2.08 | 18.93 | 111.03 |
| 7 | 3 | Ao47-3bc-4619 | 6.55E-03 | 83 | 80 | 0.07 | 259.64 | 2.04 | 0.02 | 89.82 |
| 8 | 3 | Ao47-3bc-4619 | 3.02E-03 | 83 | 80 | 0.63 | 260.33 | 1.96 | 0.47 | 89.78 |
| 9 | 3 | Ao47-3bc-4619 | 1.59E-02 | 92 | 80 | 0.07 | 0 | 0.32 | 0 | 0 |
| 10 | 3 | Ao47-3bc-4619 | 5.77E-02 | 92 | 80 | 2.11 | 0 | 0.32 | 0 | 0 |
| 11 | 4 | Ao47-3bc-4619 | 4.26E-02 | 83 | 80 | 1.18 | 260.63 | 1.83 | 1.27 | 89.72 |
| 12 | 4 | Dd4-2c-4318 | 5.53E-02 | 83 | 140 | 1.2 | 189.31 | 2.44 | 0.45 | 84.41 |
| 13 | 4 | Ao47-3bc-4619 | 1.51E-01 | 85 | 80 | 1.39 | 238.83 | 2.1 | 19.82 | 111.03 |
| 14 | 5 | Ao47-3bc-4619 | 1.48E-02 | 92 | 80 | 0.07 | 0 | 0.32 | 0 | 0 |
| 15 | 5 | Ao47-3bc-4619 | 5.81E-02 | 92 | 80 | 1.42 | 0 | 0.32 | 0 | 0 |
| 16 | 5 | Zo16-3a-3337 | 6.58E-02 | 83 | 100 | 1.96 | 203.48 | 4.44 | 3.49 | 106.86 |
| 17 | 5 | Ao47-3bc-4619 | 7.56E-02 | 85 | 80 | 1.15 | 238.80 | 2.14 | 15.27 | 111.04 |
| 18 | 5 | Zo16-3a-3337 | 1.98E-01 | 89 | 100 | 1.82 | 148.60 | 6.46 | 39.39 | 171.63 |
| 19 | 6 | Zo16-3a-3337 | 4.70E-02 | 83 | 100 | 2.34 | 202.88 | 4.59 | 3.97 | 107.27 |
| 20 | 6 | Ao47-3bc-4619 | 4.65E-02 | 85 | 80 | 1.03 | 238.77 | 2.17 | 12.81 | 111.05 |
| 21 | 6 | Zo16-3a-3337 | 8.65E-02 | 89 | 100 | 2.11 | 148.58 | 6.48 | 41.3 | 171.62 |
| 22 | 7 | Ao47-3bc-4619 | 2.20E-02 | 74.86 | 80 | 1.36 | 279.76 | 5.17 | 7.61 | 66.58 |
| 23 | 7 | Ao47-3bc-4619 | 2.39E-02 | 92 | 80 | 0.84 | 0 | 0.32 | 0 | 0 |
| 24 | 7 | Ao47-3bc-4619 | 7.01E-03 | 85 | 80 | 1.58 | 238.85 | 2.08 | 15.92 | 111.01 |
| 25 | 8 | Ao47-3bc-4619 | 4.08E-02 | 83 | 80 | 1.2 | 260.63 | 1.83 | 1.29 | 89.72 |
| 26 | 8 | Ao47-3bc-4619 | 4.86E-02 | 92 | 80 | 1.69 | 0 | 0.32 | 0 | 0 |
| 27 | 8 | Ao47-3bc-4619 | 4.30E-02 | 85 | 80 | 0.93 | 238.78 | 2.14 | 11.48 | 111.06 |
| 28 | 9 | Ao47-3bc-4619 | 1.93E-03 | 92 | 80 | 0.8 | 0 | 0.32 | 0 | 0 |
| 29 | 9 | Ao47-3bc-4619 | 7.25E-04 | 92 | 80 | 0.07 | 0 | 0.32 | 0 | 0 |
| 30 | 9 | Ao47-3bc-4619 | 7.49E-03 | 85 | 80 | 1 | 238.79 | 2.13 | 10.07 | 111.05 |
| 31 | 10 | Ao47-3bc-4619 | 2.17E-02 | 74.86 | 80 | 1.18 | 279.71 | 5.18 | 6.57 | 66.58 |
| 32 | 10 | Ao47-3bc-4619 | 1.86E-01 | 92 | 80 | 2.07 | 0 | 0.32 | 0 | 0 |
| 33 | 11 | Zo16-3a-3337 | 1.10E-01 | 89 | 100 | 1.85 | 148.55 | 6.57 | 37.3 | 171.61 |
| 34 | 12 | Zo16-3a-3337 | 9.76E-02 | 83 | 100 | 2.16 | 204.07 | 4.36 | 4.03 | 106.5 |
| 35 | 12 | Ao47-3bc-4619 | 7.25E-02 | 85 | 80 | 1.82 | 238.86 | 2.1 | 24.19 | 111 |
| 36 | 12 | Zo16-3a-3337 | 1.15E-01 | 89 | 100 | 1.69 | 149.22 | 6.38 | 35.26 | 171.29 |
| 37 | 13 | Ao47-3bc-4619 | 1.62E-02 | 77 | 80 | 2.58 | 296.81 | 7.86 | 2.24 | 46.45 |
| 38 | 13 | Zo16-3a-3337 | 5.56E-03 | 83 | 100 | 1.08 | 202.64 | 4.6 | 1.41 | 107.36 |
| 39 | 13 | Ao47-3bc-4619 | 1.37E-01 | 85 | 80 | 1.95 | 238.87 | 2.08 | 27.78 | 110.99 |
| 40 | 14 | Zo16-3a-3337 | 3.09E-01 | 89 | 100 | 2.14 | 148.55 | 6.54 | 48.45 | 171.61 |
| 41 | 15 | Ao47-3bc-4619 | 2.02E-02 | 83 | 80 | 0.89 | 260.54 | 1.87 | 0.87 | 89.74 |
| 42 | 15 | Ao47-3bc-4619 | 2.10E-02 | 92 | 80 | 0.07 | 0 | 0.32 | 0 | 0 |
| 43 | 15 | Ao47-3bc-4619 | 3.97E-02 | 92 | 80 | 1.33 | 0 | 0.32 | 0 | 0 |
| 44 | 16 | Ao47-3bc-4619 | 1.59E-02 | 83 | 80 | 0.9 | 260.37 | 1.95 | 0.83 | 89.77 |
| 45 | 16 | Dd4-2c-4318 | 4.85E-02 | 83 | 140 | 1.36 | 189.37 | 2.43 | 0.51 | 84.39 |
| 46 | 16 | Ao47-3bc-4619 | 1.04E-01 | 85 | 80 | 1.13 | 238.80 | 2.13 | 15.35 | 111.04 |
| 47 | 16 | Dd4-2c-4318 | 5.16E-02 | 85 | 140 | 1.2 | 168.69 | 4.55 | 17.37 | 103.66 |
| 48 | 17 | Ao47-3bc-4619 | 4.52E-02 | 74.86 | 80 | 1.39 | 279.77 | 5.17 | 8.45 | 66.58 |
| 49 | 17 | Ao47-3bc-4619 | 8.82E-02 | 92 | 80 | 1.95 | 0 | 0.32 | 0 | 0 |
| 50 | 17 | Ao47-3bc-4619 | 5.46E-02 | 85 | 80 | 0.98 | 238.78 | 2.14 | 12.4 | 111.06 |
| 51 | 18 | Ao47-3bc-4619 | 3.74E-02 | 77 | 80 | 1.42 | 296.53 | 7.98 | 1.35 | 46.5 |
| 52 | 18 | Zo16-3a-3337 | 2.54E-02 | 83 | 100 | 2.11 | 202.90 | 4.6 | 3.33 | 107.29 |
| 53 | 18 | Ao47-3bc-4619 | 1.38E-01 | 85 | 80 | 1.53 | 238.82 | 2.13 | 21.7 | 111.02 |
| 54 | 18 | Zo16-3a-3337 | 4.54E-02 | 89 | 100 | 1.63 | 149.21 | 6.39 | 30.44 | 171.31 |
| 55 | 19 | Ao47-3bc-4619 | 1.82E-02 | 92 | 80 | 1.25 | 0 | 0.32 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 56 | 19 | Ao47-3bc-4619 | 7.68E-03 | 92 | 80 | 0.07 | 0 | 0.32 | 0 | 0 |
| 57 | 19 | Ao47-3bc-4619 | 1.29E-01 | 85 | 80 | 0.9 | 238.71 | 2.2 | 12.16 | 111.1 |
| 58 | 20 | Ao47-3bc-4619 | 4.11E-02 | 91 | 80 | 1.92 | 157.39 | 6.6 | 55.58 | 221.37 |
| 59 | 20 | Ao47-3bc-4619 | 1.18E-01 | 85 | 80 | 1.39 | 238.82 | 2.13 | 19.24 | 111.03 |
| 60 | 21 | Ao47-3bc-4619 | 1.64E-01 | 85 | 80 | 0.82 | 238.76 | 2.16 | 11.71 | 111.07 |
| 61 | 22 | Ao47-3bc-4619 | 1.69E-03 | 85 | 80 | 0.63 | 238.69 | 2.22 | 5.02 | 111.12 |
| 62 | 23 | Ao47-3bc-4619 | 1.81E-02 | 85 | 80 | 0.8 | 238.76 | 2.16 | 8.85 | 111.07 |
| 63 | 24 | Ao47-3bc-4619 | 1.43E-01 | 85 | 80 | 1.53 | 238.83 | 2.11 | 21.76 | 111.02 |
| 64 | 25 | Ao47-3bc-4619 | 3.48E-02 | 77 | 80 | 1.25 | 296.49 | 7.99 | 1.18 | 46.5 |
| 65 | 25 | Dd4-2c-4318 | 2.01E-02 | 77 | 140 | 1.73 | 218.96 | 3.1 | 1.2 | 44.94 |
| 66 | 25 | Ao47-3bc-4619 | 9.28E-02 | 85 | 80 | 1.2 | 238.79 | 2.15 | 16.22 | 111.04 |
| 67 | 26 | Dd4-2c-4318 | 5.17E-02 | 77 | 140 | 1.65 | 220.78 | 2.32 | 1.29 | 44.62 |
| 68 | 26 | Ao47-3bc-4619 | 1.38E-01 | 85 | 80 | 1.36 | 238.82 | 2.12 | 19.28 | 111.03 |
| 69 | 26 | Dd4-2c-4318 | 1.07E-01 | 85 | 140 | 1.39 | 168.78 | 4.53 | 21.81 | 103.63 |
| 70 | 27 | Dd4-2c-4318 | 3.30E-01 | 77 | 140 | 2.11 | 219.07 | 3.06 | 2.03 | 44.92 |
| 71 | 27 | Ao47-3bc-4619 | 5.41E-02 | 85 | 80 | 1.23 | 238.79 | 2.15 | 15.69 | 111.04 |
| 72 | 27 | Dd4-2c-4318 | 7.34E-02 | 85 | 140 | 2.04 | 169.05 | 4.43 | 30.76 | 103.55 |
| 73 | 28 | Ao47-3bc-4619 | 4.76E-02 | 77 | 80 | 1.85 | 296.64 | 7.94 | 1.82 | 46.48 |
| 74 | 28 | Dd4-2c-4318 | 6.06E-02 | 77 | 140 | 2.27 | 219.12 | 3.04 | 1.8 | 44.92 |
| 75 | 28 | Ao47-3bc-4619 | 2.87E-01 | 85 | 80 | 1.47 | 238.82 | 2.13 | 22.62 | 111.02 |
| 76 | 28 | Dd4-2c-4318 | 1.61E-01 | 85 | 140 | 1.95 | 169.02 | 4.43 | 31.93 | 103.56 |

*(Ao47-3bc-4619 is SWAT Code of Entisol soils, Dd4-2c-4318 is SWAT Code Mollisol soils, Zo16-3a-3337 is SWAT Code of Vertisol soils).*

## 4. Results and Discussion

Water balance is the main driving force behind all the processes in SWAT because of its impacts on the surface runoff and sediments within the watershed area . The most important elements of water balance in a basin consist of precipitation, surface run-off, lateral flow, base flow and evapo-transpiration. All these elements, with the exception of precipitation, have to be predicted using appropriate modeling tool because their quantification by measurement is not easy Therefore, SWAT model was used to quantify each of the hydrological processes occurring in the study area considered in this study.

In SWAT modelling, sediment yield can be defined as the total amount of sediment leaving the HRU and entering main channel during the time step . It is one of the important parameters to be estimated for efficient water management and planning of watershed area. The contributions of each sub-basins in the watershed area to sediment yield during the period of simulation period was examined using the calibrated SWAT model.

It was noted that HRU no. 58 from sub-basin 20 with catchment area of 4.11 Hactares with entisol (clayey loam) soil has the highest rate of 55.58 T/Ha of sediment yield during the simulation period. HRU no.40 from subbasin 14 admeasuring 30.9 Hactares with vertisol (silty loam) soil has shown maximum contribution of sediment of 14.971 Tons per year. A total of 91.39 Tons of sediment yield was estimated by the model as the potential sediment yield of the basin between the simulation periods of 2012-2013. Table gives the HRU wise results for sediment yield. Entisols have permeability of 1.65 mm/hour in top layer and 37 mm/hour in lower layers. Entisols contributed maximum runoff to the reach. Comparatively mollisols (Silt clay loam) contributed least runoff to the reach. Figure 5 shows the HRU wise runoff and sediment yield.

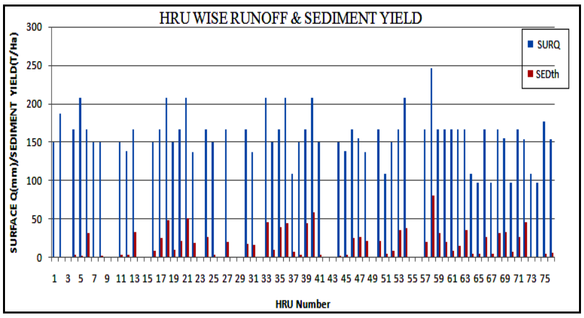


***Figure 5***. *Graph showing hydrologic response unit wise runoff and sediment yield*

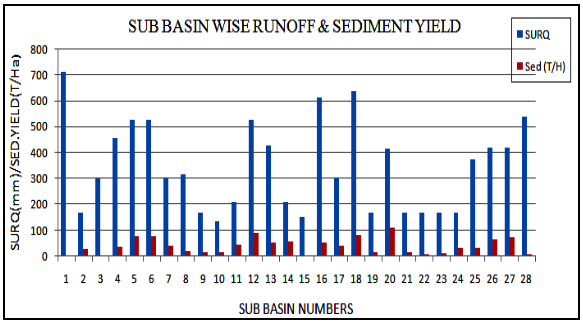


***Figure 6.*** *Graph showing sub basin wise runoff and sediment yield*

## 5. Conclusions

The Arc SWAT interface of SWAT model has been used successfully for exploring hydrological characteristics of the Kaneri watershed using HRU based approach. Considering the sediment yield and surface runoff in different HRUs and sub basins, it is concluded that HRU no.58 has maximum surface runoff and sediment yield and needs more water and soil conservation structures to be provided in it. But HRU no.3,9,10,14,15,23,26,28,29,32,42,43,49,55,56 do not show any runoff and sediment yield thus not needing any soil and water conservation structures. Similarly Sub basin no 1 has maximum soil loss needing maximum soil conservation structures in it, whereas sub basin no 10 has lowest soil loss hence needs least soil conservation measures. Thus SWAT model if used for other watersheds, will help in finding the sub basins as well as HRUs needing more care for watershed management according to the severity of soil loss from the area.

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