HYDROLOGICAL AND WATER QUALITY MODELLING USING SWAT FOR DONI RIVER

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Abstract - The present study was undertaken with an aim to study the Hydrological and Water Quality parameters of the Doni River Basin using SWAT Model. For model application, the Basin area was divided into 7 sub-basins and 15 HRUs. The Basin comprises mainly of 6 land use (with more than 85% agriculture area coverage). After the successful execution of the model, for 20 years it shoes that evapotranspiration and potential evapotranspiration of study area was found to be 195 mm and 402mm respectively. After the successful execution of the model, it shows the sediment yield to be highest in September and October months the total sediment loading was found to be 1.86Ton/ha. The Average annual basin values of nutrients like Organic N, Organic P, NO3 yield, NO3 in rainfall, Organic P in Soil, and Organic N in Soil are the main role in the water quality issues. SWAT model was simulated for the period of 20 years (year 1998–2018) and the correlation coefficient was found out to be 0.80, which shows the good relationship between rainfall and runoff values. Available hydrological data (i.e. from 1998-2018) was split into two groups for calibrating and validating parameter of the model (1996 and 1997 was taken as warm up periods).

The model was calibrated at Talikote gauging site on daily basis time scale. The model was auto-calibrated and validated using SWAT cup SUFI-2 software. Model performance was analyzed based on quantitative statistical analysis and visual comparison between observed and simulated flows. Nash and Sutcliffe Efficiency (NSE) and R^2 was taken as the main objective function during calibration and validation. The average daily calibration and validation showed good model response with NSE of 0.71 and 0.78 respectively. The coefficient of determination (R^2) for daily calibration and validation was 0.75 and 0.80 respectively. Overall, the model in simulating streamflow at Talikote gauging site can be rated as very good and the calibrated model could be used for runoff simulation for this agriculture dominating watershed.

Keyword: SWAT, HRU, SUFI-2 Software, Calibration, Validation.

1. INTRODUCTION

The Soil and Water Assessment Tool (SWAT) model (Arnold et al., 1998) is a continuous, long term, distributed parameter model that can simulate surface and subsurface flow, soil erosion and sediment deposition, and nutrient fate and movement through watersheds. SWAT has been applied worldwide for hydrologic and water quality simulation. SWAT, developed by Agricultural Research Services of USDA, has gained popularity in the recent past, witnessing continued refinement and is being used in the present study to quantify basin runoff. SWAT is a hydrological model functioning on a time step of daily or monthly. Today, SWAT is widely used to assess the environmental impacts of land use on water quantity and quality in small agricultural fields to continental-size watersheds with varying soil types, topography and land uses. Furthermore, SWAT, being a continuous time model, is capable of simulating periods ranging from 1 to 100 years, providing output on daily, monthly or annual time scales. SWAT model has been applied to different basins of India for simulating runoff and sediment yield and the results have been found to be reasonably satisfactory. The Doni River is the important tributary to Krishna River,it joins the Krishna to the southwest of the town of Talikote at the downstream of the Almatti dam. Sudden flash floods occur in the rainy season near Katnalli and Basavana Bagewadi. It is prone to irregular flooding and water is not suitable for use even for washing. Hence, SWAT model is used to estimate the Hydrological and Water Quality parameters and also, Model calibration and validation were conducted through sensitivity analysis and uncertainty analysis using the SUFI-2 algorithm in SWAT CUP.

1.2 HYDROLOGICAL MODELLING

Hydrological modelling can be defined as the characterization of real hydrologic features and system by the use of small-scale physical models, mathematical analogues, and computer simulations. Hydrologic modeling is used to answer environmental transport questions where water excess, scarcity, or dissolved or solid content is of primary importance. Because of the nature of environmental predictions, there is no single best model.

1.4 OBJECTIVES OF THE STUDY:

Precipitation, runoff, Soil loss are some of the parameters that play an important role in deciding the status of the watershed. In addition, these studies must be conducted to implement the watershed management practices. The objectives of the present study is;

- To setup hydrological model for study area.
- To Estimate Runoff using daily rainfall data for different sub basins of Doni River basin using SWAT.
- To calibrate and validate the model for monthly time step.
- To assess hydrological and nutrient component in the study area
- To study rainfall runoff relationship in the study area.

2. LITERATURE REVIEW

Arnold *et al.,* (1995, 1996), Neitsch *et al.,* (2001) SWAT (Soil and Water Assessment Tool) model was developed for the watershed. It is physical based model i.e. related with movement of sediment and water, growth of crop and nutrient cycling. It predicts runoff, sediment yield, chemical yield, impingement of managing land on water and vegetal land over varying soils. It is continuous time simulated model.

Bingner (1996) SWAT model was used for Godwin Creek Watershed which is located in northern Mississippi for a period of 10 years. SWAT predicts runoff of various watershed or basins over period of time. The study gave the sensible results in which individual storm simulations were lesser than those of storms aggregating on annual basis. This study states that SWAT accuracy can be increased if sub basins are split into various sub basins which resulted into increased variance in vegetative land cover and soil.

Arnold *et al.,* (1998) SWAT model was used to estimate the sediment transportation, erosion of soil and hydrology in Trinity River basin located at Texas that is Richland-Chambers watershed. Necessary input data's are being arranged to the model by the use of GIS interface. Efficient use GIS interface for SWAT model for data management and collection. From this study it is understood that, SWAT predicts stream flow, soil erosion and sediment transportation.

Manguerra *et al.,* (1998) SWAT model is been used in Animal Science (3.28 km^2), Greenhill (113.8 km^2) and Camp Shelby watersheds. In this study, hydrologic response units concept is adopted which is sufficient to represent spatial variability in the river basin. In this study, division of watershed can be done in presence of site specific water impoundments. Improved runoff is predicted through relative easy and automated return flow to stream flow, curve numbers with space and time.

King *et al.,* (1999) SWAT model is used to evaluate SCS daily curve number and Green-Ampt Mein-Larson methods which simulates excess rainfall on river basins with multiple rain gauges. In this study, SWAT is modified to obtain breakpoint rainfall data and route stream flow on daily time basis for Green-Ampt method. This study reports that there is no important advantage can be gained by the use of point of discontinuous rainfall and routine time basis while evaluating the large basins

M. P. Tripathi, R. K. Panda, N. S. Raghuwanshi2 and R. Singh(2004) The Nagwan watershed of Upper Damodar Valley situated in Hazaribagh District of Bihar State in eastern India was selected for the study. The watershed has a drainage area of 92.46 km^2 . Model simulated monthly rainfall for the period of 18 years was compared with observations. Simulated monthly rainfall, runoff and sediment yield values for the monsoon season of 8 years (1991–1998) were also compared with their observed values. In general monthly average rainfall predicted by the model was in close agreement with the observed monthly average values. Also, simulated monthly average values of surface runoff and sediment yield using generated rainfall compared well with observed values during the monsoon season of the years 1991–1998. The model performance was also evaluated for the monthly average values of rainfall, runoff and sediment yield for the monsoon season of the years 1991 to 1998 Mean rainfall-109.78mm sediment yield during monsoon season- 4.09 t/ha

Kangsheng Wu, Carol A. Johnston(2007) Objective to compare the effects of calibrating the Soil and Water Assessment Tool (SWAT) watershed model with different climatic datasets representing drought (1948–1949) versus average (1969–1970) conditions. The 901 km^2 watershed of the South Branch Ontonagon River (USGS gauging station 04039500 at Ewen, MI) was selected for study. The effects of the different climatic conditions on parameter response and sensitivity were evaluated,and performance of the two calibration versions was compared using a common validation period, 1950–1965. For the drought- and average-calibration periods, models were well calibrated, as indicated by high Nash-Sutcliffe efficiency coefficients Surface runoff was estimated by the SCS Curve Number method from daily precipitation records using default values provided in SWAT, which were acceptable based on land use and soil data in the study area. The Muskingum method was used for channel water routing. Model calibration was conducted by comparing the SWAT simulated data with the USGS observed discharge at 04039500 on monthly basis. Special attention was given to the calculation and evaluationof potential evapotranspiration (PET), The Priestley–Taylor model was used in SWAT to estimate PET. evaluationof potential evapotranspiration (PET), The Priestley–Taylor model was used in SWAT to estimate PET.

Shimelis G. Setegn, Ragahavan Srinivasan and Bijan Dargahi(2008) The main objective of this study was to test the performance and feasibility of the SWAT model for prediction of streamflow The Lake Tana basin comprises an area of 15,096 km^2 including the lake area. It was applied to the Lake Tana Basin for the modeling of the hydrological water balance. The sensitivity analysis of the model to sub basin delineation and HRU definition thresholds showed that the flow is more sensitive to the HRU definition thresholds than sub basin discretization effect Despite data uncertainty, the SWAT model produced good simulation results for daily and monthly time steps. The calibrated model can be used for further analysis of the effect of climate and land use change as well as other different management scenarios on stream flow and of soil erosion.

S.S. Panhalkar(2014) study is to derive the parameters required for runoff modeling using the geospatial database and estimate the runoff of the Satluj basin. For the present study, Satluj basin up to the Bhakra dam has been selected as a study region. The geographical limits of the Satluj basin right from start up to the Bhakra dam lie between Latitudes 31_N to 33_N and Longitudes 76_E to 80_E. The Catchment area of the river Satluj upto the Bhakra dam is about 56,874 sq. km Average annual rainfall and snowfall are 485 mm and 168 mm respectively. The total sediment loading is 51.27 T/HA. The average annual surface runoff is 79.67 mm.

Venkatesh (2018) SWAT is been used and calibrated for River Manimala basin which is situated in Kerala covering an area of 780 km^2 and evaluate components of hydrology for the basin to target on protection and management. The runoff and rainfall at station Thondara the data is used in this study from 2000 to 2007. From the results it is shown that runoff is influenced by these parameters such as CN, ESCO, and SOL_AWC, whereas base flow was influenced by lower values of GW_REVAP and ALPHA_BF. Additionally, the values of RMSE and NOF suggest for acceptance of rainfall-runoff model. With lower values of RMSE and NOF, calibration can be adjusted as good which is admissible for assessing engineer problem and application. The calibrated parameter values can also be used for further stream flow simulations in this catchment.

3. STUDY AREA AND DATA PRODUCTS

3.1 General Description of Study area

The Doni River basin is taken as study area for the present work, which lies on the Krishna River basin in Vijayapura district. It has a longitude of **77^0, 15', 22''E to77^0, 26', 15'' E and latitude of 13^0, 27', 45'' to 13^0, 15', 30'' N and Doni is** the major tributary of Krishna River. The basin area up to the confluence point of Doni with the Krishna is about **2900** km^2. However, the Central Water Commission has established a gauging site upstream of the confluence covering about **1344.18 km^2**of Doni watershed.

The river Doni originates about 7 Km south of Jath town in sangali district, Maharashtra to the west of Vijayapura districts of karanataka. It joins the Krishna to the southwest of the town of Talikote at the downstream of the Almatti dam. While its total length is 176 km and Sudden flash floods occur in the rainy season near Katnalli and BasavanaBagewadi.

The Doni River has a winding course and due to its salt content, saline layers are formed on the banks of the river during summer. Its valley is rich with fertile alluvial soil. During rainy season, due to flood, it is quite common to see small embankments washed away and thick beds of slush accumulate.

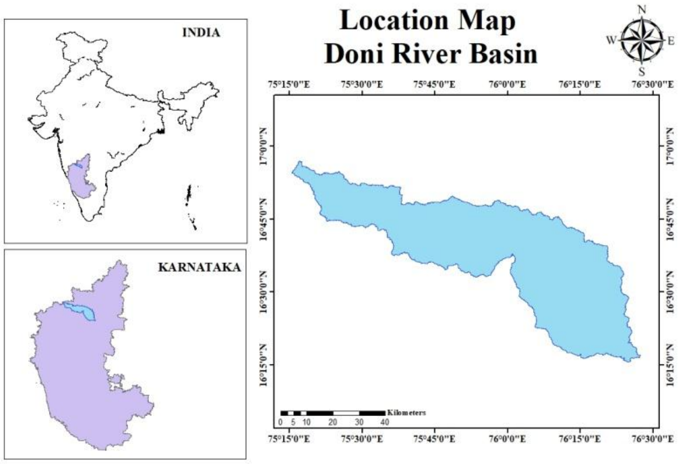

Fig 1: Location Map of Doni Watershed

3.2 MODEL SETUP AND PREPARATION OF INPUT DATABASE

In the present study, SWAT2012interface was used to meet the objective of the study. The model works in GIS environment and has some hardware and software requirement. The software required for the interface includes.

1. Microsoft Windows 10 Operating system.
2. ArcGIS- Arc View 10.4
3. ArcGIS Spatial Analyst 10.4 extension

The SWAT is a multi-parameter model and requires spatial catchment information with supporting database. The input files are created using the following datasets.

A. SPATIAL DATASET: Digital Elevation Model (DEM), Land cover /Land use Map, Soil Map.

B. DATABASE FILES : Soil database, Land use database, Weather generation table, Precipitation table, Runoff data table, Temperature data table, Relative humidity data table, Wind speed data table.

Location of outlet, weather generation gauges, rain gauges, temperature gauges, relative humidity gauge and wind station, Land cover look up table, Soil use look up table.

3.3 SPATIAL DATASET AND DESCRIPTION

3.3.1 DIGITAL ELEVATION MODEL (DEM)

The DEM of the study area was downloaded from USGS earth explorer where elevation data at 30 m resolution acquired through shutter radar topographic mission (SRTM) is available for the globe. The DEM was filed by ArcSWAT in order to avoid erroneous flow direction raster. The clipped DEM is having the elevation ranging from 402 m to 721 m and the resulted Doni digital elevation model is shown below Map.

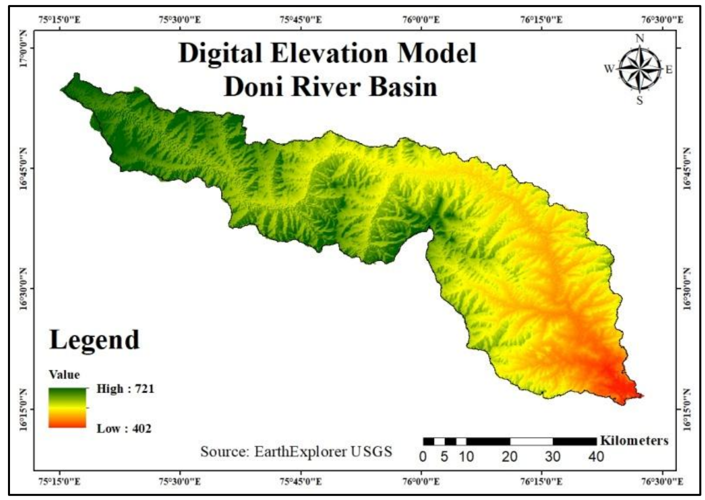

Fig 2:DEM of Doni River

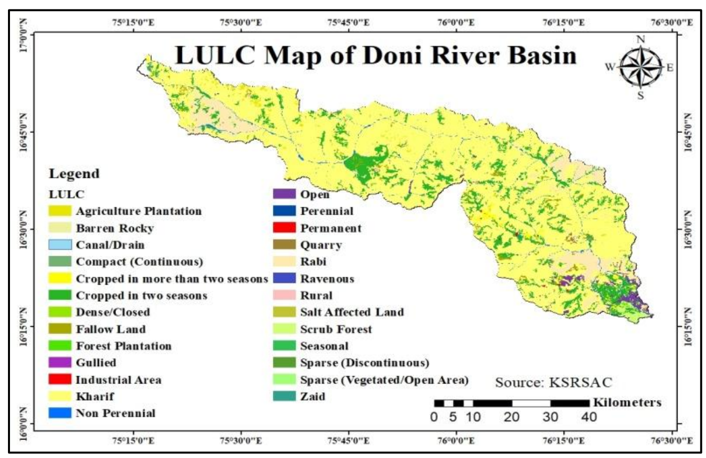

Fig 3: LULC Map of Doni River

3.3.2 LAND COVER/LAND USE MAP

LULC Data obtained from Karnataka State Remote Sensing Application Center (KSRSAC), which stood very much useful in deriving different land uses and land cover of the study area considered. Major classes classified include water, forest, barren land, agriculture land, range land and agriculture Land. The Land Use map of DoniRiver Basin is shown in Map below.

3.3.3 SOIL MAP

The soil map was obtained from the K(KSRSAC) and converted symbology as per Food and agricultural organization (FAO), Global. Soil data of Doni River Basin has been divided mainly into two groups i.e. clayey and Loamy majority of the soil in Doni River Basin falls under clayey soil class. Soil map of Doni River Basin is shown in Map.

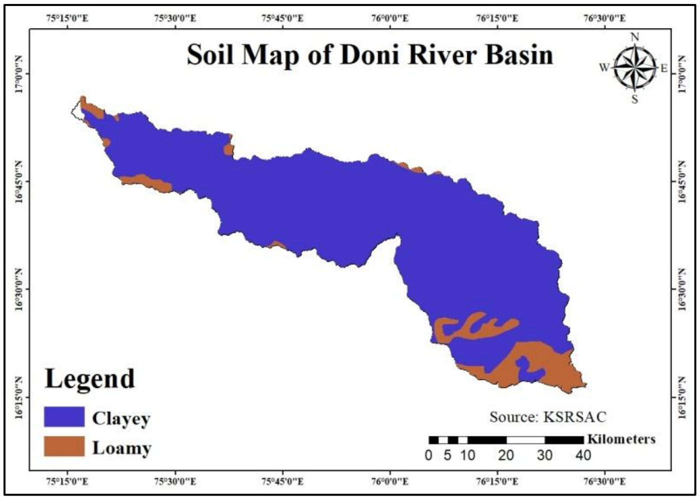

Fig 4: Soil Map of Doni River

Table 1: Data Sets Used

Sl.No	Data Used	Source
1	Soil Map (2018)	Karnataka State Remote Sensing Application Center (KSRSAC) and symbolized as per Food and agricultural organization (FAO), Global soil
2	Land Use & Land Cover map(2018)	Karnataka State Remote Sensing Application Center (KSRSAC), Bengaluru
3	Rainfall data (1996-2018)	Water Resources Department (WRD), Bengaluru
4	Digital Elevation Model(2021,30m resolution)	USGS Earth Explorer (SRTM)

4. METHODOLOGY

SWAT, basin is divided into the number of sub-basins. This is done due to the varying land, soil, slope within basin. Further subbasins are divided into number of Hydrologic Response Units (HRUs). The HRU is an area with unique combination of land use, soil class and slope. The user manual of SWAT model explains the set of procedure to simulate the model, which are as follows: (1) Watershed delineation (2) HRU analysis (3) Import weather data (4) Creation of input file (5) Run SWAT is shown Figure.

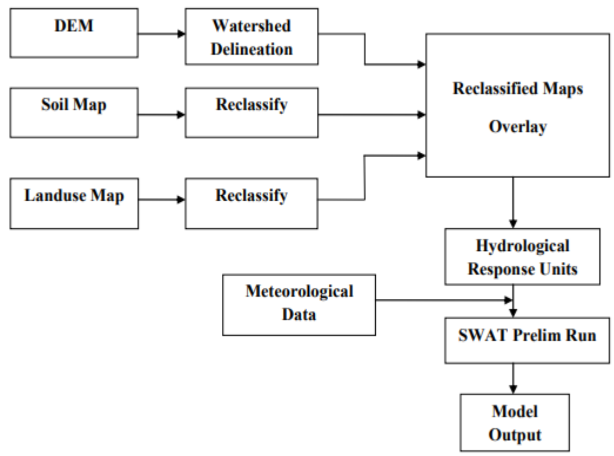

Fig 5: Flow chart representation of SWAT model.

The Penman Monteith (Monteith 1965) method was used for estimation of potential evapotranspiration (PET) and it uses MUSLE (Modified Universal Soil Loss Equation) for soil loss estimation (Williams and Berndt 1977).

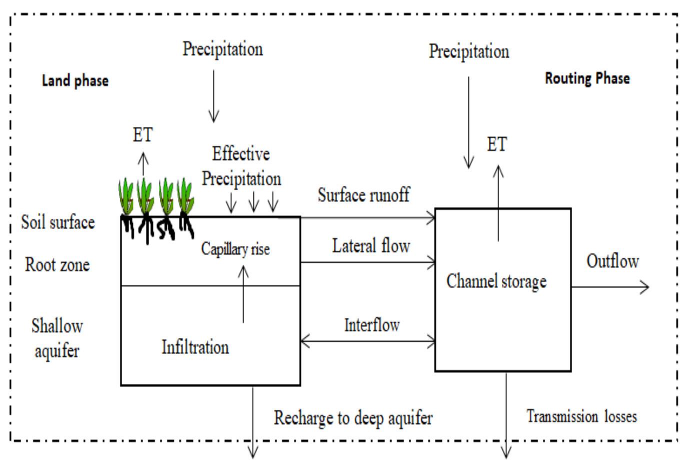

Fig 6: Water balance in land phase and routing phase

Water balance of the land phase is given in Eqn. 1 (Neitsch et al., 2005)

$$SW_t = SW_o + \sum (P_i - Q_{surf,I} - E_{a,I} - w_{seep,I} - Q_{gw,i}) \quad (1)$$

Where, SW_o and SWt are the initial and final soil moisture content, respectively. P_i, Rainfall, $Q_{surf,i}$, Runoff, $E_{a,i}$,Evapotranspiration, w_{seep}water entering into the vadose zone from the soil profile, $Q_{gw,i}$amount of return flow happening on i^{th} day. In the second stage of the SWAT hydrologic simulation, the routing stage, two options are available to route the flow in the channel networks: the variable storage and Muskinghum methods. Both are variations of the kinematic wave model. Water yield is estimated separately for each Hydrological Response Units (HRUs) separately.

Water balance in the channel reach is shown below.

$$V_{stored,t} = V_{stored,0} + V_{in,i} - V_{out,i} - tloss_i - E_{ch,i} + V_{bank,I} \quad (2)$$

Where, $V_{stored,t}$ and $V_{stored,0}$ are the volume of water stored in the reach at the beginning and end of the time step I, $V_{in,i}$and $V_{out,i}$ are the volume of water flowing into and out of the reach, respectively during the time step i. $tloss_i$Transmission loss, $E_{ch,i}$, direct evaporation from the channel reach, $V_{bank,i}$represents the volume of water added to the reach from back storage via return flow. The processes which are involved in the water balance model and the methods used for their estimation in SWAT are shown in Fig.

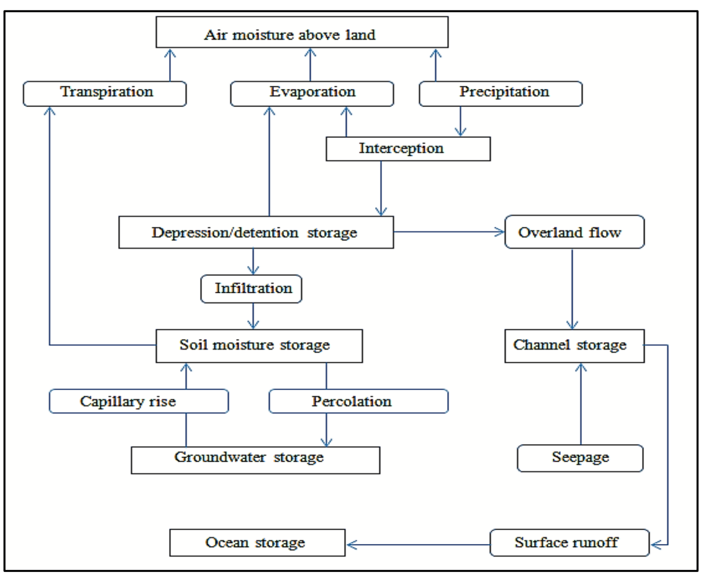

Fig 7: Schematization of storage and processes of the terrestrial part of the hydrological cycle (Mireille andLewarne 2009)

4.1 SWAT PROJECT SETUP

The first and foremost step to start working in ArcSWAT is to create a new SWAT project and setup working directory and geodatabase. All the further work will get stored in it. Details about processing being undertaken are given in following procedures. Figure below provides a brief overview and road map for setting up a SWAT project to run.

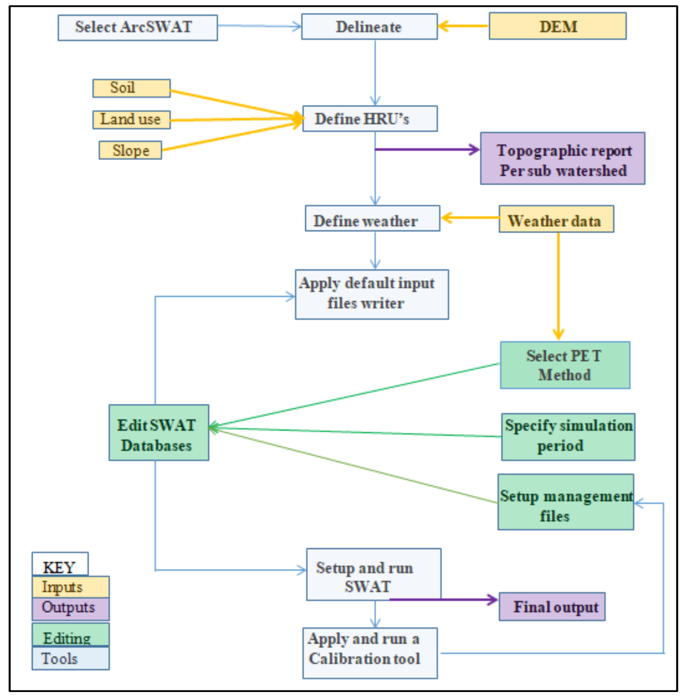

Fig 8: Workflow diagram to setup and run SWAT (Mireille and Lewarne 2009)

4.1.1 WATERSHED DELINEATION

The watershed delineation process includes five major steps, DEM setup, stream definition, outlet and inlet definition, watershed outlets selection and definition and calculation of subbasin parameters. Automated watershed delineation embedded in SWAT interface was used to delineate the watershed. Delineation of the watershed and sub-watershed was done by means of DEM data. DEM was imported into the SWAT model and projected to UTM zone 43. A mask was manually delineated over the DEM to remove the specific part, to delineate the border of the watershed and digitize the stream networks in the Doni River basin, which reduce the time of processing and burn-in a polyline stream dataset that in turn helps the subbasin reach to follow the known stream reach. Based on the area of the basin, only one outlet is defined. As a result, actual Doni catchment outlet is delineated. Lastly calculations of sub-basin parameter were made.

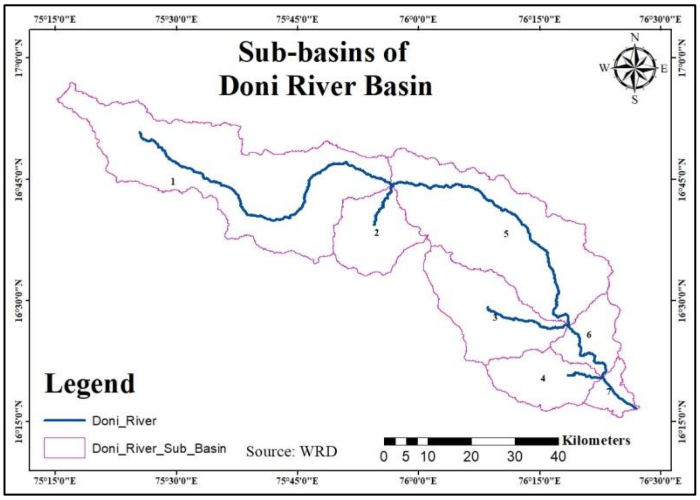

Fig 9: Sub-basins of Doni River basin

4.1.2HYDROLOGIC RESPONSE UNIT ANALYSIS

It is second step in parameterization of SWAT model. Sequence of model is carried as follows,

- Land use/ Soils/ Slope Definition
- HRU Definition
- HRU Analysis report

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HRU analysis tool bar helps in loading of the land use, soil and slope to the watershed. Using HRU analysis toolbar, land use maps are fed into model and lookup tables are provided to the model. Correspondingly, soil maps and the lookup table are provided to the model. By completion of this slope values are specified. There are 5 numbers of classes of slope entered. They are as follows; 0-2%, 2-4%, 4-8%, 8-17% and 17-9999% respectively. After loading of each data reclassify and then overlay the data's, thus overlay report will be generated. Then multiple HRU option is chosen to create multiple HRU's within each sub watershed with threshold percentage area of land use, soil and slope as 10% respectively.

4.2 CALIBRATION AND VALIDATON

4.2.1 DESCRIPTION OF THE SWAT-CUP

SWAT-CUP is a public domain computer program for calibration, validation and uncertainty analysis of SWAT model. The program links SUFI2, PSO, GLUE, ParaSol, and MCMC procedures to SWAT. Automated model calibration requires that the uncertain model parameters are systematically changed, the model is run, and the required outputs (corresponding to measured data) are extracted from the model output files. The main function of an interface is to provide a link between the input/output of a calibration program and the model. The simplest way of handling the file exchange is through text file.formats

Table 2: The parameters used in the computation, their range, and the calibrated values.

Variable.	Parameters	Description	Calibration Fitted Value	Min. Value	Max. Value
Streamflow	r__CN2.mgt	Initial SCS runoff curve number for moisture condition II	-0.111	-0.15	0.2
	v__ALPHA_BF.gw	Base flow alpha factor	0.34	0.27	0.81
	v__GW_DELAY.gw	Groundwater delay (days)	62	9	100
	v__GWQMN.gw	Threshold depth of water in the shallow aquifer for return flow to occur (mm H2O)	450	100	1000
	r__SOL_AWC.sol	Available water capacity of first soil layer	0.129	0	0.7
	v__CH_N2.rte	Manning's n (roughness) for channel	0.057	0.01	0.07
	v__GW_REVAP.gw	Groundwater re-evaporation coefficient	210	50	500
	v__SURLAG.bsn	Surface runoff lag time (days)	17	7	21

SWAT calibration and validation was performed for streamflow at the outlet of sub-basin. Streamflow was calibrated from January1998 to December 2010 and validated from January 2011 to December 2018 using observed daily discharge obtained from the CWC gauge. The calibration and validation for sediment yield, total nitrogen, and total phosphorous was not done due to non-availabilityof observed data. The R-factor and P-factor, which were computed by SUFI-2, were used to predict model uncertainty. T-statistics and P-value were used to perform sensitivity analysis.

Table 3: Performance rating of NSE

Performance Rating	NSE
Very good	0.75 < NSE < 1
good	0.65 < NSE ≤ 0.75
Satisfactory	0.5 < NSE ≤ 0.65
Unsatisfactory	< 0.5

5. RESULTS AND DISCUSSION

SWAT modelling for flow, sediments and nutrients have been performed so as to attain the pollutants details using land use and soil distribution data for a watershed as a result of which the pollutant sources that exists involve dairy manure application fields, wastewater treatment plants, croplands, and urban areas. In the Doni Basin the Average Monthly and Yearly Hydrological and Nutrient parameters like Runoff, Lateral Flow, Water Yield, Evapotranspiration, PET, Sediment yield, Total Nitrate and Total Phosphorus are obtained by model. The basin average hydrological parameters and values for the 20 years that is from 1998 to 2018 are show in Table 4.

Table 4: Average basin hydrological parameters and values

Parameters	Values
PRECIP	536.9 mm
SURFACE RUNOFF Q	248.75 mm
LATERAL SOIL Q	0.85 mm
GROUNDWATER (SHAL AQ) Q	176.80 mm
GROUNDWATER (DEEP AQ) Q	9.86 mm
REVAP (SHAL AQ => SOIL/PLANTS)	8.04 mm
DEEP AQ RECHARGE	9.69 mm
TOTAL AQ RECHARGE	193.89 mm
TOTAL WATER YLD	436.26 mm
PERCOLATION OUT OF SOIL	193.20 mm
ET	195.2 mm
PET	402.2 mm
TOTAL SEDIMENT LOADING	24.37 t/ha

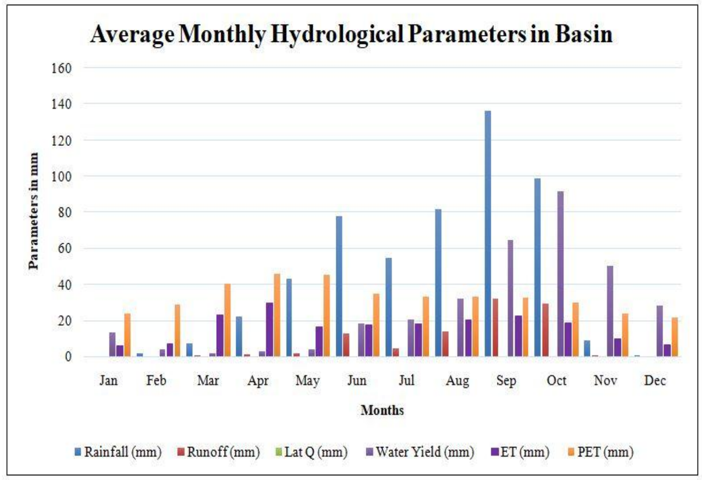

Figure 10: Average Monthly Basin Hydrological parameters

Fig.10 show the bar charts comparing the average monthly rainfall, runoff, Lateral Flow, Water yield, evapotranspiration and PET of the Basin, August and September is the month that has highest Rainfall and also September and October month has highest evapotranspiration this may be due to the earlier months that have saturated the soil the water tables rising may be contributing to the revap of the shallow aquifers.

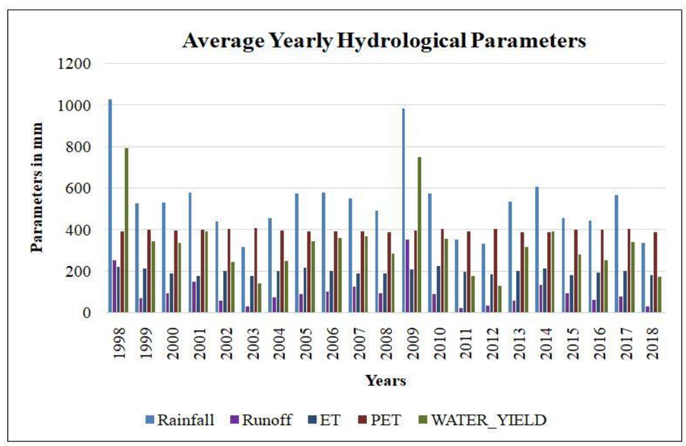

Figure 11: Average Yearly Basin Hydrological parameters

Fig. 11 show the bar charts comparing the average yearly rainfall, runoff, Water yield, evapotranspiration, and PET of the Basin. The highest Rainfall and Water yield in the year1998 and 2009respectively. Also, the Fig.15shows the bar charts comparing the average yearly nutrients components of the basin, these are majorly obtained by the Rainfall and Agricultural land uses of the basin.

The Average annual basin values of nutrients like Organic N, Organic P, NO3 yield, NO3 in rainfall, Organic P in Soil, and Organic Nin Soil was 6.763 (kg/ha),0.827 (kg/ha), 0.257 (kg/ha), 2.282 (kg/ha), 687.100 (kg/ha), and 5672.734 (kg/ha)respectively.

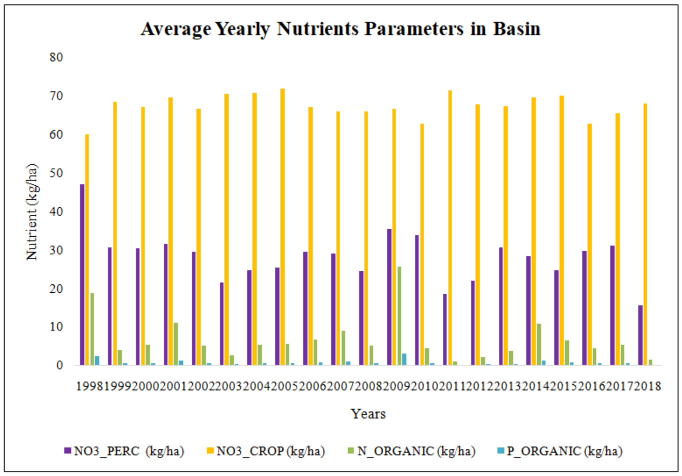

Figure 12: Average yearly nutrients components in the basin

5.1 RAINFALL-RUNOFF RELATIONSHIP

For the study the daily rainfall data of 19 gauging stations is used and all other weather data are collected from Water Resources Department (WRD) and Fig.13 shows the Annual comparison between rainfall and runoff of the DoniBasin received highest rainfall in the year of 1998 and 2009in the 20 years of period from 1998 to 2018.Fig.14 shows the Rainfall-Runoff Correlation coefficient was found to be 0.80.

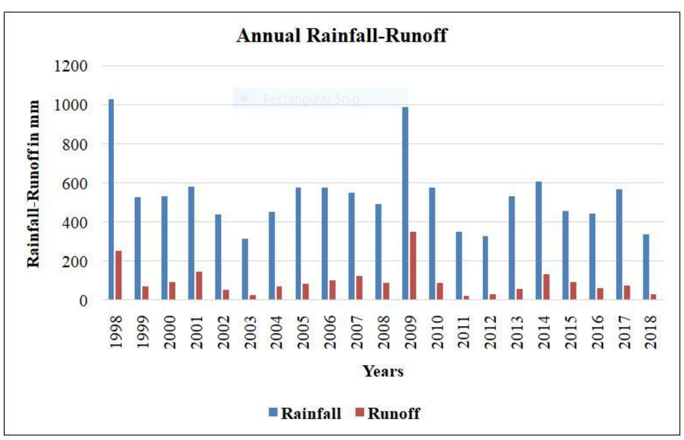

Figure 13: The comparision of Annual Rainfall-Runoff of Doni Basin

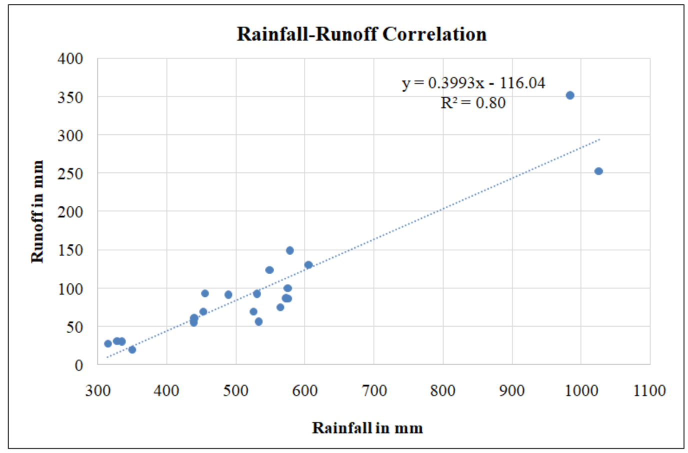

Figure 14: Correlation of Rainfall-Runoff of Doni Basin

5.2 DAILY STREAMFLOW SIMULATION RESULTS AND MODEL PERFORMANCE

5.2.1 CALIBRATION PERIOD 1998 TO 2010

In the present study area Doni basin, the following plot shown in the daily calibration of observed and simulated flow period from 1998 to 2010 years. From the Fig.18below it is seen that all high peaks are overestimated, and, in many events, deviation could be clearly seen between observed flow and simulated flow. It can be seen clearly that many of the peaks in the respective figures are not matching. Some peaks are matching but overestimated. This may be due to uncertainty in input datasets particularly use of rainfall data, Land use land cover and Soil properties.

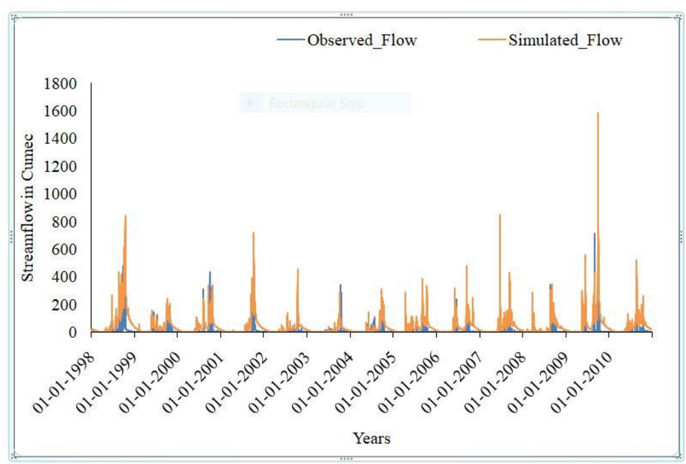

Figure 15: Daily Calibration of Observed and Simulated Flow for Doni basin

5.2.2 VALIDATION PERIOD 2011 TO 2018

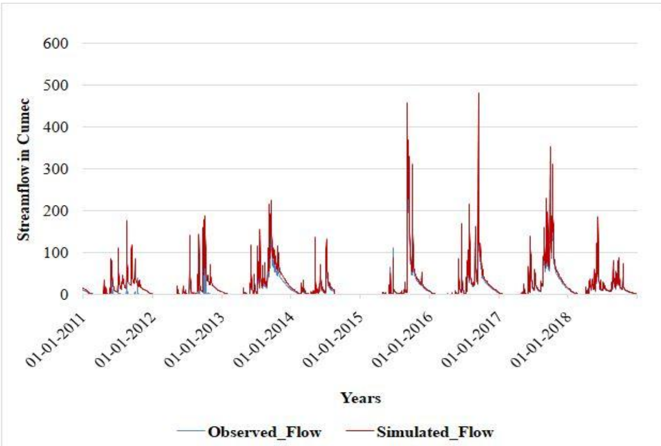

Figure 16: Daily Validation of Observed and Simulated Flow for Doni basin

Validation was performed with the same parameter value ranges and running with same 500 number of simulations. The validation period was taken also for 8 years (2011-2018). Fig.16 shows the daily validation plot between observed flow and simulated flow. In order to distinguish properly the graph showing the plot of observed and simulated flow for validation, the plot representing period from 1st January 2011 to 31st December 2018 were prepared. Simulated flow was nearly as close to the actual measured flow. some of the peaks did match and it also showed that the model did not response to some peaks of the observed flow. This could be the contribution of baseflow and uncertainty in input data.

5.2.3 MODEL PERFORMANCE

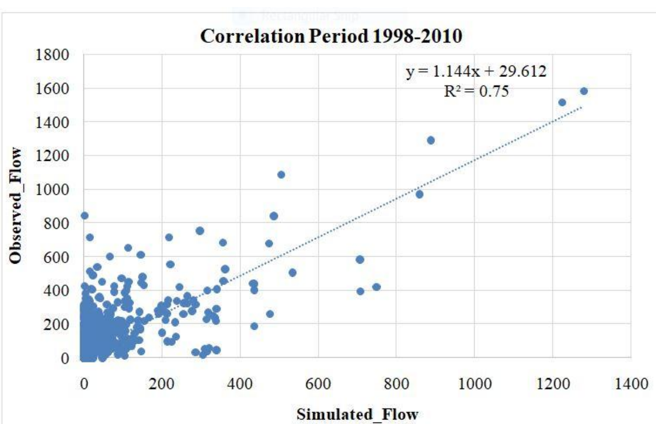

Figure 17: Correlation of Daily Calibration of Observed and Simulated Flow

The average R^2 value for daily calibration and validation was found to be 0.75 and 0.80 respectively and it is shown Fig.17 and 18 and also the values shown in Table.5.

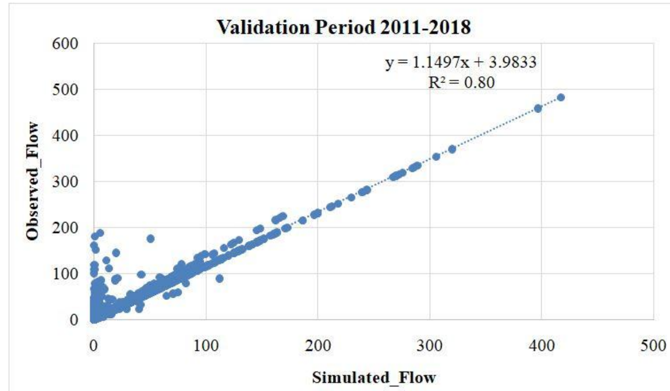

Figure 18: Correlation of Daily Validation of Observed and Simulated Flow

The average NSE value for calibration and validation was found to be 0.724 and 0.765 respectively for daily basis. Hence, the model showed good fit.

Table 5: Statistical Model Evaluation Performance for Doni Watershed in Daily Basis

Statistical Parameter	R^2	NSE
Calibration (1997-2002)	0.75	0.71
Validation (2003-2008)	0.80	0.78

6. CONCLUSIONS

SWAT model divided the Basin into 7sub basins and 15 HRUs units were created for the analysis and Average annual rainfall Obtained after successfully running SWAT model for 20years from(1998-2018)was found to be 1008mm. After the successful execution of the model, for 20 years it shoes that evapotranspiration and potential evapotranspiration of study area was found to be 195 mm and 402mm respectively. After the successful execution of the model, it shows the sediment yield to be highest in September and October months the total sediment loading was found to be 1.86Ton/ha. The Average annual basin values of nutrients like Organic N, Organic P, NO3 yield,NO3 in rainfall, Organic P in Soil, and Organic Nin Soil was6.763 (kg/ha),0.827 (kg/ha), 0.257 (kg/ha), 2.282 (kg/ha), 687.100 (kg/ha), and 5672.734 (kg/ha)respectively.

SWAT model was simulated for the period of 20 years (year 1998–2018) and the correlation coefficient was found out to be 0.80, which shows the good relationship between rainfall and runoff values. The study has shown that the SWAT model can produce reliable estimates of the different components of the hydrological cycle. The SWAT model with GIS environment show very effective tool for hydrological modelling.

The model was calibrated and validated using the observed streamflow at Talikote gauging site. The model was auto-calibrated using SUFI-2 considering 8 parameters. Based on this study following conclusions can be drawn:

1. The Nash-Sutcliffe Efficiency (NSE) for daily calibration and validation was 0.71 and 0.78 respectively.

2. The coefficient of determination (R^2) for daily calibration and validation was 0.75 and 0.80 respectively.

3. Overall, the model response well to the simulation of streamflow for the Doni River basin. The model is therefore suitable to simulate runoff behavior of agriculture dominated Doni River basin.

REFERENCES

1. Abbaspour K C, Johnson C A, Genuchten M T V. 2004. Estimating Uncertain Flow and Transport Parameters Using a Sequential Uncertainty Fitting Procedure. Vadose Zone Journal, pp 1341-1351.

2. Abbaspour K C, Rouhalonejad E, Vaghefi S, Srinivasan R, Yang H, Kløve B. 2015. A continental-scale hydrology and water quality model for Europe Calibration and uncertainty of a high-resolution large-scale SWAT model. Journal of Hydrology 524, pp. 733–752.

3. Abbaspour, C.K. (2013) SWAT-CUP 2012: SWAT Calibration and Uncertainty Programs—A User Manual. 103.

4. Abraham L Z, Roehrigi J, Alamirew D A.2007. Calibration and Validation of Hydrologic Model for Meki Watershed, Ethiopia. University of Kassel-Witzenhausen and University of Göttingen.

5. Arnold, J.G., Moriasi, D.N., Gassman, P.W., White, M.J., Srinivasan, R., Santhi, C.,

6. Arnold, J.G., Neitsch, S.L., Kiniry, J.R., Williams, J.R., 2011. Soil and Water Assessment Tool Version. 2009. Texas water resources institute technical report No. 406.

7. Behrendt, H., Opitz, D. 2000. Retention of nutrients in river systems: dependence on specific runoff and hydraulic load, Hydrobiologia, 410: 111–122.

8. Birhanu Z. 2009. Hydrological modeling of the Kihansi River catchment in South Central Tanzania using SWAT model. International Journal of Water Resources and Environmental Engineering: Vol. 1 (1), pp. 001-010.

9. Bøggild, C.E., Knudby, C.J., Knudsen, M.B., Starzer, W. 1999. Snowmelt and runoff modelling of an Arctic hydrological basin in west Greenland, Hydrological Processes, 13: 1989–2002.

10. Cao W, Bowden BW, Davie T. (2006). Multi-variable and multi-site calibration and validation of SWAT in a large mountainous catchment with high spatial variability. Hydrol Process 20:1057–1073

11. Chew, C.Y., Moore, L.W., Smith, R.H. 1991. Hydrological simulation of Tennessee's North Reelfoot Creek watershed, Research Journal of the Water Pollution Control Federation, 63(1): 10–16.

12. Dessu S B, Melesse A M. 2012. Modeling the rainfall–runoff process of the Mara River basin using the Soil and Water Assessment Tool. Hydrological Process: 26, 4038–4049.

13. Diwakar S K, Kaur S, Patel N. 2014. Hydrologic Assessment in a Middle Narmada Basin, India using SWAT Model. International Journal of Engineering Technology and Computer Research (IJETCR), Volume 2 Issue 6; Page No. 10-25.

14. Green, W.H. and Ampt, G.A. (1911) Studies in SoilPhysics, Part 1, the Flow of Air and Water through Soils. The Journal of Agriculture Science, 4, 11-24.

15. Haan, C. T., D. E. Storm, T. Al-Issa, S. Prabhu, G. J. Sabbagh, and D. R. Edwards. 1998. Effect of parameter distributions on uncertainty analysis of hydrologic models. Trans. ASAE 41(1): 65-70.

16. Haldar R, Singla S, Singla R, Khosa R. 2014. Hydrologic Modeling for the Gandak Basin Using SWAT with Sensitivity Considerations. International. International Journal of Earth sciences and Engineering: ISSN 0974-5904, Volume 07, No. 02.

17. Harmel, R.D., Griensven, A.V., Liew, M.W.V., Kannan, N., Jha, M.K., 2012.SWAT: Model use, Calibration, and Validation. ASABE. Vol. 55(4): 1491-1508.

18. Herbst, M., Fialkiewicz, W., Chen, T., Pütz, T., Thiéry, D., Mouvet, C., Vachaud, G., Vereecken, H. 2005a. “Intercomparison of Flow and Transport Models Applied to Vertical Drainage in Cropped Lysimeters”, Vadose Zone Journal, 4(2): 240–254.

19. Ireson, A., Makropoulos, C., Maksimovic, C. 2006. Water Resources Modelling under Data Scarcity: Coupling MIKE BASIN and ASM Groundwater Model, Water Resources Management, 20: 567–590.

20. Jajarmizadeh M, Harun S, Abdullah R, Salarpour M. 2012. Using Soil and Water Assessment Tool for Flow Simulation and Assessment of Sensitive Parameters Applying SUFI-2 Algorithm. Caspian Journal of Applied Sciences Research, 2(1), pp. 37-44.