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AN INTEGRATED STUDY USING GIS AND SWAT METHOD FOR RAINFALL RUNOFF MODELLING IN KULSI WATERSHED, ASSAM

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Abstract—**The present study is based on the estimation of runoff using GIS and SWAT in the Kulsi Watershed, Assam. Soil and Water assessment tool (SWAT) is a physically based distributed parameter model which was developed to predict runoff, sediment, erosion from specific watersheds under different input conditions. For understanding the rainfall-runoff behavior of the basin, SWAT hydrological model was used and divided in 19 sub-watersheds and 188 Hydrogical Response Units. The watershed comprises of four Land use classifications (River/water bodies, Open forest, dense forests and barren land) with three soil classes. The delineated area of the study is found to be 1754.39 km². The study indicates that the annual rainfall runoff relationship correlates with magnitude of total runoff. From the calibration output, the simulated stream flow hydrograph deviates slightly with the observed stream flow hydrograph. The model was auto calibrated and validated using SWAT-CUP SUFI2 for 10 year i.e. from 1988-1997 .The average Nash Sutcliffe efficiency (NSE) for monthly calibration and validation was found to be 0.18 and 0.70 respectively. The coefficient of determination (R^2) value for monthly calibration and validation was found to be 0.31 and 0.73 and RSR value for calibration and validation was found to be 0.91 and 0.55 respectively. The study was also carried out to perform the sensitivity analysis of different parameters responsible for stream flow generation. Based on the analysis, SCS runoff curve number (CN2.mgt), Groundwater "revap" coefficient (GW_REVAP.gw), Groundwater delay days (GW_DELAY.gw), Saturated hydraulic conductivity (SOL_AWC.sol), Base flow alpha factor (ALPHA_BF.gw), Threshold depth of water in the shallow aquifer required for return flow to occur (mm) (GWQMN.gw) were found to be the most sensitive parameters. Overall the SWAT model performance was found to be satisfactory for stream flow simulation and the calibrated model can be used for runoff generation and sustainable water resource projects and development.**

Keywords—**Rainfall runoff, Soil and Water Assessment Tool, Hydrological Response units, stream flow hydrograph, calibration and validation, threshold depth.**

I. INTRODUCTION

Rainfall is an essential component of the hydrological cycle, and changes to its pattern have a direct impact on the water resources. The changing pattern of rainfall in consequence of climate change is now concerning issues to water resource managers and hydrologists (Srivastava et al. 2016). Along with rainfall runoff also plays a important hydrological variable in water resource research. Estimating direct runoff in ungauged river basins is difficult and time-consuming. Traditional runoff prediction models call for a lot of hydrological and meteorological information. (Kangsabanik and Murmu, 2017). There is an immediate need to investigate the Rainfall-Runoff behavior of the area in order to better understand the hydrological phenomena as they change over time and how to influence those changes. Catchment modeling is also essential for estimating various hydrological variables in order to construct effective and safe water structures or for forecasting (Schultz, G.A., 1993). The Soil and Water Assessment Tool (SWAT), developed by USDA's Agricultural Services, is a watershed model used to assess the influence of climate change and anthropogenic factors on stream flow, sediment and nutrient transport, and agricultural chemical transfer, as well as simulating basin runoff. (Arnold et al., 1998)The model simulation is performed using the gridded meteorological data from NASA MERRA of 0.5˚ x 0.625˚ resolution, Land use Land Cover Grid derived using Supervised classification of Lands at 5 images, soil Grid from FAO soil portal and the model is run for the period of 12 years (1988-2000) and the stream flow discharge and surface discharge is generated in SWAT output.

II. STUDY AREA

The present study area taken is the catchment of Kulsi river. The Kulsi River is a south bank tributary of the Brahmaputra river system. The Kulsi river basin lies between latitude 25°50ˈ13ˈˈN and 25°58ˈ26ˈˈN and longitude 91°20ˈ38ˈˈE and 91°23ˈ25ˈˈE. It is composed of three rivers, namely Um Khri, Um Krishniya and Um siri. All these three rivers flow north and are sourced from the west Khasi hill range. It flows north-west and enters Assam at Ukium and after that it flows north up to Kulsi village through the plains of Assam and finally it outflows into the Brahmaputra near Nagarbera in Kamrup district. The river's length from Kulsi village to Nagarbera is roughly 76 kilometers. Within the Kamrup and Goalpara Districts of Assam, as well as the west Khasi Hills and East Garo Hills Districts of Meghalaya, the river Kulsi drains a total of 3770 sq. km.Out of the whole catchment, 685 sq. km. are in Assam's plain catchment and 3085 sq. km. are in Meghalaya and Assam's hill catchment. Evergreen forests cover the hill range, which receives a lot of rain during the monsoon season. Kulsi river is around 220 km long overall, from source to outfall, out of which 100 km flows through Meghalaya, and the remaining 120 km through Assam state.

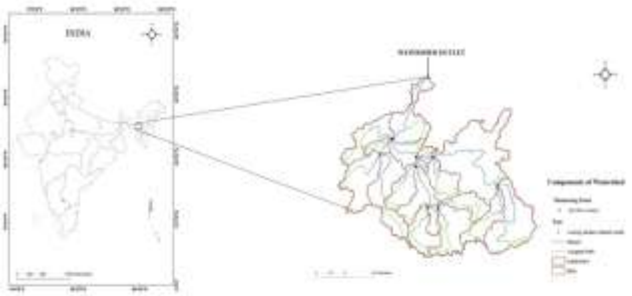


Fig. 1. Study Area map

1. Rainfall Pattern

The average annual rainfall of the basin is 1870.6 mm and receives the maximum annual rainfall during the south west monsoon period i.e. May to September. In the study, the daily rainfall data was collected for 12 year period (1988-2000) from the two stations Ukium and Mairang.

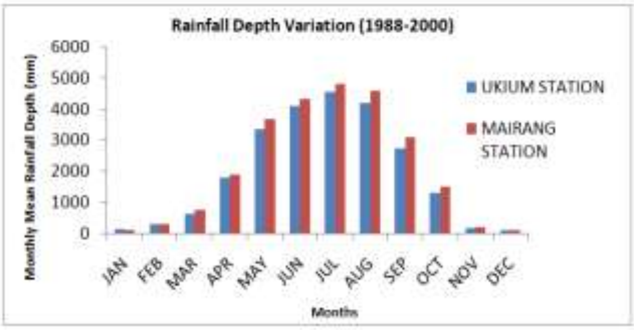


Fig 2: Monthly mean Rainfall depth

2. Temperature Variation

The average monthly maximum temperature is received during the May is 30.05°C and the average monthly minimum temperature received is 7.6°C in the month of January .The normal daily mean monthly maximum and minimum temperature for Ukium station is 29.8°C and 19.73°C. The normal daily mean monthly maximum and minimum temperature for Mairang station is 22.82°C and 13.75°C.

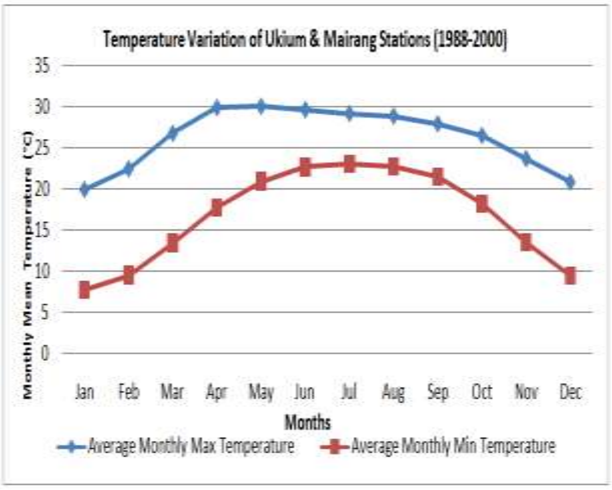


Fig 3: Monthly mean temperature (1988-2000)

3. Land use-Land cover

The Land use data was prepared using LANDSAT 4-5 TM C2 L1 image downloaded from USGS Earth Explorer. The downloaded file contained 7 bands and bands 4, 3, 2 are stacked together into one imagery using the band composite tool. Extraction by mask is done with proper projection in Arc GIS and the image is classified (supervised classification) by identifying different signatures present in the watershed. Out of 12 year period, the LULC map has been developed for an interval of every four year period which is 1988, 1992, 1996 and 2000. The classification was done into four classes that include Rivers/Water bodies (0.89%), Open forests (37.84%), dense forest (36.9%) and barren lands (24.37%).

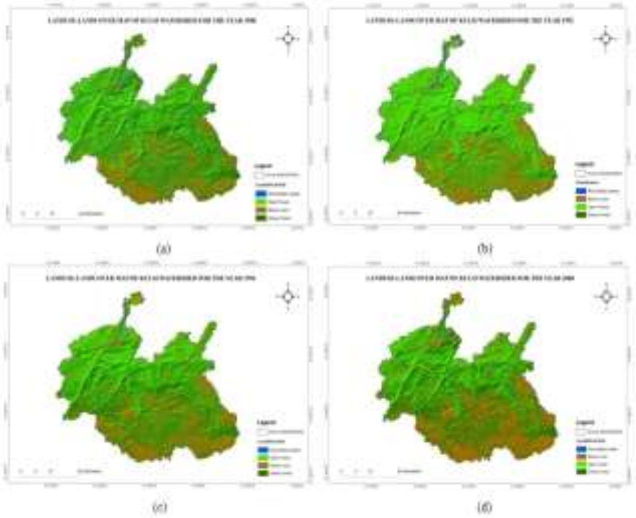


Fig 4: (a)Landuse and Landcover map for the year 1988, (b) Landuse and Landcover map for the year 1992, (c) Landuse and Landcover map for the year 1996, (d)Landuse and Landcover map for the year 2000

4. Soils

The soil data for the study has been obtained from the Digital Soil Map of the World of the FAO (Food & Agriculture Organization) UNESCO soil portal of the world. It is a 30 arc-second raster database that incorporates global soil data that has been updated on a regional and national level with more than 15000 individual soil mapping units. Soil data of Kulsi watershed has been divided into two categories Orthic Acrisols and Distric Nitosols having different chemical properties. The soils are usually loamy to sandy texture with different clayey properties.

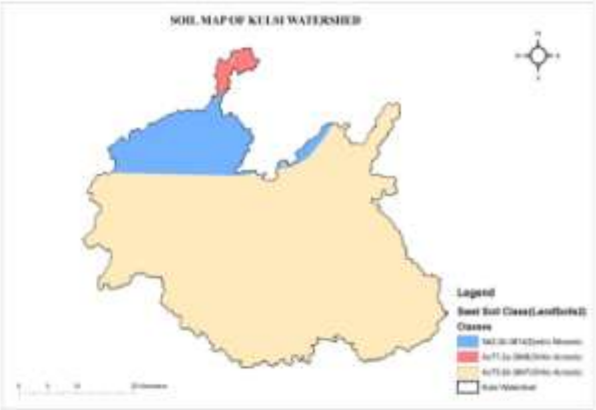


Fig 5: Kulsi watershed soil classes

III. METHODOLOGY

1. PROCESSES INVOLVED

Numerous sorts of spatial and temporal input data are needed for SWAT. SWAT must process, aggregate, and perform spatial analysis on these data using GIS tools as it is a semi-distributed model. Therefore, as a free supplementary extension called ArcSWAT2012 for ArcGIS, it will be paired with GIS software for making the model easier. (Kangsabanik and Murmu, 2017).The SWAT model was created to determine, on a daily time scale, how land use and management affect water, sediment, and agricultural chemical yields in ungauged watersheds. Hydrological assessment studies that forecast the impact of water and land management strategies can be conducted using SWAT. The most significant inputs for SWAT to model hydrology and water quality in a watershed are weather, soil qualities, terrain, vegetationand land management methods. (Neitsch,2002). It has the potential to be a useful tool for predicting runoff, sediments, nutrients, and pesticides from both rural and urban users. One of its benefits is that it may operate for between 150 and 300 years, making it valuable for water resources planning , management and decision making policies. Some of the process involves in SWAT are discussed below:

A. Surface Runoff

A modified SCS curve number or the Green & Ampt infiltration method is used to calculate surface runoff. In the curve number method, the curve number varies non linearly with moisture content of the soil. The SCS curve number approach is an empirical conceptual technique created for computing surface runoff under various soil types and land usage. Surface runoff volume predicted in SWAT using SCS curve number method is given below

$$Q_{\mathrm{surf}} = \frac{(R_{\mathrm{day}} - 0.2S)^2}{(R_{\mathrm{day}} + 0.8S)} \qquad (1)$$

where,Q_{surf} is the accumulated runoff or rainfall excess (mm),R_{day} is the rainfall depth forthe day (mm),and S is retention parameter (mm) and $R > 0.2S$ Runoff will occur when $R_{\mathrm{day}} > 0.2S$.The retention parameter varies spatially due to changes in soils, land use, management and slope and temporally due to changes in soil water content. The retention parameter is defined as

$$S = 25.4\left(\frac{1000}{CN} - 10\right) \qquad (2)$$

where CN is the curve number for the day.

B. Evapotranspiration

Evapotranspiration isthe primary mechanism by which water is removed from a watershed. Numerous methods have been developed to estimate ET. Three of these methods havebeen incorporated into SWAT2000: the Penman-Monteith method and the Hargreaves method. The Penman-Monteith equation combines components that account for energy needed to sustain evaporation, the strength of the mechanism required to remove the water vapor and aerodynamic and surface resistance terms. The Penman-Monteith equation is

$$\lambda E = \frac{\Delta.(H_{net} - G) + \rho_{air}.c_p.[e_z^o - e_z]/r_a}{\Delta + \gamma.(1 + r_c/r_a)} (3)$$

where, λE is the latent heat flux density ($MJm^{-2}d^{-1}$), E is the depth rate evaporation(mmd^{-1}), D is the slope of the saturation vapor pressure-temperature curve, de/dT (kPaoC-1), H_{net} is the net radiation ($MJm^{-2}d^{-1}$), G is the heat flux density to the ground ($MJm^{-2}d^{-1}$), ρ_{air} is the air density (kgm^{-3}), c_p is the specific heat at constant pressure (MJ kg^{-1} ° C^{-1}),ez°the saturation vapor pressure of air at height z (kPa), ez is the water vapor pressure of air at height z (kPa), γ is the psychometric constant (kPa°C^{-1}), $r_c$is the plant canopyresistance (sm^{-1}), and $r_a$is the diffusion resistance of the air layer (aerodynamicresistance) (sm^{-1}).

C. Channel routing

The variable storage routing method was developed by Williams (1969)and used in the HYMO (Williams and Hann, 1973) and ROTO (Arnold et al.,1995) models. For a given reach segment, storage routing is based on the continuity equation:

$$V_{in} - V_{out} = \Delta V_{stored} \qquad (4)$$

where $V_{in}$is the volume of inflow during the time step (m^3 H2O), V_{out} is the volume ofoutflow during the time step (m^3 H2O), andV_{stored} is the change in volume of storageduring the time step (m^3 H2O).This equation can be presented as :

$$\Delta t.\left(\frac{q_{in,1} + q_{in,2}}{2}\right) - \Delta t.\left(\frac{q_{out,1} + q_{out,2}}{2}\right) = V_{stored,2} - V_{stored,1}$$
(5)

where, Δt is the length of the time step (s) and $q_{in,1}$ and $q_{in,2}$ are the inflow rate at thebeginning and end of the time step (m3/s), respectively. $q_{out,1}$and $q_{out,2}$are the outflow rate at the beginning and end of the time step (m^3/s). $V_{stored,1}$and $V_{stored,2}$ are the storagevolume at the beginning and end of the time step (m^3).Travel time is computed by dividing the volume of water in the channel by the flow rate.

$$TT = \frac{V_{stored}}{q_{out}} = \frac{V_{stored,1}}{q_{out,1}} = \frac{V_{stored,2}}{q_{out,2}} (6)$$

where, TT is the travel time (s), V_{stored} is the storage volume (m^3), and q_{out} is the dischargerate (m^3/s).

2. MODEL SETUP

For the hydrological modeling, certain spatial and non-spatial data sets are required for simulation. For generation of SWAT output, Arc SWAT2012 is used in Arc GIS with inputs such as DEM (Digital Elevation Model), LuLc map, Soil map and Hydro-meteorological data. The ArcSWAT2012 which allows us to delineate the sub-watersheds based on tan programmed method using DEM. The total area of the catchment is found to be 1754.39 km^2 .The minimum and maximum elevations of the study are 21 m and 1922 m respectively. The catchment is divided into 19 sub basins. The DEM (Digital Elevation Model) is extracted from USGS earth explorer (ASTER GLOBAL DEM V3) 30m and is projected into a appropriate projection system of datum D_wgs_1984. The Land use-Land cover map was prepared from LAND SAT 4-5 TM C2 L1 image of 7 bands from USGS Earth Explorer was used for generating the Satellite imagery and supervised classification is done. Soil map of spatial resolution of 1:50,000 were obtained from the Digital Soil Map of the World of the FAO (Food & Agriculture Organization) UNESCO soil portal.

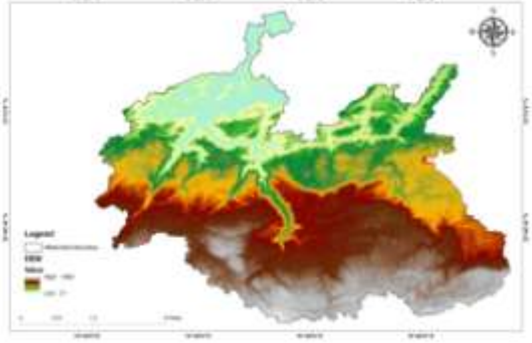


Fig. 6. Watershed DEM

Daily rainfall and temperature data for the years (1988-2000) were collected for two stations in Kulsi River Basin from the National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) Prediction of Worldwide Energy Resource (POWER) of resolution 0.5 x 0.625. The observed discharge data in the present study was measured originally in the site Chaygaon A.T road crossing (26°04'24.4"N 91°25'48.0"E) which is located 6-7 km away from the outlet of the study area of Kulsi watershed maintained by Hydrology Division , Water Resource Department , Guwahati.

The LULC map and Slope map are imported to the model using SWAT and slope characteristics are analyzed and for each sub-watershed, the land HRU's (Hydrological Response Units) are determined. In the present study a total 188 HRU's are found in the Kulsi watershed. For specifying the Land use layer, Land use category is used and soil table for specifying the soil type for each category to be modeled. Based on the infiltration rate , the soil map reclassified the database into four hydrological soil group (HSG) named A,B,C and D out of which Type C and D are present in our study area. The LULC map is also reclassified into 4 categories. Also the reclassification of the Slope map is done into 5 classes that are 0-3%, 3-8%, 8-15%, 15-30% and above 30%. Next all the data layers of land use, soil and slope data are overlaid and hydrologic response units (HRUs) within the catchment are determined. A threshold percentage of 10% has been acquired for all Land use, soil and slope classes to eliminate minor Land use, soil and slope. The work flow diagram of the SWAT simulation is shown below.

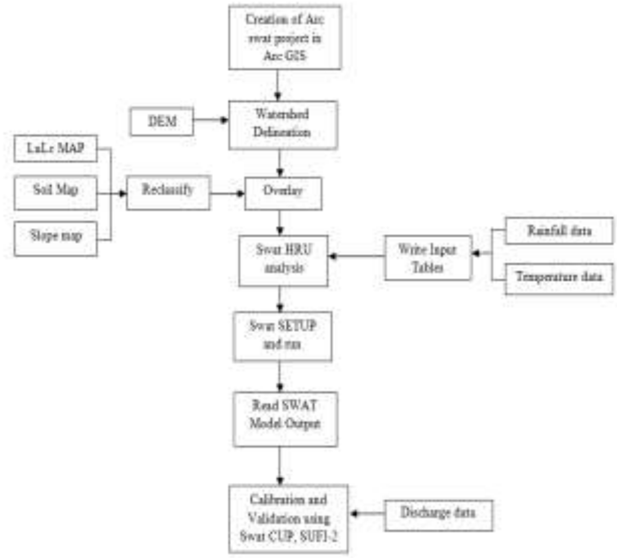


Fig. 7. Workflow diagram of SWAT simulation

In the present study, Arc SWAT_2012.10.18 interface was used for the modeling. For Calibration, Validation and Sensitivity analysis process SWAT-CUP (Calibration Uncertainty Program) 2019 SUFI-2 (Sequential Uncertainty Fitting version 2.0) procedure was used. First the calibration was done for a period of 10 years at monthly time steps. Observed data from 1988 to 2000 was used for calibration and data from 1988 to 1992 has been used for the calibration of parameters and performance of the calibrated model has been validated using independent dataset from 1993 to 1997.

The interactive method that underlies SUFI-2 reduces the parameter values with each iteration. 500 simulations were allowed throughout each iteration step. The best simulation can be displayed in the output results, which will be the best statistical coefficient result, after the number of times the iteration was specified. All the statistical coefficients can be calculated throughout each iteration. The conceptual model, parameters, and measurable data are just a few of the sources of uncertainty that are taken into account by SUFI-2's parameter uncertainty.

Models are evaluated to compare how closely the simulated values match the observed data. Evaluations of the performance of hydrologic models employ a variety of statistics and approaches. In the current investigation, the following graphical and numerical performance criteria were applied:

1. The coefficient of determination (R^2): It describes the proportion of the total variance inthe measured data that can be explained by the model. It could be calculated by the equation given below

$$R^2 = \left[\frac{\sum_{i=1}^{N}[o(i)-o_{avg}][\mathrm{S(i)}-\mathrm{S}_{\mathrm{avg}}]}{[\sum_{\mathrm{i=1}}^{\mathrm{N}}(\mathrm{o(i)}-\mathrm{o}_{\mathrm{avg}})^2]^{0.5}[\sum_{\mathrm{i=1}}^{\mathrm{N}}(\mathrm{S(i)}-\mathrm{S}_{\mathrm{avg}})^2]^{0.5}}\right] (7)$$

where, O(i) is the ith observed parameter, Oavg is the mean of the observed parameters, S(i) is the ith simulated parameter, Savg is the mean of model simulated parameter and N isthe total number of events

2. Nash Sutcliffe Efficiency (NSE): It is a normalized statistic that determines the relative magnitude of the residual variance compared to the measured the variance and given by equation 8

$$\mathrm{NSE} = 1 - \left[\frac{\sum_{\mathrm{i=1}}^{\mathrm{n}}(\mathrm{Y}_{\mathrm{i}}^{\mathrm{obs}} - \mathrm{Y}_{\mathrm{i}}^{\mathrm{sim}})^2}{\sum_{\mathrm{i=1}}^{\mathrm{n}}(\mathrm{Y}_{\mathrm{i}}^{\mathrm{obs}} - \mathrm{Y}_{\mathrm{i}}^{\mathrm{mean}})^2}\right] \qquad (8)$$

Where $\mathrm{Y}_{\mathrm{i}}^{\mathrm{obs}}$ is the ith observation for the constituent being evaluated, $\mathrm{Y}_{\mathrm{i}}^{\mathrm{sim}}$ is the ith simulated value for the constituent being evaluated,$\mathrm{Y}_{\mathrm{i}}^{\mathrm{mean}}$ is the mean of observed data for the constituent being evaluated, and n is the total number of observations.

3. RMSE Standard deviation ratio (RSR): The Root Mean Square error Standard deviation ratio is a commonly used error index statistics. RSR incorporates the benefits of error index statistics and includes a scaling/normalization factor, so that the resulting statistic and reported values can apply to various constituents.

$$\mathrm{RSR} = \frac{\sqrt{\sum_{\mathrm{i=1}}^{\mathrm{n}}(\mathrm{Q}_{\mathrm{m}} - \mathrm{Q}_{S})\mathrm{i}^2}}{\sum_{\mathrm{i=1}}^{\mathrm{n}}(\mathrm{Q}_{\mathrm{m,i}} - \mathrm{Q}_{\mathrm{m}})^2} \qquad (9)$$

Where Q is a variable (e.g., discharge), m and s stand for measured and simulated variables, and i is the ith measured or simulated data.

4. 95PPU (95 % Prediction Uncertainty) Plot : The 95% probability distributions are calculated at the 2.5% and 97.5% levels of the cumulative distribution of an output variable and it is called 95% prediction uncertainty (95PPU). (Bloschl et al., 2013; Abbaspour, 2015)

The Sensitivity analysis of the parameters has been performed by SWAT-CUP SUFI2 software using Global sensitivity analysis. The parameters used in the study are SCS runoff curve number (CN2.mgt), Groundwater delay (GW_DELAY.gw), Groundwater "revap" coefficient (GW_REVAP.gw), Saturated hydraulic conductivity(SOL_AWC.sol), Base flow alpha factor (ALPHA_BF.gw), and Threshold depth of water in the shallow aquifer required for return flow to occur(GWQMN.gw).

IV. RESULTS AND DISCUSSION

1. Landuse-Landcover

The study shows the structure of the SWAT-based model used in the modeling of the Rainfall Runoff process. The annual rainfall over the 12 year period shows a non uniform trend. The average annual rainfall of the basin is 1870.6 mm and receives the maximum annual rainfall during the south west monsoon period i.e. May to September. The normal daily mean monthly maximum and minimum temperature for Ukium station is 29.8°C and 19.73°C and for Mairang station is 22.82°C and 13.75°C. The study area's Landuse-Landcover

(LULC) map identifies and offers details about the major activities (Land use) that took place there. By using LULC maps, the type of area covered in the study area such as water bodies, agricultural land, barren lands, and forest land is found out respectively. The total area covered in the study area was found to be 1754.39 km². The curve number value is highly dependent on the soil surface. The average curve number was found to 76.23

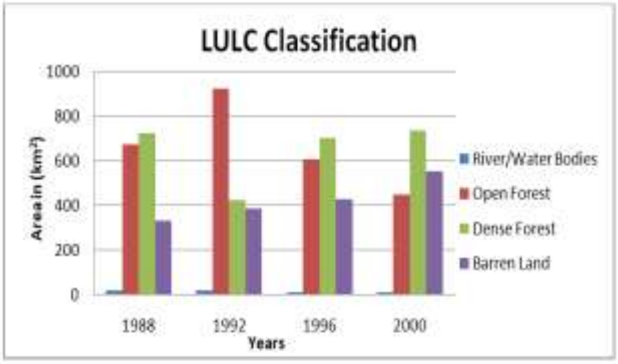


Fig. 8.Area wise Landuse-Landcover comparison

The daily rainfall in the catchment area is studied for 12 year period i.e. from 1988 to 2000.The runoff for the study was calculated using SWAT method and the average monthly stream flow out of the reach was analyzed for the study. The average rainfall depth in the watershed is 3741.25 mm and the average stream flow out runoff and surface runoff is found to be 3843.3 cumecs and 8842.2 mm.

2. SWAT model Calibration and Validation

The main objective of the calibration of the model is to reduce the discrepancy between the monthly stream flow that is measured and that which is simulated in order to match the projected values with a decent goodness of fit.The auto calibration and validation through SUFI2 algorithm of SWAT-CUP software gives results on visual comparison and statistical criteria such as Nash –Sutcliffe Efficiency (NSE), coefficient of determination (R²) and RMSE observations standard deviation ratio (RSR). The monthly calibration results for the year 1988-1997 were found as R²: 0.31, Nash – Sutcliffe Efficiency (NSE): 0.18 and RMSE standard deviation ratio (RSR) 0.91.Again for validation, the available hydrological data was split into two groups (1988-1992) and (1993-1997). The results were found as R²: 0.73, Nash – Sutcliffe Efficiency (NSE): 0.70 and RMSE standard deviation ratio (RSR) 0.55.

Table-1 Monthly Calibration and Validation statistical model results

Statistical Parameter	R²	NSE	RSR
Calibration (1988-1997)	0.31	0.18	0.91
Calibration(1988-1992) & Validation (1993-1997)	0.73	0.70	0.55

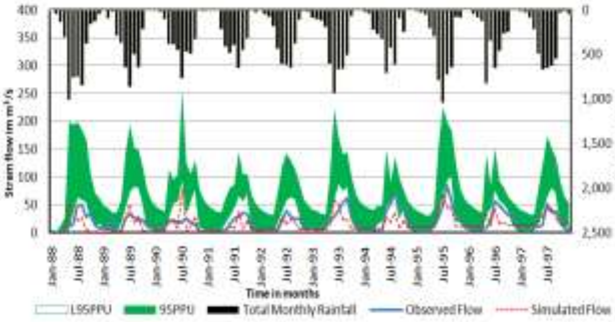


Fig. 9.Monthly Calibration from 1988 to 1997

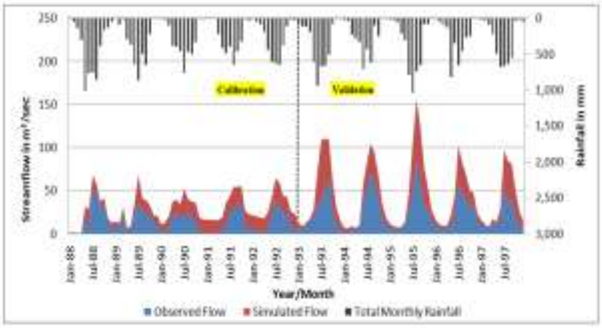
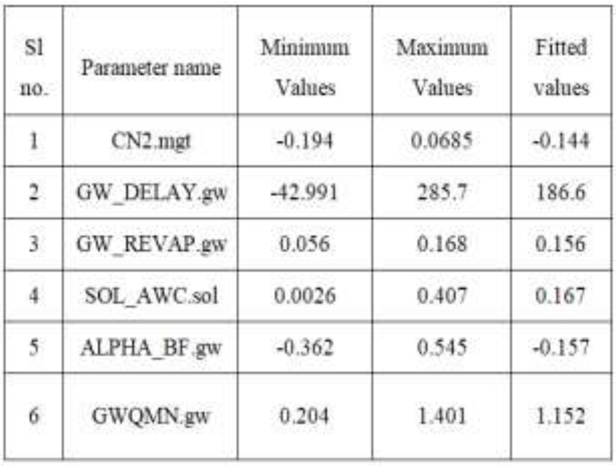


Fig. 10.Monthly Calibration (1988-1992) and Validation (1993-1997)

The above figure 12 and figure13 shows the analogy between the monthly observed flow and simulated flow generated in the SWAT-CUP SUFI2 algorithm with contrast to the respective rainfall. From the Fig 12, we can analyse that the simulated flow is higher than the observed flow .The visual plots from the fig shows that high peaks are underestimated and in numerous events deviation could be clearly seen between the observed and simulated flow. In the year 1995-1996, high amount of runoff can be seen with the highly rainfall event.

Parameter Sensitivity has been performed by SWAT-CUP SUFI2 software using Global sensitivity analysis. The parameters used in the study are SCS runoff curve number (CN2.mgt), Groundwater "revap" coefficient (GW_REVAP.gw), Groundwater delay days (GW_DELAY.gw), Saturated hydraulic conductivity (SOL_AWC.sol), Base flow alpha factor(ALPHA_BF.gw), Threshold depth of water in the shallow aquifer required for return flow to occur (mm) (GWQMN.gw)The results of the sensitivity analysis for most sensitive parameters of the model are listed in Table 2.

Table -2 Most sensitive parameters with calibrated value



Sl no.	Parameter name	Minimum Values	Maximum Values	Fitted values
1	CN2.mgt	-0.194	0.0685	-0.144
2	GW_DELAY.gw	-42.991	285.7	186.6
3	GW_REVAP.gw	0.056	0.168	0.156
4	SOL_AWC.sol	0.0026	0.407	0.167
5	ALPHA_BF.gw	-0.362	0.545	-0.157
6	GWQMN.gw	0.204	1.401	1.152

V. CONCLUSION

Hydrological modeling using SWAT can be done to meet the water requirements for effective agricultural operations and optimal management for sustainable water resources. Using Arc SWAT in GIS, the watershed was delineated and 19 sub watersheds were formed with 188 Hydrological Response units which generated the stream flow from the common watershed outlet point. According to the study, the majority of the area roughly 70% is covered in forest, and it has a mild to steep slope. Both the runoff generated from the surface and stream flow out, is found to be higher than the rainfall amount in the study area. The model was calibrated and validated using the monthly observed stream flow at Kulsi A.T road crossing site for a period of 10 years.

The runoff generated using SWAT was auto calibrated and validated for 10 year period from 1988 to 1992 and 1993 to 1997 using SWAT-CUP SUFI2 process. The average Nash Sutcliffe efficiency (NSE) for monthly calibration and validation was found to be 0.18 and 0.70 respectively. The coefficient of determination (R^2) value for monthly calibration and validation was found to be 0.31 and 0.73 and RSR value for calibration and validation was found to be 0.91 and 0.55 respectively. The result of calibration (1988-1992) and validation period (1993-1997) showsthat Nash Sutcliffe efficiency is 0.70 which is within the acceptable limit although it overestimates the performance during the peak flow and underestimates during lean flow. The R^2 value for the validation period is found 0.73 which is satisfactory.

Based on the findings, we could anticipate that the reason for higher runoff in the study area can be due to inability of the topsoil to retain water with less infiltration and evapotranspiration which allows the storm water to easily flow off downstream areas. This event further leads to erosion and flooding in the lower elevated areas. Overall, the model provides an accurate and quick estimate of created runoff at a specific location. The actual spatial rainfall, temperature, and humidity have not been accurately represented in the model due to the lack of hydrological and meteorological stations in the watershed, which is why the simulated hydrograph deviating from the observed hydrograph.The annual runoff depth can be impacted by any extreme shift in the rainfall regime, especially heavy or low rainfalls brought on by climate change in the study area.When it comes to water flow and availability, the SWAT can be a useful tool for integrated basin management, especially in basins where forests and agricultural lands predominate.This will increase the possibility of irrigation and lead to better agricultural management techniques, which will both directly and indirectly improve people's socioeconomic conditions.

VI. REFERENCE

[1] Abbaspour, K., Johnson, C., & van Genuchten, M. (2004). Estimating Uncertain Flow and Transport Parameters Using a Sequential Uncertainty Fitting Procedure. Vadose Zone Journal, 3(4), 1340-1352. doi: 10.2136/vzj2004.1340

[2] Abbaspour, K.C., 2015. SWAT-CUP 2012: SWAT Calibration and Uncertainty programs-a User Manual. Eawag (Swiss Federal Institute of Aquatic Science andTechnology), Zurich, Switzerland

[3] Arnold, J., Allen, P., Muttiah, R., & Bernhardt, G. (1995). Automated Base Flow Separation and Recession Analysis Techniques. Ground Water, 33(6), 1010-1018. doi: 10.1111/j.1745-6584.1995.tb00046.x

[4] Baishya, B. (2006). MODELLING HYDROLOGICAL COMPONENTS AND IMPACT OF LAND USE/LAND COVER CHANGE ON HYDROLOGICAL REGIME. Andhra University.

[5] Blöschl, G., Sivapalan, M., Wagener, T., Savenije, H., & Viglione, A. (2013). Runoff prediction in ungauged basins. Cambridge [etc.]: Cambridge University Press.

[6] DAS, K., & SARMA, B. (2018). Assessment of Water Demands and Availability of Kulsi River Basin. . International Journal for Research In Engineering Application & Management, 04(05).

[7] Kangsabanik, S., & Murmu, S. (2017). Rainfall-runoff modelling of Ajay river catchment using SWAT model. IOP Conference Series: Earth and Environmental Science, 67, 012033. https://doi.org/10.1088/1755-1315/67/1/012033

[8] Karki, M. (2020). Simulation of Rainfall -Runoff of Kankai River Basin Using SWAT Model: A Case Study of Nepal. International Journal For Research In Applied Science And Engineering Technology, 8(8), 308-326. doi: 10.22214/ijraset.2020.30867

[9] NEITSCH, S., ARNOLD, J., KINIRY, J., SRINIVASAN, R., & WILLIAMS, J. (2022). Soil and Water Assessment Tool User Manual Version 2000.

[10] Schultz G A, (1993). Application of GIS and remote sensing in hydrology. IAHS publication, N.211, pp. 127-140.

[11] Shanbor Kurbah, & Dr. Manoj Kumar Jain. (2017). Rainfall-Runoff Modeling of a River Basin using SWAT Model. International Journal of Engineering Research And, V6 (12). https://doi.org/10.17577/ijertv6is120111

[12] Sharma, S., (2019). Estimation of Runoff for Kulsi River Basin using NRCS Curve Number and Geographic Information System,.

[13] Srivastava, P., Singh, R., Tripathi, S., & Raghubanshi, A. (2016). An urgent need for sustainable thinking in agriculture – An Indian scenario. Ecological Indicators, 67,611-622.doi: 10.1016/j.ecolind.2016.03.015

[14] Williams, J. R., & Hann, R. W. (1978). Optimal operation of large agricultural watersheds with water quality restraints. Texas Water Resources Institute.

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