International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 12 ǁ December 2022 ǁ PP. 54-59

Assessment of Stream flow in Ken River Basin Using SWAT Model

Alok Singh
M.Tech Student
Civil Engineering Department
MANIT, Bhopal
Madhya Pradesh, India

Dr. A.K. Thawait
Assistant Professor
Civil Engineering Department
MANIT, Bhopal
Madhya Pradesh, India

Abstract—*Stream flow is a major component of hydrological cycle which is define as the amount of water flowing in a river. In this research, Soil and Water Assessment tool was used to Hydrological Model the Rainfall-runoff relationship, in a catchment located in the Ken River watershed at* Madhya Pradesh *and Uttar Pradesh, the outlet of Ken River in Banda district, Uttar Pradesh, India. The time series data for 20 years from 2001 to 2020 were used in the Assessment of Stream flow process. A Soil and Water Assessment tool (SWAT) methodology was employed to forecast daily Stream flow and monthly Stream flow as a function of daily precipitation and monthly precipitation. The discharge data of is taken from* Central Water Commission (CWC) *and the precipitation data is collecting from Indian Meteorological Department (IMD). The ARC-SWAT software was chosen for use in the current study. Land use and Land cover Data is downloaded from Esri land cover with the year 2014. Agriculture covered more than 60% of the entire area, followed by forest cover at 27%, according to the land use map for the year 2014. The soil data is taken from FAO Soil data map. Black soil is predominant in Ken watershed. In ARC-SWAT, input data was divided in Two segment (2000-2013), (2014-2020), Calibration and validation purpose respectively. The output from ARC-SWAT was statistically tested with statistical parameters, i.e. Coefficient of Determination (R^2) and Nash Sutcliffe Efficiency (NSE). The model was auto-calibrated and validated using SWAT-CUP software From 2001 to 2020, the model was auto-calibrated using SUFI2. From 2001 to 2013, the observed and model flow were Calibrate and Form 2014 to 2020 is a validate period. The Nash-Sutcliffe Efficiency (NSE) for daily calibration and validation was 0.743 and 0.768, respectively, while the NSE for monthly calibration and validation was 0.731 and 0.782. For daily calibration and validation, the coefficient of determination (R^2) was 0.710 and 0.0736, respectively, and 0.775 and 0.733 for monthly calibration and validation. Overall, the performance of the SWAT model in simulating stream flow at Banda gauging site. In this study, the results obtained show clearly that the Soil and Water Assessment tool are capable of model rainfall-runoff (Stream flow) relationship. The Soil and Water Assessment tool approach could provide a very useful and accurate tool to solve problems in water resources studies and management.*

Keywords—Rainfall-runoff relationship; SWAT-CUP; calibration and validation; Coefficient of Determination (R^2);Nash Sutcliffe Efficiency (NSE).

Date of Submission: 22-11-2022 Date of acceptance: 06-12-2022

I. INTRODUCTION

Fresh liquid water suitable for human. It is can be found in rivers and reservoirs as surface water or in aquifers as ground water Although the total amount of fresh liquid water accessible has stayed constant over time, water demands are growing by the day to day due to population increase, economic development, urbanisation, and other factors. Rainfall patterns will likely be affected by climate change, resulting in increasing volatility and issues in stream flow and water supply management.

The runoff prediction plays an important scientific and practical role in the engineering project and water resource management (Parajka et al. 2013) such as the design and management of the reservoirs. The most valuable and commonly used tool for the prediction of runoff is thehydrological models (Tegegne et al., 2017). The hydrological modelling is mathematical process which represent the hydrologic process and the interaction between them (Gosain and Tanaka, 2009).it is determined by using the input data and the observed stream flow and it also include theparameter which represent the physical properties of the catchment. The model parameter can be calibrated by observed stream flow and model simulations (Edijatno et al., 1999).

The SWAT model was employed for various hydrological applications under several agro-climatic regimes among various physically-based models. The SWAT is a hydrological model that is physically grounded, and semi-distributed having capability of simulating continuously for long periods (Pandey et al., 2016), it was developed by the USDA Agricultural Research Service (ARS) to forecast the effect of activities related to land management on the transport of hydrology, pollutants and sediment in complex, large watersheds (Borah and Bera 2003). Several researchers have tested the SWAT hydrologicmodel for runoff globally (Akiner and Akkoyunlu, 2012; Pandey et al., 2015), sediment load (Xuet al., 2009; Qiu et al., 2012; Himanshu et al., 2017) and nutrient (Gildow et al., 2016; Qiu et al.,2018), who reported that model performance was satisfactory.

The main objectives of the study is to understand the Rainfall-Runoff (stream flow) behavior of the Ken watershed using SWAT model and to find out the most sensitive parameters which are critically responsible for the hydrologic response with pre-defined conditions. The model simulation is performed using the gridded meteorological data from IMD of 0.25o X 0.25o resolution, Land use Land Cover Grid derived using Supervised classification of (ESRI), soil data taken from FAO soil map with spatial resolution 1:150000 and the model run for the period of 20 years (2001-2020). SWAT-Calibration and Uncertainty Programs Sequential Uncertainty Fitting (SUFI2) was used for calibration and validation of the model. Calibration was carried out for the period of 13 years (2001-2013) where a set of parameters commonly responsible for basin Hydrologic response in Indian conditions were used for model adjustment. Validation was also carried out for the period of 7 years (2014-2020) in order to verify the response of the basin using the calibrated fitted values. The model performance and evaluation however was analyzed using the statistical parameters such as Nash Sutcliffe Efficiency (NSE) and coefficient of determination (R^2).

II. STUDY AREA

A. *Ken Basin*

The Yamuna is the peninsula India's fourth largest south-flowing river. The Ken River is a tributary of the Yamuna. It rises at an elevation of around 82 metres above mean sea level from the Ahirgawan village in the Kaimur hills (northwest slopes) in the Jabalpur district of Madhya Pradesh (MP) (msl). The Ken River is a prominent river in central India's Bundelkhand area, flowing through the states of Madhya Pradesh and Uttar Pradesh. Between the Kaimur hill range, the river travels through Madhya Pradesh and Uttar Pradesh. The river is 427.2 kilo- metres long from its source to its confluence with the Yamuna. It flows for 292.1 kilo- metres (181 miles) in Madhya Pradesh, 84 kilo- metres (52 miles) in Uttar Pradesh, and 51.1 kilometres (32 miles) between the two states out of a total length of 427.2 kilometres (265 miles). Kali, Alona, Shyamari, Mir Hasan, Bearma, Sonar, Urmil, Kutri, Banne, and Chandrawal are some of the Ken River's major tributaries. The study area is located along the Ken River, which is part of the Yamuna River's sub-basin in Madhya Pradesh and Uttar Pradesh, India. The Ken sub-basin areas come under the Bundelkhand region. This study area lies between longitude 78o 30'57" and 80o 37'53" latitude 23o 08'03" and 25o 53'15". Banda gauge station, which covers a catchment area of roughly 28739.063 square kilo- metres, of which 24849 square kilometers are in MP and the remainder 3890.63 square kilo- metres are in UP, is located at the catchment's outlet. The gauge station code NCA Banda GDQ site of the Central Water Commission (CWC) situated in Banda (UP) at The minimum and maximum elevation range is from 82 m to 752 m. The location of study area is shown in Fig. 1.

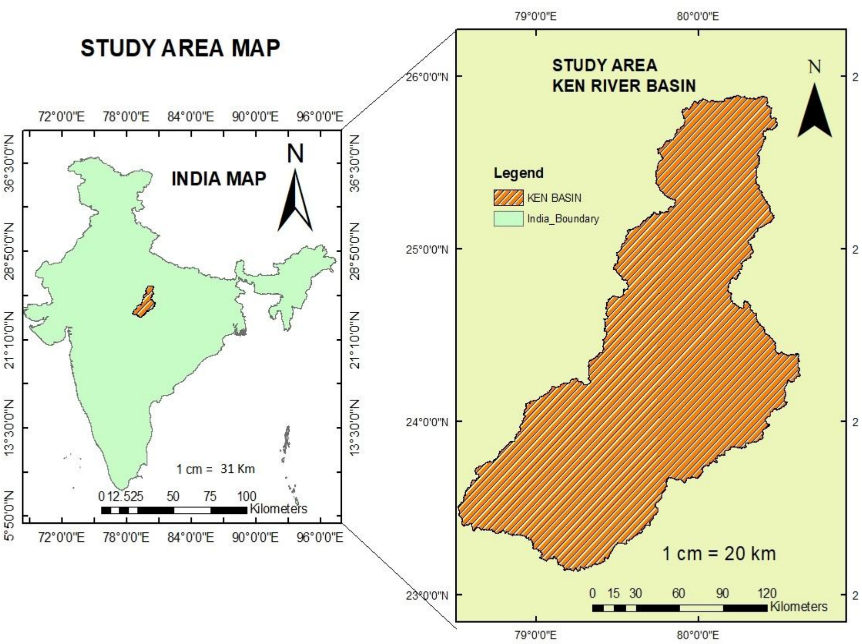

Fig. 1 -Location Map of the study area

B. Climate

The research area of Ken river watershed, Banda is outlet point, district-Banda (UP). The basin's climate is dry and tropical, while extremes of heat and cold are common in some areas. The warm weather begins in March and lasts until the middle of June. The month of May is frequently the hottest. This season is generally dry.

C. Rainfall Pattern

The monsoon season lasts from the middle of June until the end of September, with an average annual rainfall of 934.2 mm. The month of July is usually when the most rain falls. In the Ken Watershed, total 39 IMD grid found. Here, I am used the IMD grided data. **{**Himanshu et. al., (2016)}.

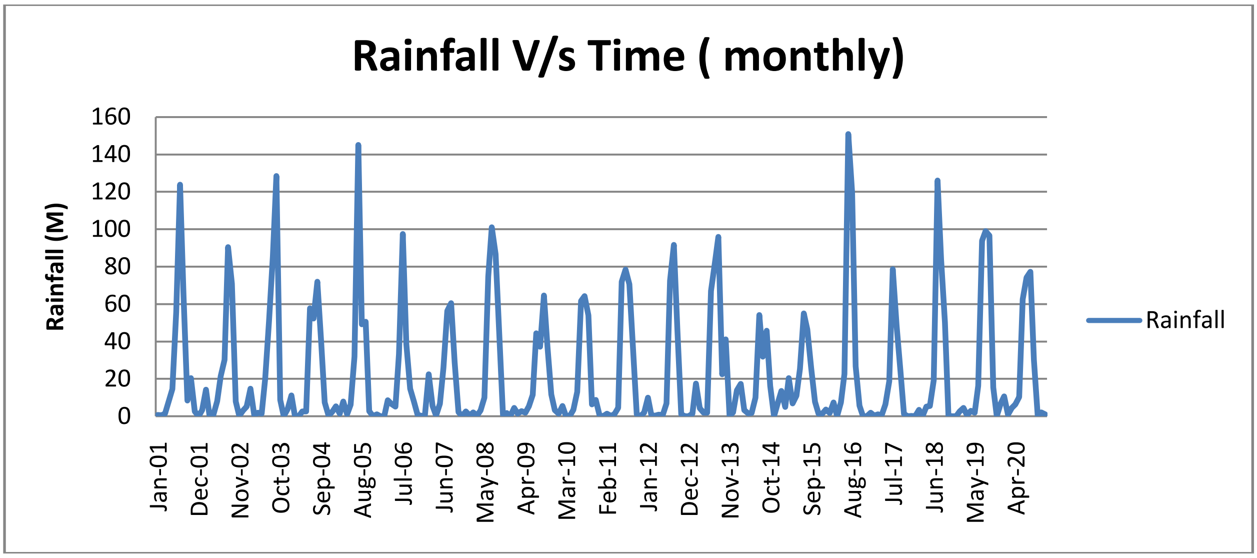

Fig.2 :Avg. Rainfall(monthly) v/s Times (Source-IMD)

C. Temperature

In the winter, the mean daily maximum temperature ranges from 12.3oC to 26.9oC, while in the summer, the mean daily minimum temperature ranges from 23oC to 46.8oC. Maximum and Minimum temperature 1° × 1°daily data from IMD from 2001-2020.

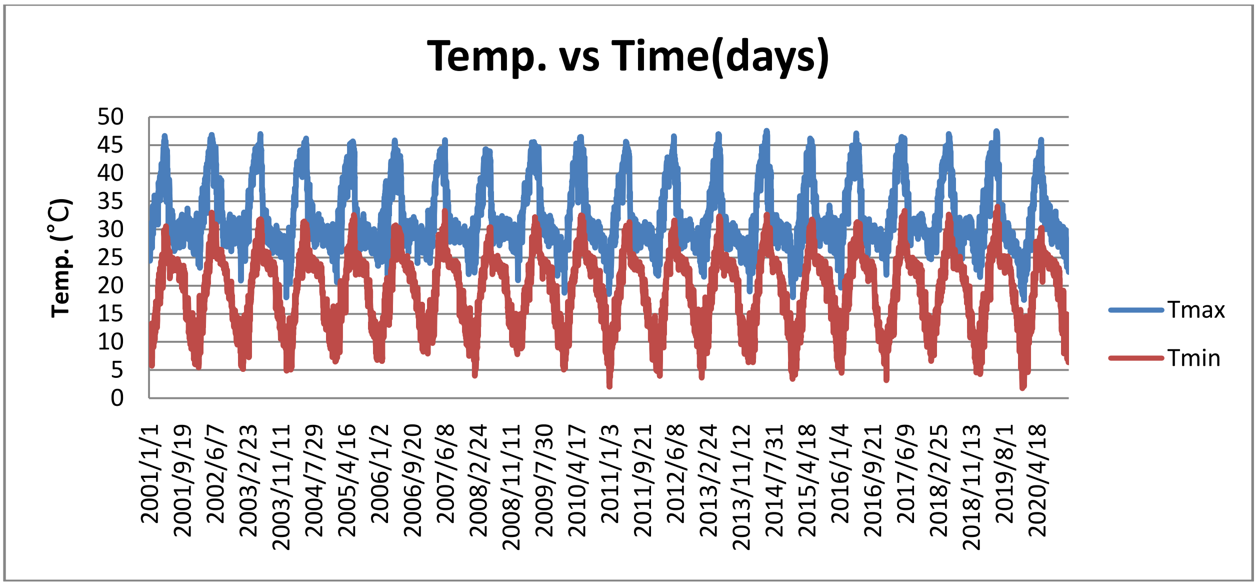

Fig. 3 -Daily mean temperature (2001-2020)

D. Land Use/ Land Cover

The land use of Ken watershed in 2014 shows that the cultivable lands dominate with 60% coverage, followed by forest cover with 22.3% stretch, 5.4% area under scrub/pasture and barren/rocky and remaining 1.13% of the total area comes in wetland and 7% Vegetation. The Land use and Land cover data is downloaded by ESRI with 10m resolution. LULC map of Ken river Basin is shown in Fig 4

Table 1 : LULC class Table of KEN watershed

Sr. NO.	Area of types of LULC(M2)	Types of LULC	SWAT code for LULC	% of Area of land cover
1	325918734.1	WATERBODY	WATR	1.134039344
2	2172681368	VEGETATION & GRASS	FRSD	7.559878877
3	17491183037	CROPS	AGRL	60.86084556
4	784384646.9	BUILT-UP AREA	URML	2.729278674
5	7965464201	HILLS & Forest	SWRN	27.71595755
Total	28739631987			100

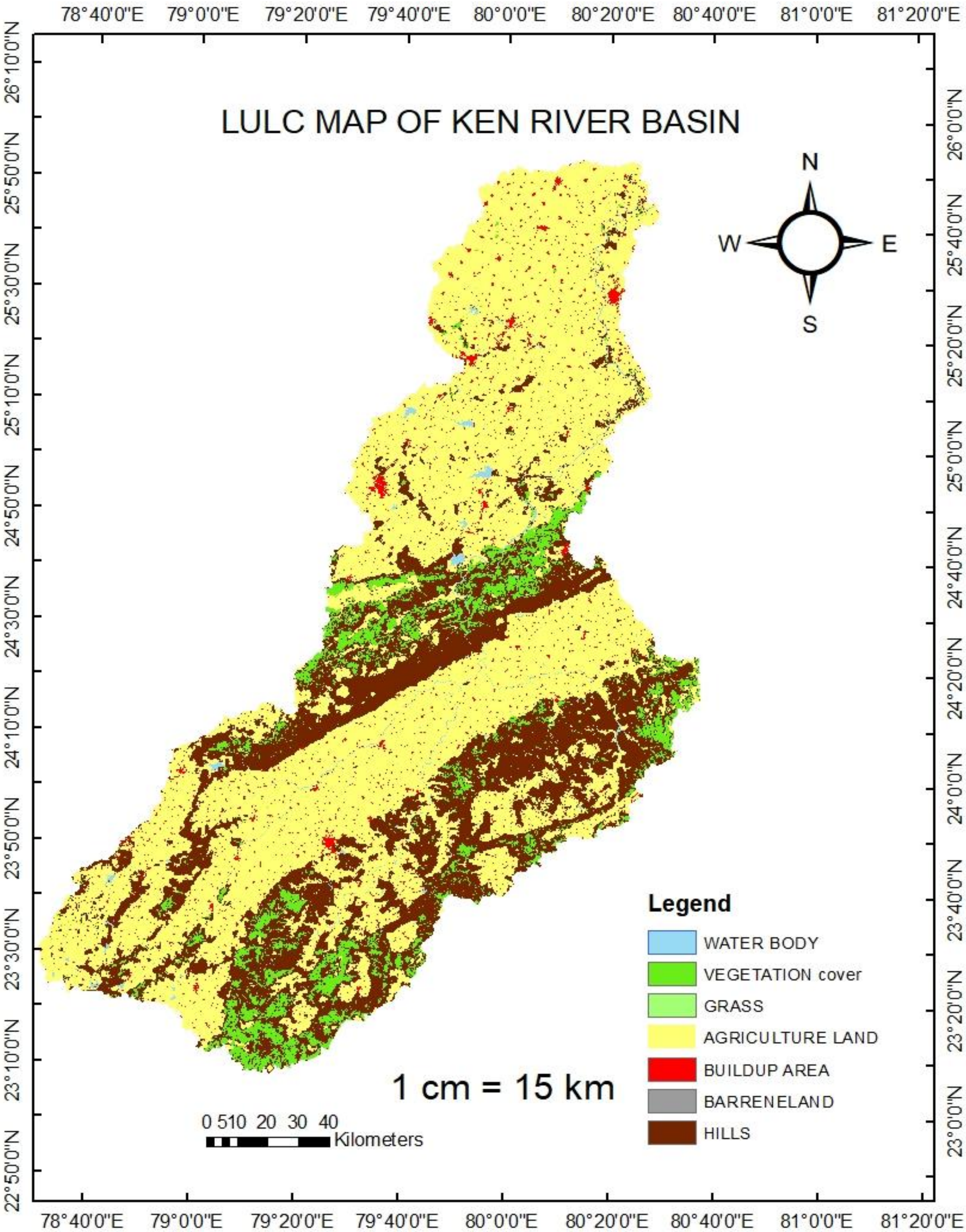

Fig. 4 - Basin LULC Classes

E. Soils

The available information on soil survey conducted in the Ken basin indicates that medium black cotton soils are predominant in the basin. The coastal plains are composed of alluvial clays with a layer of black soil on top. Mostly the soil is lighter, open and drained. This Data is taken from FAO data . The soil texture on the Ken River basin is shown in fig. 5

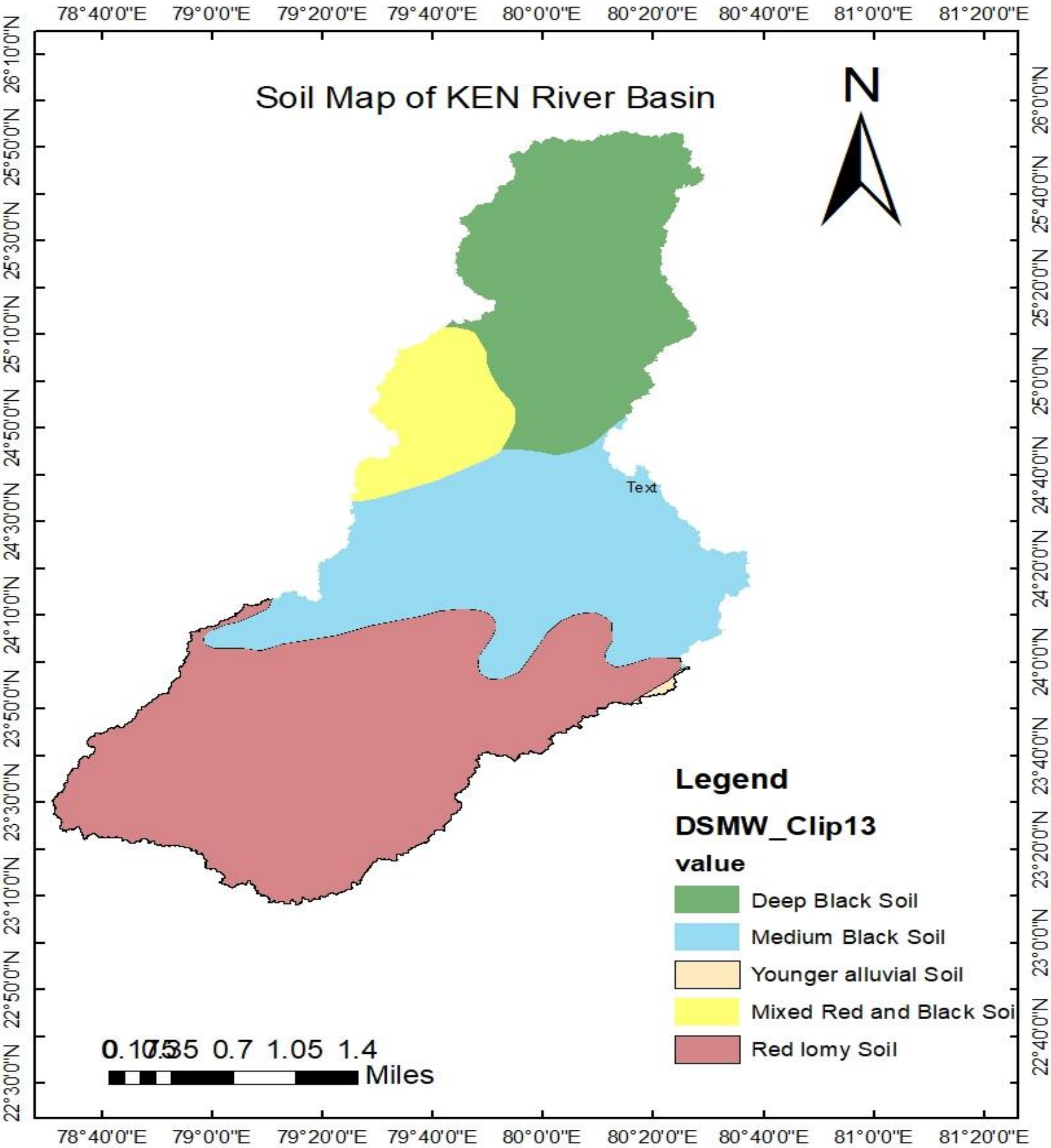

Fig. 5 - Basin Soil Classes

III. METHODOLOGY

The SWAT model was employed for various hydrological applications under several agroclimatic regimes among various physically-basedmodels. The SWAT is a hydrological model that is physically grounded, and semi-distributed having capability of simulating continuously for long periods (Pandey et al., 2016), it was developed by the USDA Agricultural Research Service (ARS) to forecast the effect of activities related to land management on the transport of hydrology, pollutants and sediment in complex, large watersheds (Borah and Bera 2003). Several researchers have tested the SWAT hydrologicmodel for runoff globally (Akiner and Akkoyunlu, 2012; Pandey et al., 2015), sediment load (Xuet al., 2009; Qiu et al., 2012; Himanshu et al., 2017) and nutrient (Gildow et al., 2016; Qiu et al.,2018), who reported that model performance was satisifactory.

A. Surface Runoff

SWAT simulates peak runoff rates and surface runoff quantities for each HRU by changing thethe Green & Ampt infiltration method or soil conservation service curve number (SCS-CN), respectively (Neitsch et al., 2005). The SCS-CN method has been utilized in the present study.

Natural Resources Conservation Service Curve Number method (USDA–SCS 1972):

For each HRU, SWAT simulates peak runoff rates and surface runoff volumes using a modification to the Green & Ampt. infiltration method or soil conservation service curve number (SCS-CN) (Neitsch et al., 2005), respectively. In the present analysis the SCS-CN approach was used.:

$Q = \frac{(P-0.3S)^2}{(P+0.7S)}$ ………………….. For all soil regions

$Q = \frac{(P-0.1)^2}{(P+0.9S)}$…………………….... For black soil regions

WhereQ is the daily surface runoff (mm),P is the daily rainfall (mm) &s is a retention parameter.

S, the retention parameter, that varies across watersheds because all differ in soil, land use, management, and slope, and in time due to soil water content changes. The variable s is relatedto CN by the SCS equation

$$S = \frac{25400}{CN} - 254$$

Using a modified version of the SCS-CN system (Neitsch et al. 2005), SWAT simulates surfacerunoff volumes for each HRU and peak runoff levels using a modified logical system.

B. Evapotranspiration

The evapotranspiration is estimated in SWAT using three options; (i) Priestley–Taylor (Priestley and Taylor 1972), (ii) Penman-Monteith (Monteith 1965) and (iii) Hargreaves (Hargreaves et al. 1985). In the present analysis, the combination of the CN method for run-offestimation and the ET with the Penman-Monteith method is used as this is the best combinationto estimate evapotranspiration and run-off (Kannan et al. 2007).

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$

Where *λET* is the latent heat flux density (MJ m-2 d-1), Rn is the net radiation (MJ m-2 d-1), Δ is the slope of the saturation vapor pressure-temperature curve, E is the depth evaporation rate (mm d-1), G is the heat flux to the ground (MJ m-2 d-1), cp is the specific heat at constant pressure (MJ m-2 oC-1), ρair is the density of air (kg m-3), rs is the canopy resistance of plants (s m-1), ra is the aerodynamic resistance (s m-1), eo is the vapor pressure of air at saturation at height z (kPa), es is the water vapor pressure of air (kPa), and γ is the psychometric constant (kPa oC-1).

c. *Flow Routing*

Using the variable storage coefficient method (Williams 1969), or the Muskingum method (Chow 1959), the flow routing in the river channels is computed. In the present study, the variable storage coefficient method is used.

IV. DATA SETS AND MODEL SETUP

Hydrological modeling of the river basin requires certain types of data before simulation: spatial and non spatial data. model requires spatial data like DEM, SOIL MAP, LULC MAP, and METEOROLOGICAL DATA. The DEM of the study area was downloaded from https://earthexplorer.usgs.gov/, where elevation data at 30 m resolution acquired through shutter radar topographic mission (SRTM) is available for the globe. To get the DEM of the study area, the original DEM (Figure 6) is projected into an appropriate projection system like Asia North Lambert Conformal Conic having a datum of D_WGS_1984_44_N and clip by mask. LAND USE LAND COVER MAP was prepared from ESRI images using the Supervised classification having cell size of 30 m. SOIL MAP with spatial resolution of 1:50,000 was obtained from FAO Soil map (Figure 5).

Other than the spatial datasets requirement,extensive non-spatial datasets are required as well for better simulation. Daily gridded Meteorological data such as temperature, precipitation, wind speed, relative humidity, solar radiation were obtained from the Reanalysis climate model, daily ranfall and temperature data taken from IMD grided data and other data is taken from MERRA (NASA Prediction of Worldwide Energy Resource (POWER)) of the resolution of 0.5º X 0.5º. The discharge data in the present study was measured originally at the site in Ken, Banda District of Uttar Pradesh maintained by the Central Water Commission. The daily data was obtained from Center Water Commission (CWC) for the period of 20 years (2001 to 2020). The input projected DEM is selected firstly along with providing existing stream network for stream definition. The watershed is defined by selecting the major outlet point, which is followed by the definition of the watershed. Also, The watershed is defined by selecting the major outlet point with the area 28454.54 km^2, which is followed by the definition of the watershed Sub-basin map was generated with SWAT equipped with ARCGIS. After providing the research area's demographics and establishing the outflow point, sub-basin parameters were calculated, resulting in the construction of 21 sub-basins with varying elevations and percentages of land use categories. The smallest sub-basin created was km^2 and the largest sub-basin created was of km^2. After delineating the watershed, it showed that there are 27 sub-basins in the study area and the complete area of the watershed constitutes about 43842.34 Km^2. From the topographic report obtained after watershed delineation, found that the min and max elevationare 85m and 1368m respectively with a mean elevation of about 510.65m. whereas 90% of thearea lies below 728m.Then for the HRU analysis, the Land use, soil and slope maps are defined with 5 classes for Land use as discussed earlier, soil map has 6 classes (Table 4.) and slope map with 5 slope classes extending from 0-10%, 10%-20%, 20%-30%, 30%-50% & 50%-9999%. HRU has beendefined and after the process, it is found that there are 1123 HRU's formed in the watershed and the land use/soil/slope class details were given a The steps consist of:

1. New project setup in SWAT.
2. Watershed delineation in which stream network is burned in. Outlet point is selected.
3. HRU Analysis i.e. HRU definition and analysis of the reports.
4. Write SWAT input tables.
5. Edit SWAT input.
6. SWAT simulation run

The model was created using ARC-SWAT 2012 and ARCGIS 10.5.SWAT. After the simulation of the runoff from the SWAT model, calibration and validation is carried out using SWAT-CUP. The SWAT-CUP method (SWAT Configuration and Uncertainty Procedures) is a software that interfaces with ArcSWAT to calibrate, test, and it assess the sensitivity of the SWAT model. Itwas designed to provide more versatility and efficiency to the SWAT model configuration to face the limitations of ArcSWAT configuration functions in the ArcGIS environment. The application's benefit is thus the ability of it to include a wide variety of functions and broader and accommodating interfaces for model parameterization, calibration, and validation. The methodology for the process of soil erosion modelling using SWAT is given in the Fig-in the form of a flow chart.

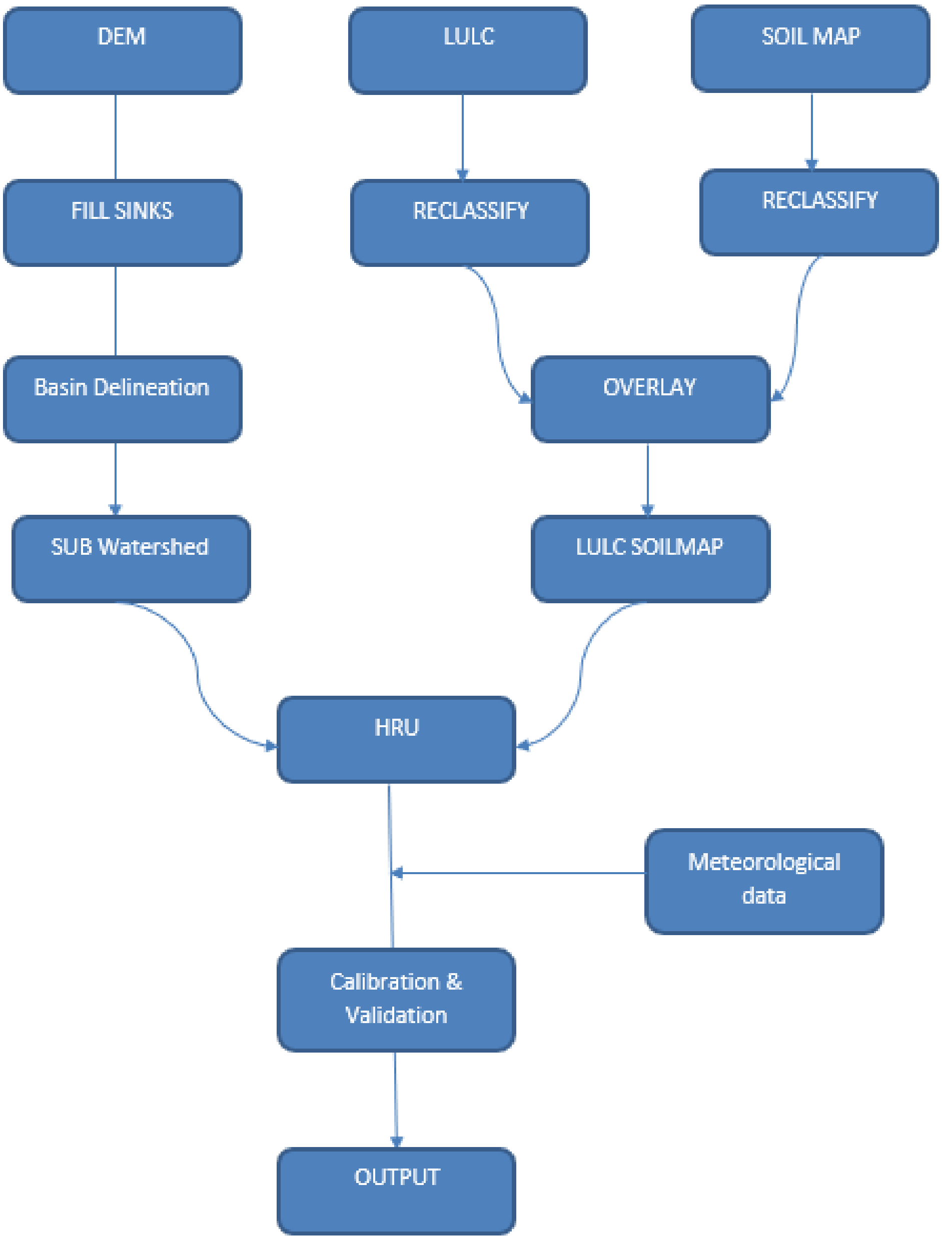

Fig -5 Flow chart for the methodology of SWAT

V. ANALYSIS AND DISCUSSION OF RESULTS

SWAT-CUP (SWAT Calibration Uncertainty Procedures) Is a calibration computer software for the SWAT versions. SWAT-CUP is a software for the public domain, which is free to use. The software ties SWAT procedures to GLUE, parasol, SUFI-2, MCMC, and PSO. It makes an overview of the SWAT model's sensitivity, calibration, validation, and uncertainty. A more efficient SWAT edit system is provided in the new version of SWAT-CUP in which all SWAT parameters are allowed to handle that includes rotation management and different soil layers, precipitation data, etc. 20 parameters placed at the end of their program is allowed by the users which linked into SWAT. Parallel processing is included in SWAT-CUP, using Bing Map outlet position visualization, multi-objective feature development, extraction, and calculation of 95 PPU for all variables in output.ric, output.sub, output.hru files without measurements, and one-on-a-time sensitivity analytics. The testing and validation of the software were performed using SWAT CUP. The sensitive analysis was performed to determine the most important parameters for model calibration. The important parameters were adjusted automatically using the algorithm Sequential Uncertainty Fitting (SUFI-2) (Abbaspour et al. 2007).

In the present study, analysis has been carried out at daily and monthly time steps. Observed data from 2001 to 2020 has been used for calibration of parameters of the model and the performance of the calibrated model has been validated using independent data set from 2014 to 2020. SUFI-2 is based on iterative process which will narrow the parameter value after each iteration process. Each iteration process was set up to 400 simulations. During each iteration, all the statistical coefficients can be calculated at each time and after the number of time the iteration was set, the best simulation can be shown in the output results that will be the best statistical coefficient result. Parameter uncertainty in SUFI-2 accounts for all sources of uncertainties such as driving variables (e.g. rainfall), conceptual model, parameters and measured data (Abbaspour et al. 2004). Pfactor and d factor have been used to evaluate the strength of calibration and uncertainty measures in addition to Coefficient of correlation (R^2)) and Nash–Sutcliff Efficiency (NSE) (Abbaspour et al. 2007). For ideal condition, the P-factor should tend towards 1 and have a d-factor close to 0. When acceptable values of P-factor and d-factor are reached, then the parameter uncertainties are in the desired parameter ranges. Coefficient of correlation (R^2) could be calculated using Equation 9.

$$R^2 = \left(\frac{\sum_{i=0}^{n} \left(Y_i^{obs} - Y_{mean}^{obs}\right)\left(Y_i^{sim} - Y_{mean}^{sim}\right)}{\sqrt{\sum_{i=1}^{n} \left(Y_i^{obs} - Y_{mean}^{obs}\right)^2} \sqrt{\sum_{i=1}^{n} \left(Y_i^{sim} - Y_{mean}^{sim}\right)^2}} \right)^2$$

where Yi obs is the ith observed data,Ymean obs is the mean of observed data,Yi sim is the ith simulated value,and Ymean sim is the mean model simulated value.

Table 2: Statistical (R^2) Parameter Performance Rating (Source- Kurbah et al-2017)

Performance rating	R^2
Very good	$R^2 > 0.70$
Good	$0.60 < R^2 \leq 0.70$
Satisfactory	$0.50 < R^2 \leq 0.60$
Unsatisfactory	$R^2 < 0.50$

$$E_{NS} = 1 - \left[\frac{\sum_{i=1}^{n} \left(Y_i^{obs} - Y_i^{sim}\right)^2}{\sum_{i=1}^{n} \left(Y_i^{obs} - Y_{mean}^{obs}\right)^2} \right]$$

where Yi obs is the ith observed data,Ymean obs is the mean of observed data,Yi sim is the ith simulated value,and Ymean sim is the mean model simulated value.

Table 3: Statistical (NSE) Parameter Performance Rating (Source- Kurbah et al-2017)

Performance Rating	NSE
Very good	0.75 < NSE ≤ 1.00
Good	0.65 < NSE ≤ 0.75
Satisfactory	0.50 < NSE ≤ 0.65
Unsatisfactory	NSE ≤ 0.50

A. SWAT model calibration and validation

The “SWAT model was first set up on the basis of daily data and monthly data, as described in the previous chapter. The original model run lasted ten years, from 2001 to 2020. The preliminary simulated stream flow results were compared to actual (observed) stream flow from the ken basin's Banda gauge.

The model simulated flow being greatly underestimated as compared to observed flow despite the occurrence of a rainfall event. This could be the reason of high infiltration and low soil water content in post-monsoon land use land cover (agriculture land covers roughly 60 percent of total area).
When there is persistent high rainfall, the model anticipates high runoff, which is seen to be steadily retreating in the brown circle. This suggests that basin characteristics such as slope (80% area coverage for slopes ranging from 0 to 10%) may play a role in obtaining such a hydrological response. Similarly, the green circle indicates that high rainfall events result in large runoff computation. This could explain why rainfall data is inaccurate since it was estimated using gridded meteorological data with a coarse resolution, which can be improved if observed station data sets are available.

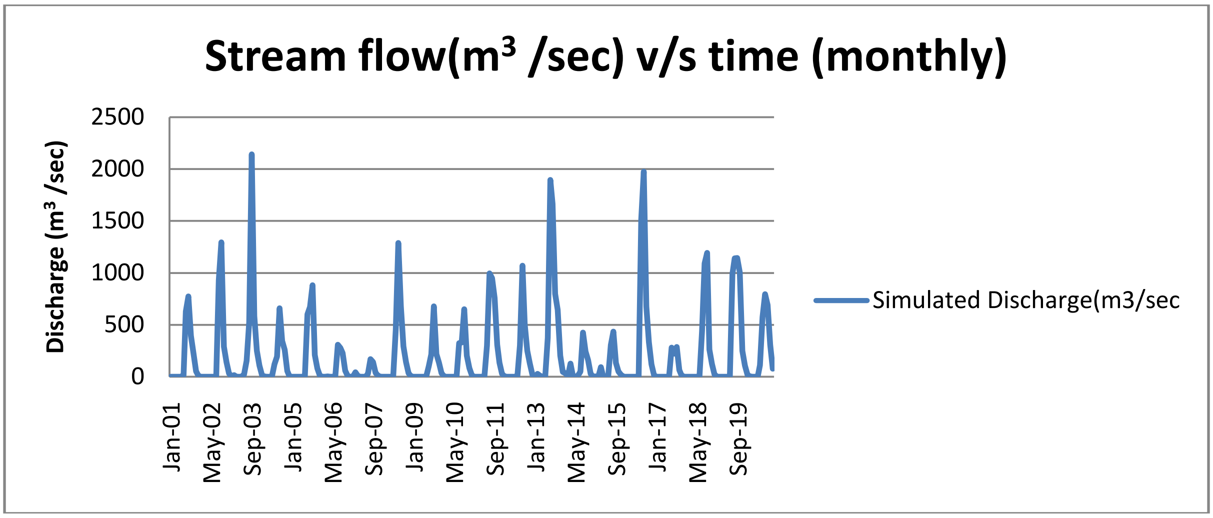

Fig. 5.6 – Monthly Stream flow from 2001 to 202

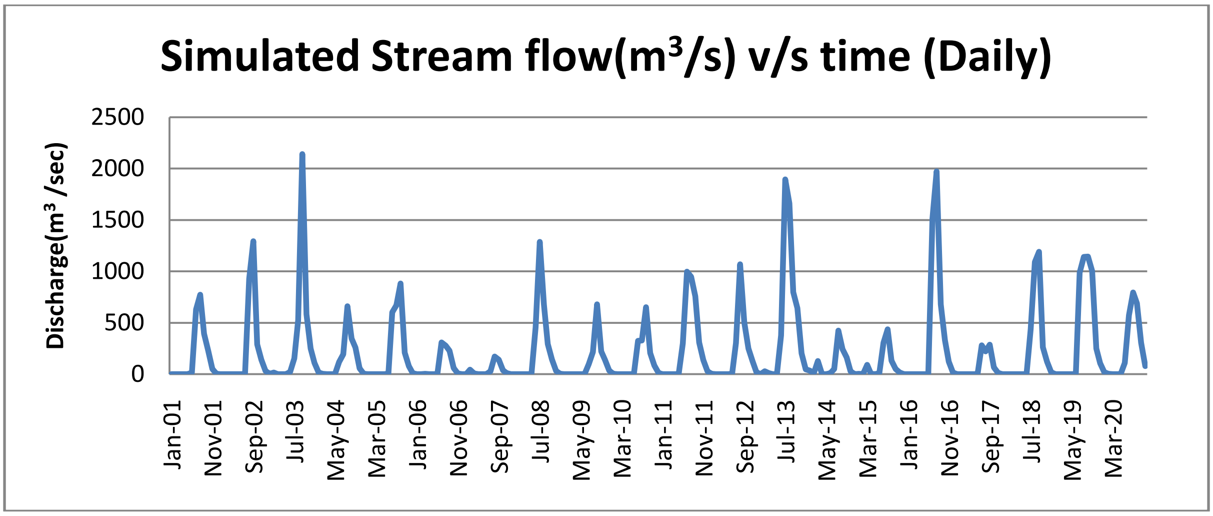

Fig. 5.7- Daily Stream flow v/s Times

For the calibration and validation periods, plots of observed and model estimated monthly runoff have been prepared, which are presented in Figures 5.4 and 5.5. Because averaging of the data compromised all the basin factors necessary for hydrological response, the visual match between observed and computed values is better than daily simulated runoff values, as can be seen from plots of monthly runoff values.

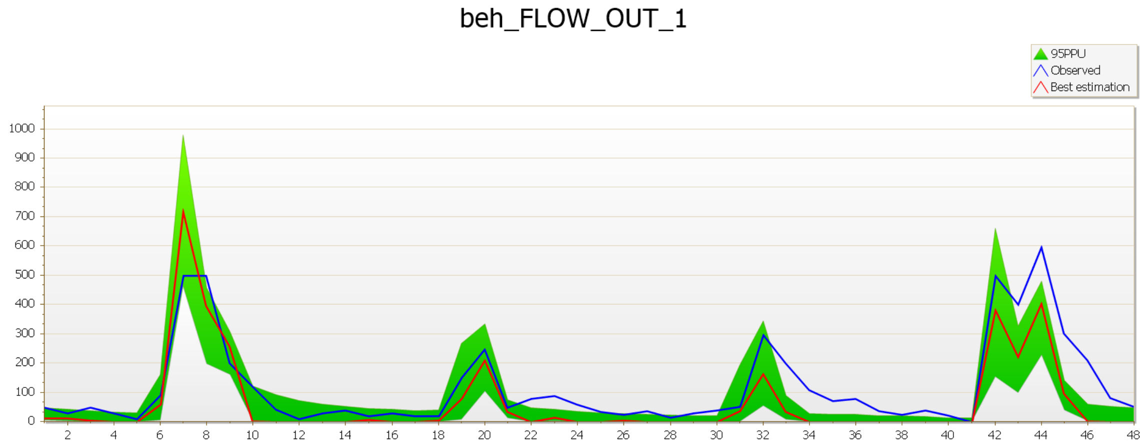

Fig. 5.8 – Monthly calibration from 2001 to 2013

Fig.5.8 – Monthy calibration from 2001 to 2013

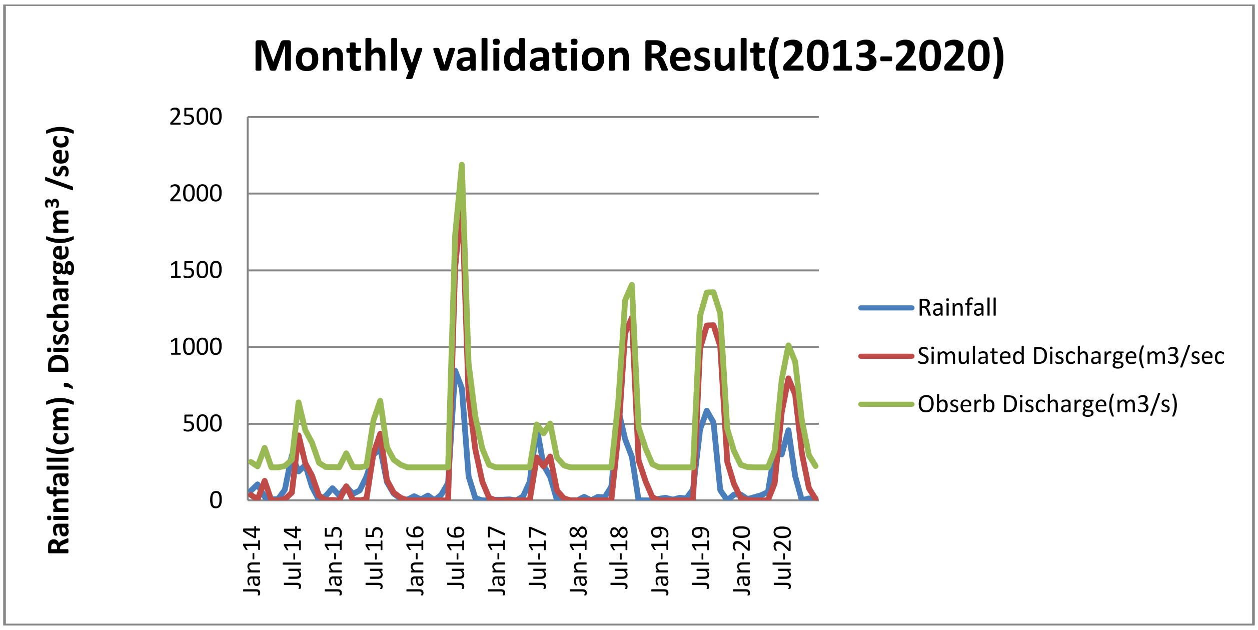

Fig. 5.9 – Monthly validation from 2013 to 2020

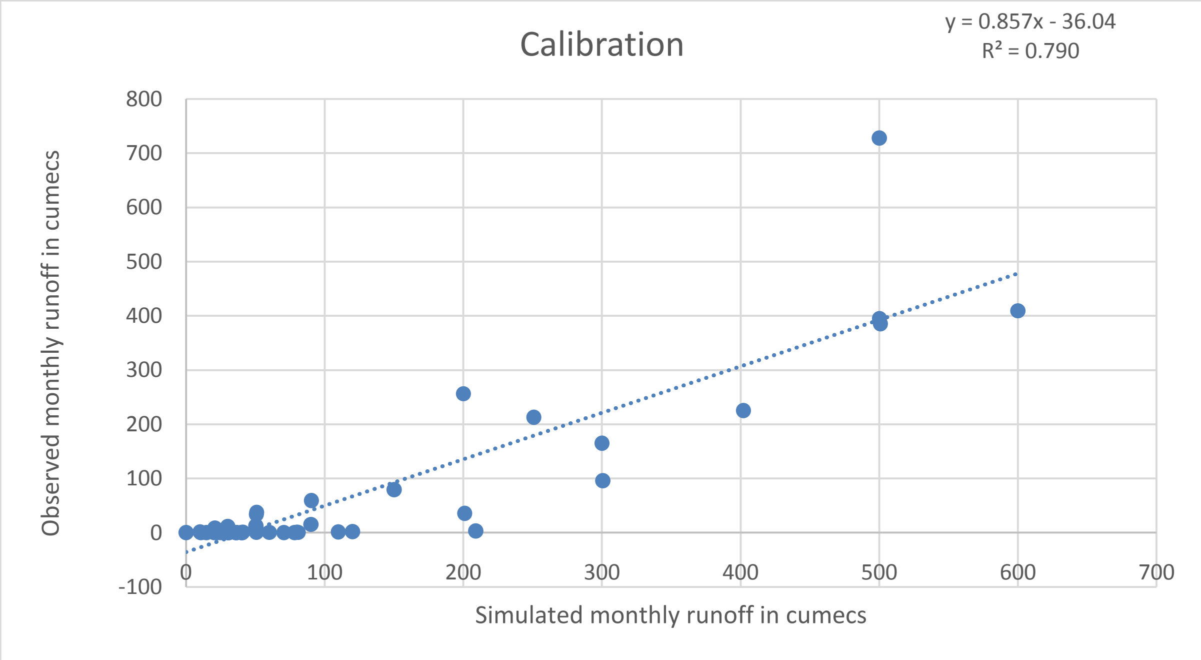

Fig. 5.10 – Monthly validation from 2013 to 2020

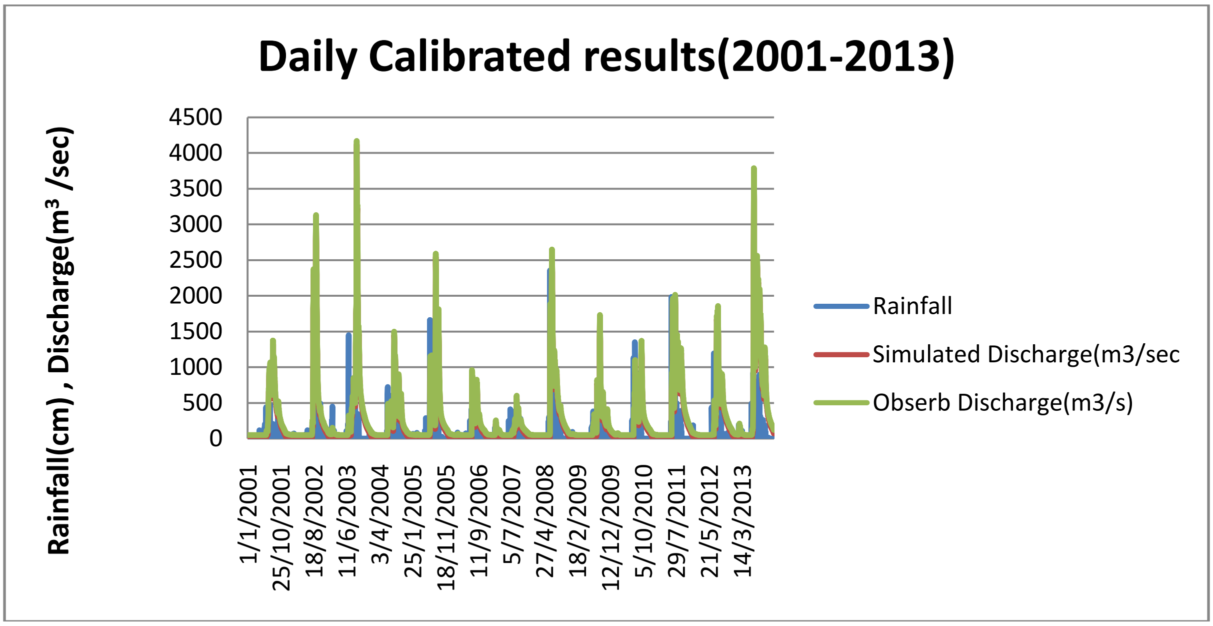

Fig. 5.11 – Daily calibration from 2001 to 2013

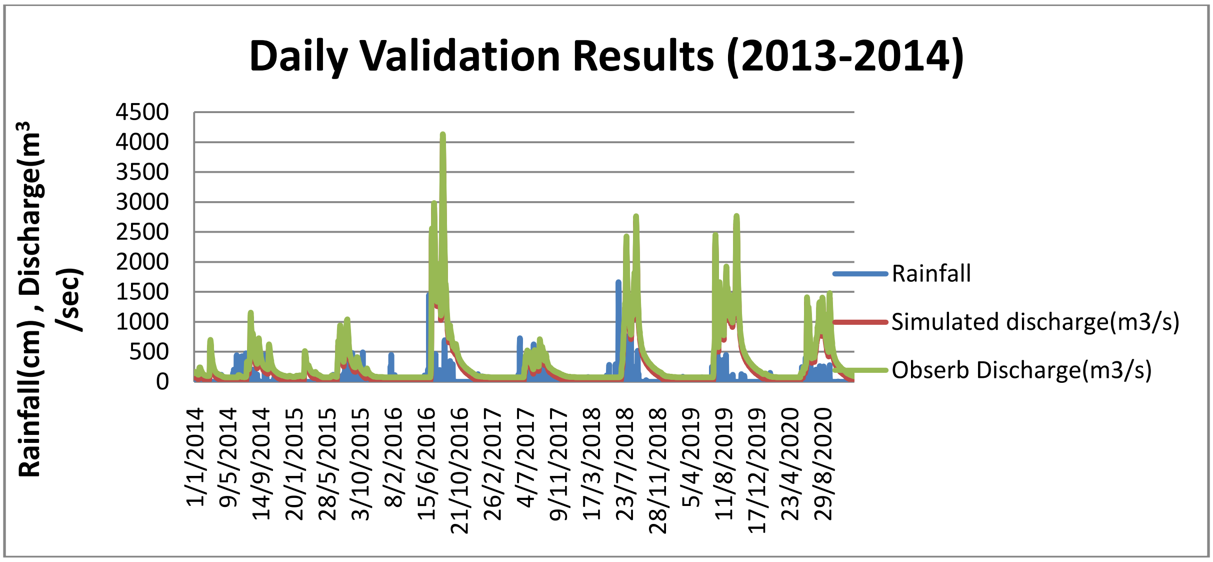

Fig.5.12 – Daily Validation from 2013 to 2020

Tables 5.8 and 5.9 show the results of statistical evaluation criteria used to check model performance for daily and monthly periods, respectively. The model's performance can be classified as very good based on the performance evaluation criteria listed in Table 4.5, as can be seen from these tables.

Table 4 : Daily calibration and validation statistical model results

Statistical Parameter	R^2	NSE
Calibration (2001-2013)	0.710	0.743
Validation (2013-2020)	0.736	0.768

Table 5 : Monthly calibration and validation statistical model results

Statistical Parameter	R^2	NSE
Calibration (2001-2013)	0.775	0.731
Validation (2013-2020)	0.733	0.782

As Table 5.1, the results is satisfactory to good . As a result, SWAT can be a useful tool for integrated basin management in terms of water flow and availability, especially in basins with a high concentration of agricultural crops. This will increase the potential for irrigation and better agricultural management methods, hence improving people's socioeconomic conditions both directly and indirectly.

5.6 SENSITIVITY ANALYSIS

For the sensitivity analysis in the process of determining the key parameters governing the hydrological process for streamflow computation represented by the SWAT model, a set of parameters were utilised. These parameters were identified and selected by referring from relevant studies carried (Cao et al. 2006; Khan et al. 2014; Kushwaha et al. 2013; Jain et al. 2014; Manaswi et al. 2014; Singh et al. 2013) and SWAT technical documentation (Neitsch et al. 2002). Parameter sensitivity has been performed by SWAT CUP SUFI-2 software using Globalsensitivity analysis. The parameters used in the study area were
CN2.mgt-- SCS runoff curve number
ALPHA_BF.gw- Baseflow alpha factor (1/days)
GW_DELAY.gw- Groundwater delay
GWQMN.gw- Threshold water depth in shallow aquifer required for return to reach occur.
In Table 5.3 ,Results of sensitivity analysis for most sensitive parameters of the model are listed

Table 6: Most sensitive Parameters with calibrated values in SWAT_CUP

Parameter	Minimum Value	Maximum value	Fitted Value
CN2.mgt	-0.2	0.2	-0.12
ALPHA_BF.gw	0	1	0.54
GW_DELAY.gw	20	120	73.8
GWQMN.gw	80	900	523.8

CN2.mgt – adjustment by Relative method is used for model parameter

VI. CONCLUSIONS

The Ken River is one of the important tributary of the lower Yamuna basin located in the state of Madhya Pradesh and utter pradesh. As per the study conducted it is found that most of its area is covered with agricultural land (more than 60%) and possess mild slope and less forested area. In order to meet the maximum and efficient water requirement for proper agricultural practices and productivity, proper planning for sustainable management of water resources can be carried out using Hydrological model like SWAT. The model was calibrated and validated using the daily observed stream flow at Banda gauging site for a period of 20 years. The model was auto-calibrated using SUFI2 from 2001 to 2013. The validation for observed and simulated flow was from 2014 to 2020. From 2001 to 2020, the model was auto-calibrated using SUFI2. From 2001 to 2013, the observed and model flow were validated. The Nash-Sutcliffe Efficiency (NSE) for daily calibration and validation was 0.593 and 0.718, respectively, while the NSE for monthly calibration and validation was 0.731 and 0.782. For daily calibration and validation, the coefficient of determination (R2) was 0.510 and 0.646, respectively, and 0.627 and 0.709 for monthly calibration and validation.

Maximum and minimum temperatures are collected as 1.0 x 1.0 grided(IMD) data, and rainfall data is taken as 0.25 x 0.25 Grided (IMD) data. As a result, we use low grid data for high accuracy. Therefore, SWAT can be an important tool for integrated basin management with respect to water flow and its availability where the significant factor lies with the basin dominated with Agriculture fields. This will bring the potential for irrigation and better agriculture management practices and directly and indirectly helps in improving the socio-economic life of the people.

REFRENCES

[1]. Abeysingha N.S. , Singh Man , Sehgal V.K. , Khana Manoj AND Pathak Himanshu(2014), are published the paper on Analysis of Rainfall and Temperature Trends in Gomti River Basin in Journal of Agricultural Physics Vol. 14, page no- 57

[2]. Abbaspour, KC (2007), 'User Manual for SWAT-CUP, SWAT Calibration and Uncertainty Analysis Programs. Swiss Federal Institute of Aquatic Science and Technology,Eawag,Du¨bendorf,Switzerland, http://www.eawag.ch/organisation/abteilungen/siam/software/swat/index_EN

[3]. Abbaspou K.C. (2015), A continental-scale hydrology and water quality model for Europe: Journal of Hydrology, pp 524.

[4]. Arnold, JG, Srinivasan, R, Muttiah, RS & Williams, JR (1998), 'Large area hydrologic modeling and assessment, Part I: model development', J. Am. Water Resour. Assoc, vol. 34, no. 1, pp. 73–89.

[5]. Anil N.C., Sankar G.Jai, Rao M. Jagannadha, Prasad I.V.R.K.V. and Sailaja U.(2011), Studies on Land Use/Land Cover and change detection from parts of South West Godavari District, A.P – Using Remote Sensing and GIS Techniques in J. Ind. Geophys. Union , Vol.15, No.4, pp.187-194

[6]. Al-Bakri J., Al-Jahmany Y., (2013) "Application of GIS and Remote Sensing to Groundwater Exploration in Al-Wala Basin in Jordan" Journal of Water Resource and Protection, 5:962-971.

[7]. Arnold, JG, Srinivasan, R, Muttiah, RS & Williams, JR (1998), 'Large area hydrologic modeling and assessment, Part I: model development', J. Am. Water Resour. Assoc, vol. 34, no. 1, pp. 73–89.

[8]. Asadi S., Shahrabi J., Abbaszadeh P. and Tabanmehr S. (2013), ―A New Hybrid Artificial Neural Networks for Rainfall-Runoff Process Modelling‖, Journal of Hydraulic Engineering, Vol. 121**,** PP:470-480.

[9]. Berhan..G.,..Woldeamlak..B.,Achim..B.(2015)."Model-Based.Characterization and Monitoring of Runoff and Soil Erosion in Response to Land Use/land Cover Changes in the Modjo Watershed, Ethiopia". Land degradation & development. V.26, p. 711-724.

[10]. Bera Suman and Maiti Ramkrishna (2021), are published the paper on Assessment of Water Availability with SWAT Model: A Study on Ganga River in JOURNAL GEOLOGICAL SOCIETY OF INDIA, Vol.97, page no.781-788.

[11]. Cao. W.,. Bowden .B. W., .Davie .T. (2006). For the Multi- variableand multisitecalibration and validation of SWAT in a large mountainouscatchment with high spatial variability. Hydrol Process 20:1057–1073.

[12]. Chakravarti A., Joshi N., Panjiar H. (2015), ―Rainfall-Runoff Modelling using Artificial Neural Network, Journal of Hydraulic Engineering, Vol. 8,Issue No. 14, PP: 1-7

[13]. Chandra P., Patel P.L., Gupta P.D., Porey I.D. (2015). "Estimation of sediment yield using SWAT model for upper Tapi basin" ISH journal of Hydraulic engineering. V. 20, (3), p. 29

[14]. Choudhari Kishor, Panigrahi Balram and Paul Chandra Jagadish(2014), are published the paper on Simulation of rainfall-runoff process using HEC-HMS model for Balijore Nala watershed, Odisha, India in INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES Volume 5, No 2,page no-253

[15]. Devatha C.P., Deshpande Vaibhav, Renukaprasad M.S., (2015). Estimation of Soil Loss using USLE Model for Kulhan Watershed, Chattisgarh- A case study. International Conference On Water Resources, Coastal and Ocean Engineering (ICWROE). Aquatic Procedia 4, 1429-1436.

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

[17]. Himanshu Sushil Kumar ,Pandey Ashish and Shrestha Prabin(2016), are published the paper on Application of SWAT in an Indian river basin for modeling runoff, sediment and water balance in Ken River basin,India in Springer.

[18]. Himanshu S.K., Pandey A, Yadav B, Gupta A. (2019). "Evaluation of best management for sediment and nutrient loss control using SWAT model" Journal of Soil & Tillage research journal. V. 192, p. 42-58.

[19]. Jain Sharad K., Nayak P. C., Singh Yatveer and Chandniha Surendra Kumar (2017), are published the paper on Trends in rainfall and peak flows for some river basins in India in Current Science, VOL. 112, page no- 1714.

[20]. Kiros G., Shetty A., Nandagiri L. (2016). "Performance evaluation of SWAT model for land use and land cover changes in semi-arid climatic conditions: A review" Journal of Hydrology current research. V. 6, (3), p. 1-7.

[21]. Kurbah Shanbor, Rainfall-Runoff Modeling of a River Basin using SWAT Model Article in International Journal of Engineering and Technical Research · December 2017.

[22]. Kushwaha, Akansha, Jain M K. 2013. Hydrological Simulation ina Forest Dominated Watershed Himalayan Region using SWAT Model. J. Water Resources Management, Springer, Vol.27: 3005 – 3023. (DOI: 10.1007/s11269-013-0329-9).

[23]. Kumar Senthil A. R., Sudheer K.P., Jain S.K. and Agarwal P. K. (2004), are published the paper on Rainfall-runoff modelling using artificial neural networks: comparison of network types in International Journal of Engineering Research & Technology (IJERT).

[24]. Manaswi C M, Thawait A K. 2010. Application of Soil and WaterAssessment Tool for Runoff Modeling of Karam River Basin inMadhya Pradesh. International Journal of Scientific Engineeringand Technology (ISSN: 2277-1581) Volume No.3 Issue No.5, pp: 529-532.[10] Mishra et al.

[25]. Mosabhi M., Benabdallah S., Boussema M. R. (2012). "Assessment of soil erosion risk using SWAT model" Arab Journal of geosciences. V. 658, p. 34-43.

[26]. Murty PS, Pandey A, Suryavanshi S (2014) Application of semidistributed hydrological model for basin level water balance of the Ken basin of Central India. Hydrol Process 28(13):4119–4129

[27]. Pandey A, Himanshu SK, Mishra SK, Singh VP (2016) Physically based soil erosion and sediment yield models revisited. CATENA 147:595–620

[28]. Panday Durga Prasad , Chaudhary Siddharth, Dr. Villuri Vasant Govind Kumar & Dr. Gosain A.K. (2018), are published the paper on Climate Change Impact Assesment on Hydrological Regime of Yamuna River Basin using GIS in International Journal of Engineering Research & Technology (IJERT), Volume 6 , January 2018,page no-1516.

[29]. Parajka, J., Merz, R., and Blöschl, G. (2005). "A comparison of regionalisation methods forcatchment model parameters." Hydrol. Earth Syst. Sci. Discuss., 2(2), 509–542.

[30]. Prasannakumar, V, Vijith, H, Abinod, S & Geetha, N (2012), 'Estimation of soil erosion risk within a small mountainous subwatershed in Kerala, India, using Revised Universal Soil Loss Equation (RUSLE) and geo-information technology', Geoscience frontiers, vol. 3, no. 2, pp. 209-215.

[31]. Sharma Deepshikha and Kansal Arun(2014), are published the paper on Current condition of the Yamuna River - an overview of flow, pollution load and human use CURRENT SCIENCE, 5(7).

[32]. Singh V, Bankar N, Salunkhe S S, Bera A K, Sharma J R. 2013.Hydrological stream flow modelling on Tungabhadra catchment:parameterization and uncertainty analysis using SWAT CUP, Current Science: vol. 104, No. 9, pp 1187-1199.

[33]. Tenenbaum, J. B., De Silva, V., and Langford, J. B. (2000). "A global geometric frameworkfor nonlinear dimensionality reduction." Science, 290(5500), 2319–2323

[34]. Wang, X, Shao, X & Li, D (2003), 'Sediment Deposition Pattern and Flow Conditions in the Three Gorges Reservoir : A Physical Model Study', Tsinghua Sci. Technol, vol. 8, issue 6, pp. 708–712.

[35]. CPCB(Central Pollution Control Board),Rerort in Yamuna river basin,2006-07

URL ;

- https://www.google.com/search?q=yamuna+river+basin&sxsrf
- https://pubs.usgs.gov/wri/wri00-4130/pdf/wrir00-4130.pdf
- https://www.google.com/search?q=trends+in+rainfall%2Cstream+flows+in+yamuna+river+basin&sxsr f
- http://www.columbia.edu/~vjd1/streams_basic.htm
- Url-https://sandrp.in/2015/04/13/blow-by-blow-how-pollution-kills-the-yamun-river-a-field-trip-report
- https://www.researchgate.Schematic-representation-of-thehydrologiccycle
- https://gpm.nasa.gov/education/articles/nasa-earth-science-water-cycle
- https://livingatlas.arcgis.com/landcover/ -(2014)

https://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html

AUTHORS PROFILE

1. **Alok Singh**
M.Tech Student
Civil Engineering Department
MANIT, Bhopal,
Madhya Pradesh, India

2. **Dr. A.K. Thawait**
Assistant Professor
Civil Engineering Department
MANIT, Bhopal,
Madhya Pradesh, India