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Experimental and Numerical Simulations of Sediment in Fusre River Basin, Nepal

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Abstract

This study presents about the analysis of sediment generation of the ungauged basin Fusre basin by modeling and also with the help of rainfall simulator. Many rivers in Nepal are either ungauged or poorly gauged due to extreme complex terrains, monsoon climate and lack of technical and financial supports. The Soil and Water Assessment Tool (SWAT) was applied for watershed delineation of the Fusre basin and the basin delineated into seven sub-basin that generate the river network, which also provides the information like stream link, stream order, stream length, slope etc. The calibration was performed using data from 2003 to 2010 and validation for the period from 2011 to 2015 at a daily time step. The model performance was evaluated based on computed statistical parameters. For the calibration period of the discharge and sediment flow, the performance of the model was very good, with a coefficient of determination R^2= 0.9528, Nash-Sutcliffe Efficiency NSE = 0.942, RMSE = 0.24, and Percent Bias= 14.78, Similarly, the continuous model performance for the validation period was good, with R^2 = 0.8655, NSE = 0.925, RMSE = 0.275 and Percent Bias = 18.03. Also a series of laboratory experiments was also carried out by changing the land use, soil parameter, and rainfall intensity by varying depth of soil sample and slope for comparative study with model but just for performance of apparatus. The performance of rainfall simulator was good. From the experimental method the calculation value of coefficient of determination R^2 is equal to 0.67, NSE value is equal to 0.865 and PBIAS was equal to 30. The performance of both experimental and simulated data was satisfactory.

Keywords: Sediment, Rainfall simulator, SWAT, Land use, Ungauged basin

1. Introduction:

A rainfall simulator is an important tool for the study of runoff generation and soil loss because it can be used either under laboratory conditions, or in disturbed or natural soil. This study was to describe the arrangement and operation of a rainfall simulator to evaluate soil loss in situ. Sediments are fragments of rock and minerals, loosened from the surface of earth due to weathering process and the impacts of rainfall and flowing water. When the eroded material is carried by water in motion, sediments transport occurs. The general land- use practice in the hills has intensified land erosion and thus increased the sediment transport rates in many mountain rivers where hydropower plants may be developed. Much of Nepal rain falls within the monsoon region, with regional climate variations largely being a function of elevation. Average rainfall is 1,500 mm, with rainfall increasing from west to east. Nepal has high potential for hydropower due to glaciers in the Himalayas, regular monsoon rain and local topography. Himalayan Rivers contain large quantities of sediment with hard abrasive particles, which is a hurdle for the economic exploitation of hydropower resources [1].

A rainfall simulator is an important principal apparatus for the study of infiltration, soil erosion, surface runoff & sediment transport as it allows rainfall- runoff generation under controlled & repeatable conditions.it permits generation of rainfall at a known depth & and intensity in controlled manner [2].

In this study, the soil and water assessment tool (SWAT) model, which is basically a river basin model, was used to simulate river flow. SWAT is a process-based and spatially semi distributed hydrological model developed by the United States Department of Agriculture (USDA).The SWAT hydrological model is used for the modelling which is capable of simulating surface flow, sediment deposition, nutrients movement and sub-surface flow [3]. The model data obtained from SWAT model has to calibrate with observed data and validation for each calibration was required. For the calibration and validation SWATCUP was used. Hydrologic modelling parameters, input and measured data, hydrologic models require calibration and validation [4]. Model calibration is done to estimate possible model parameters by comparing predicted data and observed data under the same period of simulation [5]. Model validation is for demonstration of model capability for accurate simulations on user's target [6].

The experiment of runoff & soil erosion in in situ study was held which describes the design and operation of rainfall simulator to evaluate soil loss insitu [7]. For the experiment four full-cone spray nozzles with a Unijet system mounted in a straight line pipe configuration, and easily transported assembled. Soil erosion in the different slopes & condition was tested by quantifying runoff & evaluating soil erosion. Twenty samples were carried out in lab & sixteen in the field with variation of slope 11, 21 & 39 % & compute runoff as well as soil erosion. Universal Soil Loss Equation- USLE were used for calibrating, validating & verifying erosion [8]. Julien boulange conducted in the area of 5 m^2 plot by providing the rainfall intensity between 20 and 100 mm/hr by changing number and type of silicon nozzles. The results show that the portable rainfall simulator which was effectively used for providing runoff, infiltration and sediment generation and transport at a field and analyse the process that affects the surface characteristics such as slope soil properties etc. [9]. Rainfall regime, vegetation cover, soil type, slopes and land use are the most important factors influencing soil erosion. In intense rainfall or storms, the velocity and size of raindrop can cause more erosion. Having vegetation cover can reduce the size and velocity of raindrop reaching the ground surface. It can also improve the infiltration capacity of the area via addition of organic matter to the soil. Due to different soil properties, soil erodibility is different for each other and results in different sediment yield [10].

Various experiments has done using SWAT model to find out the amount of soil erosion yield & it effects on hydropower generation [11]. Estimation of soil erosion loss in these regions is often difficult due to the complex interplay of many factors such as climate, land uses, topography, and human activities. The purpose of this study is to apply the Soil and Water Assessment Tool (SWAT) model to predict surface runoff generation patterns and soil erosion hazard. Results showed that a larger part of the watershed (90 %) fell under low and moderate soil erosion risk and only 10 % of the watershed was vulnerable to soil erosion with an estimated sediment loss exceeding 10 t ha^{-1} $year^{-1}$. Results indicated that spatial differences in erosion rates within the Sarrath catchment are mainly caused by differences in land cover type and gradient slope.

Sequential Uncertainty Fitting (SUFI-2) technique. SUFI-2 was used for the calibration of SOIL WATER ASSESSMENT TOOL (SWAT) model. It was calibrated for period (1979–2000) including 3 years as warm up (1979–1982), subsequently model was validated on 11 years of datasets (2001–2011). The percentage of observation covered by the 95 PPU (*p*-factor) and the average thickness of the 95 PPU band divided by the standard deviation of the measured data (*r*-factor), were taken into an account for performance evaluation of model. In calibration and validation the *p*-factor and the *r*-factor was obtained as 0.54, 0.76 and 0.68, 0.56 respectively. The coefficient of determination (R^2), Nash–Sutcliffe efficiency (NSE), percent bias (PBIAS) and RMSE-observations standard deviation ratio

(RSR) have been used for goodness of fit between observation and final best simulation. The R^2, NSE, PBIAS and RSR are 0.74, 0.73, −3.55 and 0.54 respectively during the calibration whereas in validation period values are 0.75, 0.69, 18.55 and 0.56 respectively [11].

Furse watershed basin lies in the highest rainfall zone of Nepal. The annual rainfall in this watershed from 4500 mm to 5000 mm. Control of erosion is the challenging issue because of undulation topography, frequent and heavy intensity of rainfall, excessive land use activities. For conducting the simulated rainfall experiment the samples response will be challenging that may be differ from natural storms. Intensity of rainfall, depth of runoff, infiltration capacity, slope of land, soil use, land use, vegetation’s, etc. May be slightly differ from natural storms. The process of soil erosion during heavy rainfall, the significant properties of soil grain which are transported downwards and specific effects of each property that will be challenging for analysis.

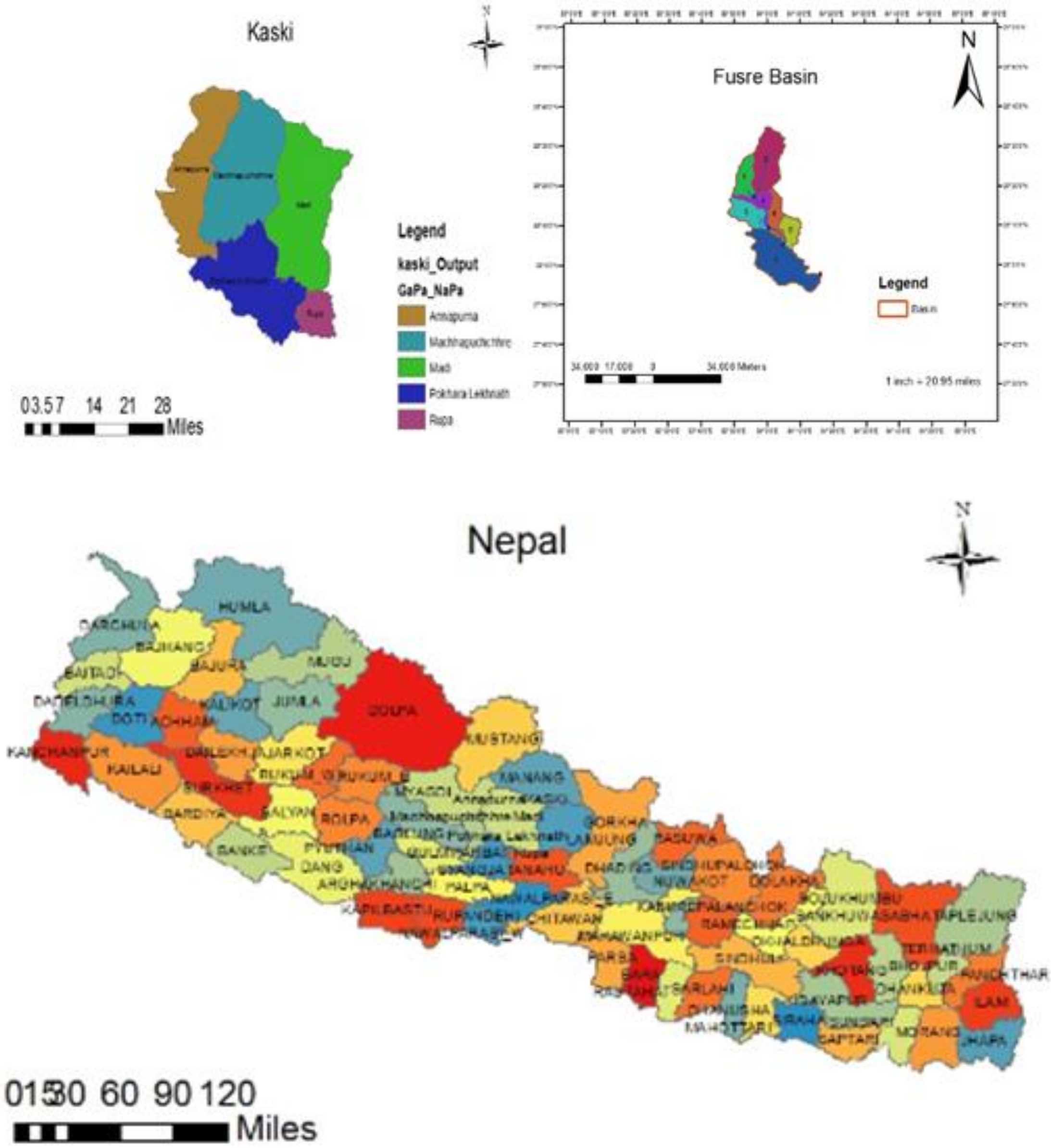

Figure 1: Study area

The main objective of this study to analysis the sediment by using experimental and numerical simulation method of the ungauged basin.

The specific objectives are:

i. To compute the amount of sediment by using Rainfall simulator in laboratory.

ii. To compute the sediments yield in a study area (ungauged Fusre basin) using SWAT model.

iii. For the comparison between experiment data from rainfall simulator and model data from SWAT model.

2. Study Area:

A study area for the project was located in Pokhara, Kaski dictrict about seven kilometres from Pokhara University. The Fig. 1 shows the study area which located from north latitude 27º 58’0.63” to 28º 20’14”and from east longitude 83º 53’40” to 84º 20’14”. The Fusre watershed basin has an area of 165 km^2 and it was one of the tributary of Seti Gandaki River. Western and Northern parts of the Fusre watershed has dominated by mountains and valley and Eastern and Southern parts are lower river basin area. The area was selected based on natural factors like evergreen forest, mixed deciduous forest etc and condition of sediment yield of river. The climate is tropical monsoon type and average annual rainfall is about 4850 mm.

3. Methodology:

This study used the Soil and Water Assessment Tool (SWAT) method to evaluate the effects of both land use and soil use effects on stream flow & sediment yield in the Fusre River Basin, Pokhara. The model inputs parameters such as land use, soil use, HRUs and slope define the catchment hydrology, sediment transport, and soil loss. And also an experimental laboratory method i.e. Rainfall simulator was used to measure the sediment data.

3.1. Data Acquisition:

a) Topography: The digital elevation model (DEM) was established using the Arcgis10.3 software technology, the resolution was 30 m and downloaded from the open sources USGS. The large DEM was clipped for the study area i.e. Fusre basin shown in Fig. 2. The soil and water assessment tools SWAT, was used based on the DEM, which mainly includes: the flow direction and flow length, flow accumulation and flow network of the surface water, and watershed boundary and sub-watershed partition was beneficial in identifying dissimilarities of land uses or soils and their impact to hydrology.

b) Land use: A land cover map of 1995 was classified based on classified land cover map and used in SWAT model set up (Figure.3). There are seven cover classes and are closed forest (FRSE), Forest Evergreen, (FRSD), agricultural area (AGRL), grassland, bare land (BARR) and water (WATR)

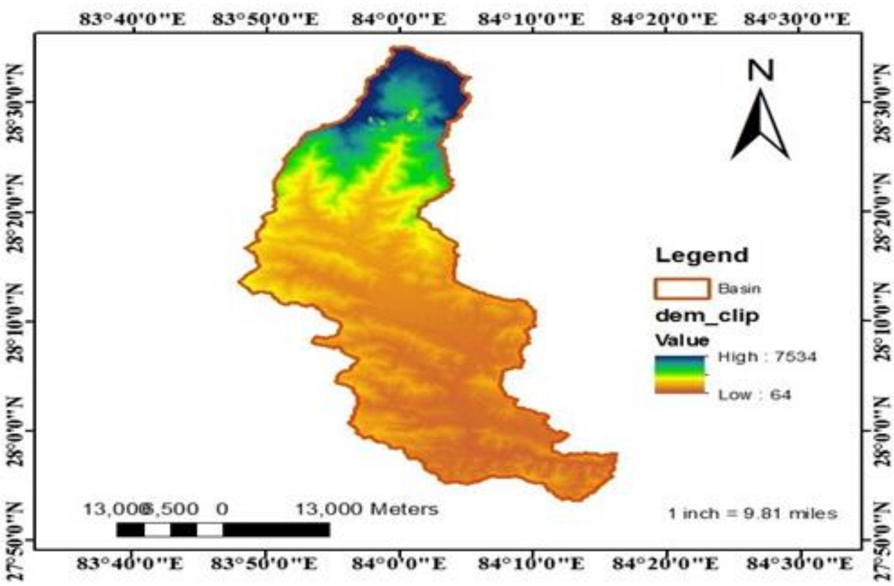

Figure 2: DEM of Fusre Basin

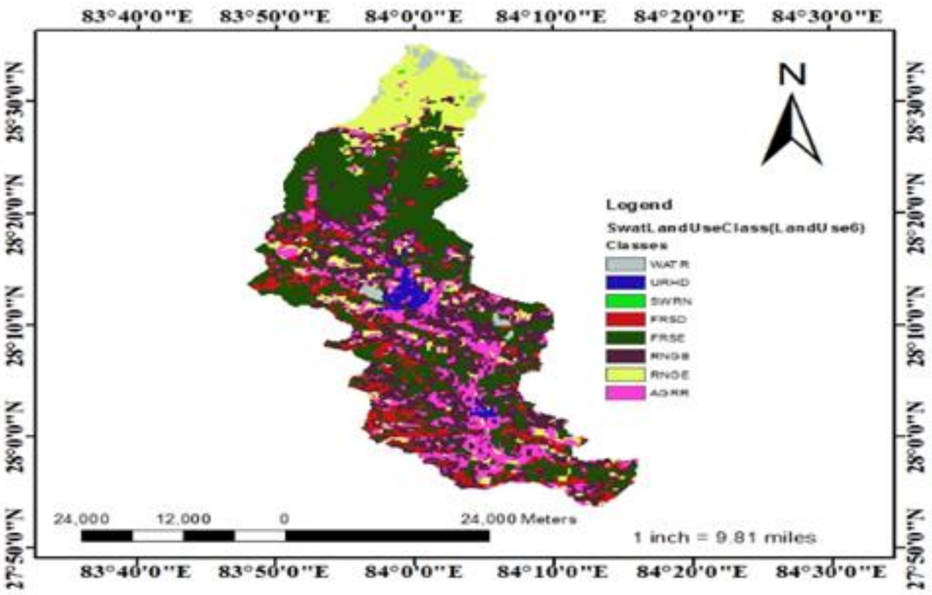

Figure 3: Land use of Fusre Basin

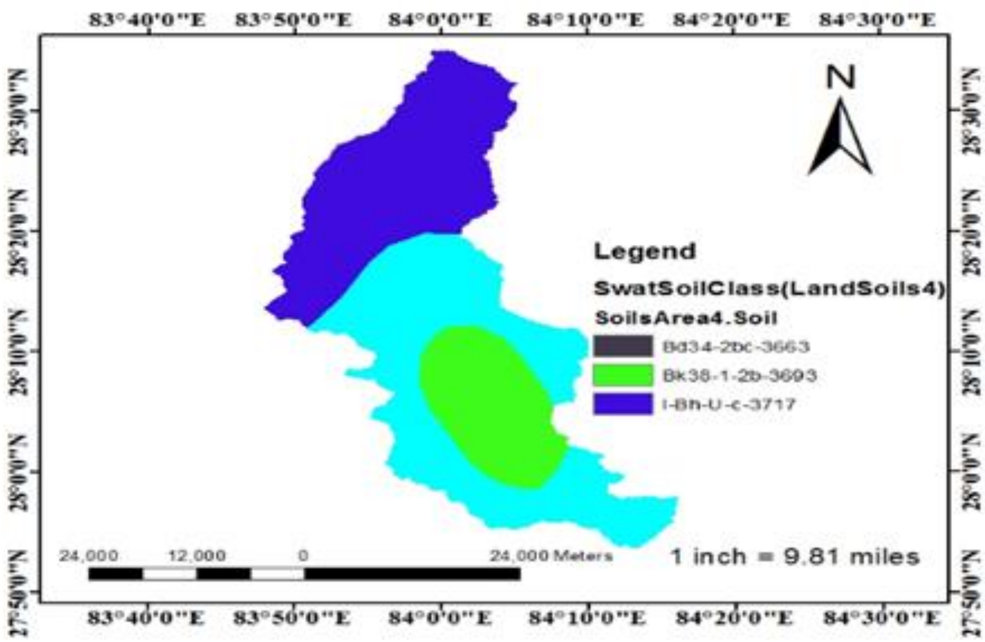

Figure 4: Soil use of Fusre Basin

c) Soil classification: To know the effect of soil properties on erosion modelling with SWAT, soil database was imported. The physio-chemical and hydrological properties of soils were collected from world soil map of FAO the version. In the soil database, the classified soils were given specific codes with their properties. In the Fusre watershed, there are three dominant soils and each soil was assigned to a soil-code from the database and classified its properties as shown in Fig. 4.

d) Hydrological Response Unit (HRU): In Hydrological Response Unit (HRU) definition, land use map of 2006, soil map and slope map were overlaid to create areas with specific land use, soil type and slope class. Multiple slope classification approach was used to include all the slopes existing within the Fusre Watershed. Slope classification of the area was followed the classification used by FAO (2003). The watershed area was classified into 5 slope classes; level to gently undulating (<10%), rolling to mild hilly (10% to 15%) Hilly to steep slope (15% to 35%) and steeply slope to mountainous (>35%) as shown in Fig. 5.

e) Meteorological data: SWAT requires daily time step meteorological data to run. The meteorological data were collected from DHM Pokhara airports meteorological station of Nepal for the period of 2000 to 2020. The stream flow for calibration and validation of the model output were also acquired from the station from 2003 to 2010. The climate is tropical monsoon type and there are three seasons, summer, rainy and winter. The temperature range is within 11℃ and 23℃ and annual rainfall is within 4500 mm and 5000 mm.

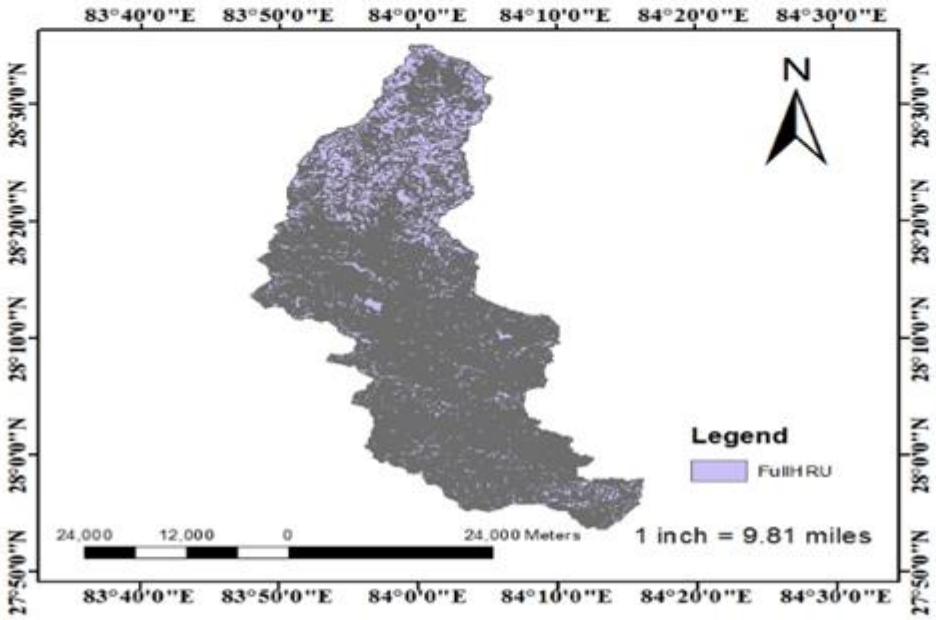

Figure 5: Hydrological response unit of basin

3.2. Modeling:

In this paper, the model is executed for 12 years from 2003 to 2015 year of both discharge and sediment data of seti basin. The data from 2003 to 2010 were used to calibrate for the data of Seti-basin, and the data from 2011 to 2015 were used to validate. Model calibration and validation was done to fit the SWAT performance on the measured data of gauged station by using the SWAT calibration and Uncertainty Procedure (SWAT-CUP)'s. It was conducted by comparison of observed values from the gauged station with the SWAT simulated value for the same time interval. In this way, the hydrograph and sediment graph were fitted by SWAT rather than the model simply optimized values. The SWAT-CUP was used for calibration and validation then after an iteration, the simulated results were compared with the observed variables of interest and the performance of model is decided based on four objective functions, namely coefficient of determination (R^2), Nash-Sutcliffe (NSE), RMSE observations and percent bias (PBIAS).

3.3. Experimental Work using Rainfall Simulator:

The rainfall was a basic input parameter to various hydrologic processes like, infiltration, runoff, soil erosion and sediment outflow. Rainfall simulator was used for the experiment of land use and soil use which helps to find out the erosion rate and amount of sediments transport in the basin. For this experiment the soil sample like clay, mixed gravel, grass cover, silt, barren land etc. were collected from site area. After that this sample was used in laboratory using rainfall simulator of having size $2m^2$. A series test for experiment was carried out by changing the land use, soil parameter & rainfall intensity. During the working the slope of the apparatus was changed with the help of driving screw. With the help of bucket and filter paper, water flow rate and sediment transport were measured. Dry soil weight samples were obtained based on the runoff filtering results. The runoff sample was filtered using filter paper so that a sediment is collected in the runoff sample. After filtering, the samples are dried in the filter paper using an oven at 80-90°C for 24 hours or when the weight of the soil sample has reached a constant weight. The amount of sediment was collected in the bucket and weights in weighting machine. Therefore the weight of sediment obtained from rainfall simulator was used for compare with sediment yield from hydrological Model.

Figure 6: Experimental arrangement of rainfall simulator

The arrangement of the rainfall simulator was done then after the process was started by fixing the rainfall intensity by taking time to fill the jar of 10 litre. The artificial rain occurs in the simulator basin of different land use, slope, and soil type the runoff, infiltration begins in the basin. The runoff volume measure in the bucket and the sediment collected in the bucket were filter by filter paper in a conical funnel.

4. Results and Discussion:

4.1. Modelling:

4.1.1. Fitted Parameters:

Based on observed data availability, the performance of the SWAT model was calibrated for the period of 2003 to 2010. The selected parameters used in calibration and validation of model performance were shown in Table 1. Based on observed data availability, the performance of the SWAT model was calibrated for the period of 2003 to 2010. The selected parameters used in calibration and validation of model performance were done by changing Parameters like CN2, ALPHA_BF, SHALLST , GWQMN, SURLAG etc. The range and fitted values of all parameters used in stream flow and sediment yield calibration are mentioned in Table 1.

4.1.2. Calibration and Validation:

A. Calibration and Validation of Discharge:

The simulated and observed value of stream flow for the calibration period of (2003 to 2010) is in Fig. 7 and the correlation is shown in Fig. 8. The performance statistics are shown in Table 2. The relation between simulated and observed value of stream flow at the outlet of the study watershed was very good with R^2 value of 0.9734. As the value of R^2= 0.9734, NSE= 0.936 and PBIAS value= 8.82, the model performance is very good for the calibration period based on monthly time step model performance.

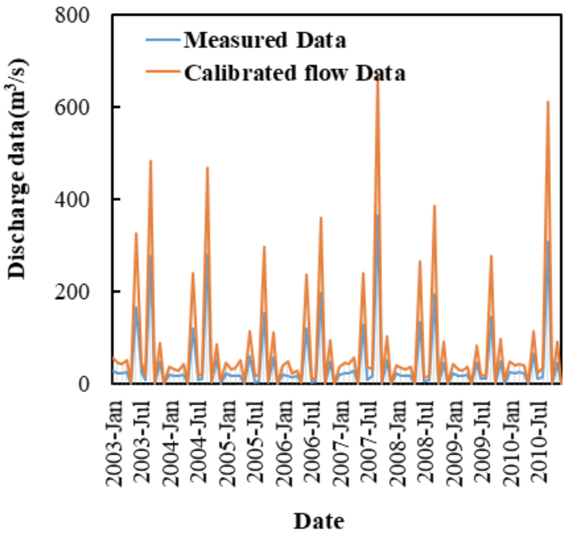

Figure 7: Comparison of the observed and best simulated monthly discharges during calibration (2003-2010).

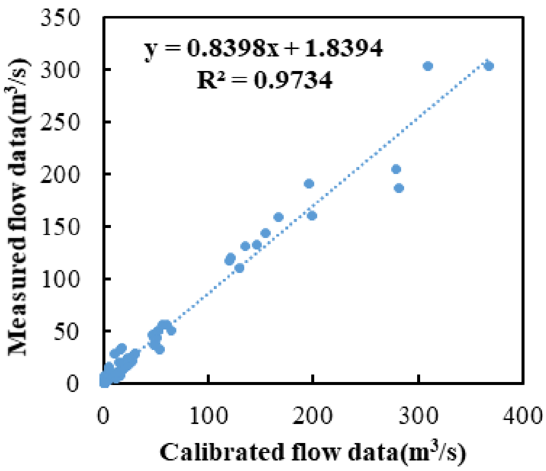

Figure 8: Scatter plots for calibration (2003-2004) at the 95% confidence level

Table 1: Model calibrated parameter values

Parameters	Parameters Description	Range	Value	Sensitivity Grade
CN2	SCS runoff curve number for moisture condition 2	37-100	76.43	Very High sensitive
SHALLST	Initial depth of water in the shallow aquifer	0-50000	2765.45	
DEEPST	Initial depth of water in the deep aquifer.	0-50000	2976.54	
GW_DELAY	Groundwater delay	0-500	7.62	
ALPHA_BF	Base flow alpha factor.	0-1	0.21	
GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur.	0-5000	631	
GW_REVAP	Groundwater "revap" coefficient.	0.02-0.2	0.07	
REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur.	0-500	89.32	
RCHRG_DP	Deep aquifer percolation fraction.	0-1	0.13	
SURLAG	Surface runoff lag time	0.05-24	5.76	High sensitive
SLSUBBSN	Average slope length.	10-150	132	
OV_N	Manning's "n" value for overland flow.	0.01-30	2.24	
ESCO	Soil evaporation compensation factor.	0-1	0.31	
EPCO	Plant uptake compensation factor	0-1	0.45	
CH_K2	Effective hydraulic conductivity in main channel alluvium.	0.01-500	31.52	
CH_N2	Manning's "n" value for the main channel.	0.01-0.3	0.019	
CH_COV1	Channel erodibility factor.	0.05-0.6	0.042	
CH_COV2	Channel cover factor.	0.001-1	0.0321	
CH_EQN	Sediment routing method	0-4	1.2	
SPEXP	Exponent parameter for calculating sediment reentrained in channel sediment routing.	1-1.5	1.32	Less sensitive
SPCON	Linear parameter for calculating the maximum amount of sediment that can be reentrained during channel sediment routing.	0.0001-0.1	0.003	
ADJ_PKR	Peak rate adjustment factor for sediment routing in the sub basin (tributary channels)	0.05-2	1.1142	
PRF	Peak rate adjustment factor for sediment routing in the main channel.	0-2	0.0652	
USLE_P	USLE equation support practice	0-1	0.062	

In the validation period of 2011 to 2015, the performance statistic of the model shows R^2= 0.95, NSE = 0.903, RSR =0.311 and PBIAS= 12.46 (Table 2). The model performance very good in the validation period of 2011 to 2015. The relation between simulated and observed value of stream flow for validation period is shown in Fig.9 and it was decreased 2.34% in comparison with calibration period. The value of NSE was decreased 3.3% and RSR was increased 5.8% within calibration and validation (Table 2).

Table 2: Monthly time step calibration and validation performance statistic

S. No.	Model Stage	R^2	NSE	RMSE	PBAIS
1	Calibration (2003-2010)	0.9734	0.936	0.253	8.82
2	Validation (2011-2015)	0.95	0.903	0.311	12.46

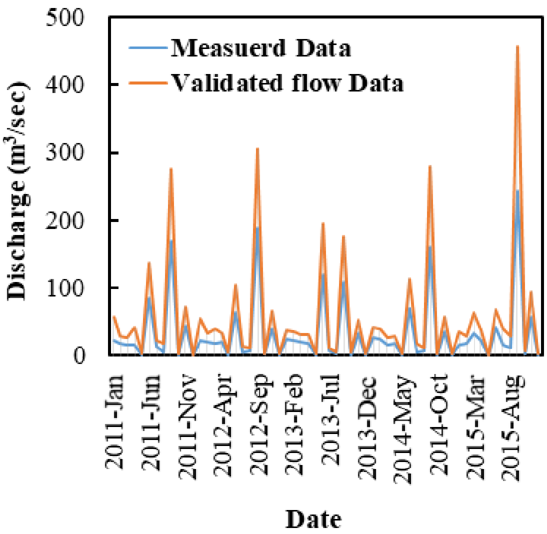

Figure 9: Comparison of the observed and best simulated monthly discharge during validation (2011-2015).

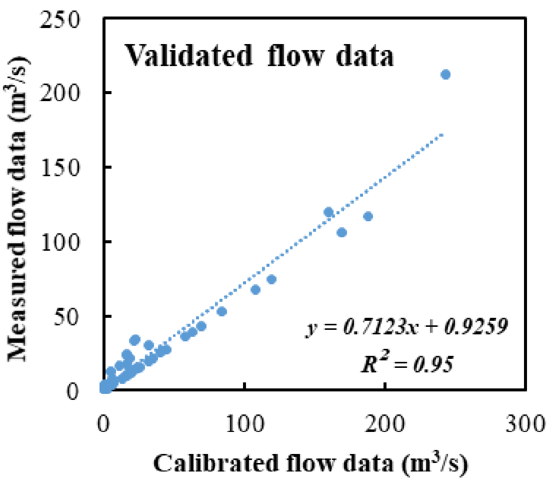

Figure 10: Scatter plots for validation (2011-2015) at the 95% confidence level

Unlike calibration period, the model underestimated stream flow for both dry season and wet season. But the results of model performance for validation period was good based on monthly time step model performance.

B. Calibration and Validation of Sediment Data:

The simulated and observed value of sediment yield for the calibration period of (2003 to 2010) is in Fig.11 and the correlation is shown in Fig 12. The performance statistics in Table 3 shows that the relation between simulated and observed value of sediment yield at the outlet of the study watershed was R^2= 0.9528, NSE= 0.942, RSR= 0.24 and PBIAS value= 14.78. According to monthly time step model performance of Moriasi.et al (2007), the model performance was very good for the calibration period of sediment yield. Based on the value of PBIAS = 14.78, the SWAT underestimated sediment yield of the Seti-Basin watershed.

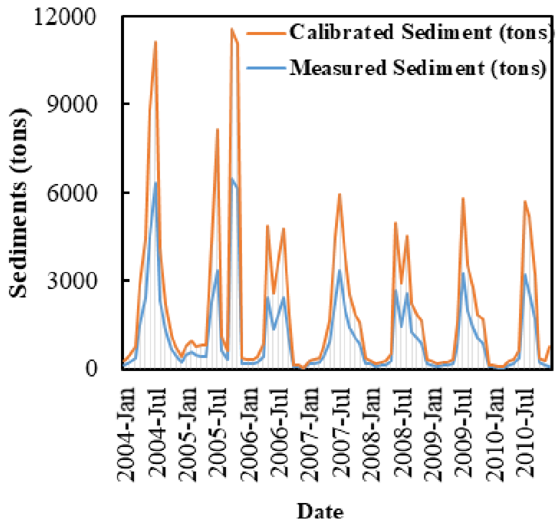

Figure 11: Comparison of the observed and best simulated monthly sediment yield during calibration (2003-2010).

In the validation period of sediment yield from 2011 to 2015, the performance statistic of the model shows R^2= 0.9528, NSE = 0.942, RSR =0.24 and PBIAS= 14.78 (Table 3). The model performance slightly decreased in R^2 and NSE and slightly increased in RMSE and PBAIS in the validation period compared with calibration period of 2003 to 2010. The relation between simulated and observed value of sediment flow for validation period is shown in Fig. 13. And it was decreased 8.73% in comparison with calibration period. The value of NSE was decreased 1.7% and RSR was increased 3.5% within calibration and validation. Like calibration period, the model underestimated sediment yield especially in wet season. The results of model performance for validation period was satisfactory based on monthly time step model performance.

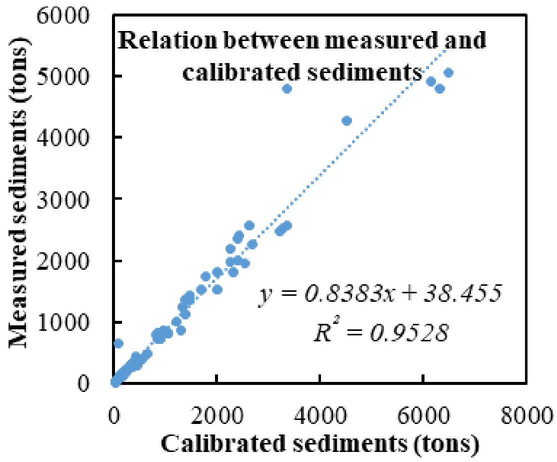

Figure 12: Scatter plots for calibration (2003-2010) at the 95% confidence level.

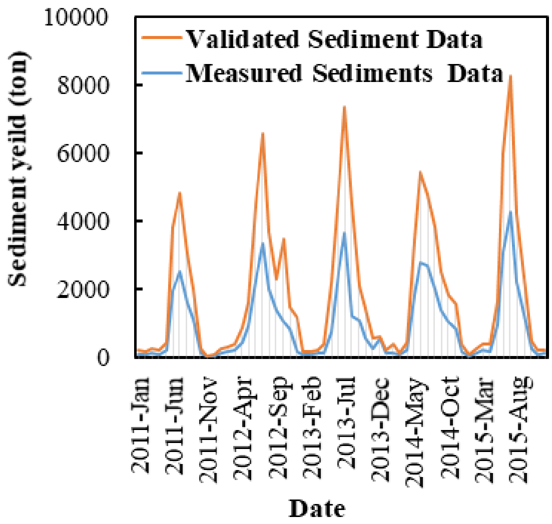

Figure 13: Comparison of the observed and best simulated monthly sediment yield during validation (2011-2015).

Table 3: Monthly time step calibration and validation performance statistic.

S.No.	Model stage	R^2	NSE	RMSE	PBAIS
1	Calibration (2003-2010)	0.9528	0.942	0.24	14.78
2	Validation (2011-2015)	0.8655	0.925	0.275	18.03

Table 4: Average discharge (m^3/s) and Sediment (ton/month) Data from 2004 to 2015

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Discharge	23.4	28.5	27	26.2	25.2	24.7	20	18.8	22.4	24	25.1	23.2
Sediment	15.9	23	43.1	101	135.2	229	316	118.3	69.3	35	50.1	32.1

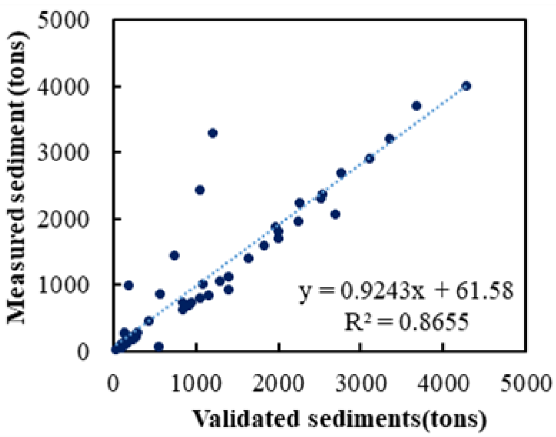

Figure 14: Scatter plots for validation (2011-2015) at the 95% confidence level

4.1.3. Calibrated and Validated Data of the Ungauged Station (Fusre Watershed Basin)

In this study the data were available for Seti basin apart from that the study area was Fusre basin which was a tributaries of Seti basin.

The sediment flow was occur maximum during the wet season and minimum in dry season. The peak value of sediment appears 545 tons in the month of Jun 2010 and minimum value appears 0.37 tons in the month of February 2015. The average sediment generation (2004- 2015) from the Fusre basin was maximum in the month of July 315.9 Tons/month and minimum in the month of January 15.9 tons/month and the total annual sediment including maximum and minimum, average sediment generate was found 1168.9 tons/year.

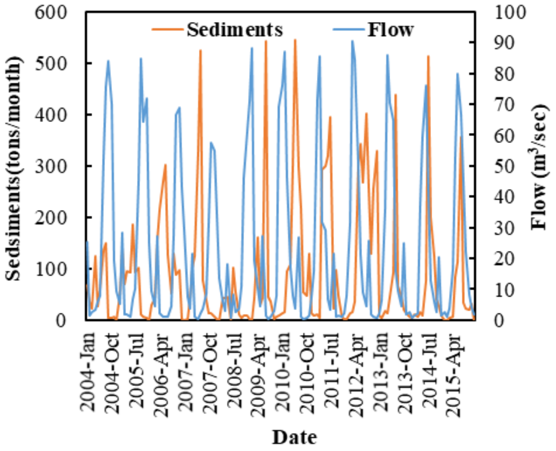

Figure 15: Sediment and Flow curve at Sub-basin 3 (Fusre Basin)

4.2. Experimental Work:

The experiment was conducted in the laboratory of Pokhara University. The apparatus Rainfall simulator of size $2m^2$ was used for collecting and measured the sediment particles with the help of filter paper & weighting machine. The land use and soil samples were collected from study area, and using different types of soil and land with varying depth slope and rainfall intensity.

The result shows that the average rainfall intensity from four samples was 443.31 mm/hr. The runoff volume of these samples was 0.02125 m^3 while average depth of samples was 0.175m with average slope 4.89. Finally the average weight of sediment was found 0.34gm in the area $2m^2$ Basin as shown in Table 5.

Table 5: Laboratory Data

S. No.	Type of land use	Intensity of Rainfall (mm/hr)	Runoff (m^3)	Area of basin (m2) (2×1)	Depth of sample (m)	Slope	Wt. of dry soil (kg)	Discharge(m3/s) of Fusre basin (area = $165km^2$)
1	Silt soil, mix gravel, grass cover, clay	640	0.034	2	0.1	5.71°	0.15	14.67
2	Mix gravel, sand, grass cover, clay	540	0.022	2	0.2	4.85°	0.1	12.38
3	Impervious material, barrel land, grass cover	388.23	0.017	2	0.2	4.71°	0.05	8.89
4	Ordinary soil, grass cover	255	0.012	2	0.2	4.28°	0.04	5.84

The result shows that the sediment yield from the rainfall simulator in the area of $2m^2$ was 0.34gm. The area of Seti- furse basin was found from the modeling was $1471km^2$. By considering this area, the sediment yield in that time was calculated as 250 ton/month. Similarly, the furse basin covered the area about $165.37km^2$ which was yield about 28.05 ton/month. The rainfall intensity that were calculated form the four number of soil sample using a bucket and stop watch. Then the time and runoff were recorded in every samples which was shown in (Table 5) to calculate rainfall intensity for each sample. The rainfall intensity for sample 1, 2, 3 & 4 were 640mm/hr., 540 mm/hr., 388.23mm/hr., and 255mm/hr. has obtained respectively. The average sediment yield per month was about in the range of (15 – 100) per month from model shown in Table 4, while the rainfall simulator shows about 28.05 tons/month which was lies in the range of model data.

4.2.1. Comparison between Experimental Data and Simulated Data:

During the experimental events the loosen soil grains transport rapidly for the very first experiment then the soil loss rate decreases for further experiment. In the simulation method there was high amount of sediment was yield in wet season and also dry season of some months this was due to various human activities and others. The rainfall pattern in the simulation and experimental method shows variation due various parameters. However, there was necessary to find the variation and compare the result from experimental and simulation method. The four sample from the rainfall simulator were taken as a measured data and the simulated discharge data of the Fusre basin was taken random from the 2003 to 2015 which were nearly equal to experiment discharge and then corresponding sediment were choose shown in table 6. According to intensity of rainfall in the rainfall simulator was elaborate into the real basin size of the study area and by calculation the maximum discharge was found 14.67m^3/s and minimum 5.84m^3/s. Similarly, in the simulation method the obtained value of discharge was taken 14.7m^3/s for comparison with experiment and the corresponding sediment yield was taken 14.62 tons. Finally, the comparison between the discharge and corresponding sediments yield was conducted for the performances statistics by the method of coefficient of determination (R^2), Nash-Sutcliffe (NSE), and observation and percent bias (PBIAS). The main objective of comparing experiment data and simulated data was to find the variation of sediment data obtained by modelling and experimental way.

Table 6: : Experimental and simulated data of the Fusre basin

Discharge(m^3/s)		**Sediment(tons)**	
Experiment	**Simulated**	**Experiment**	**Simulated**
14.67	14.7	12.37	14.62
12.38	12.88	8.3	6.67
8.89	8.7	4.1	1.45
5.84	5.8	3.2	1.28

From the experimental and simulation method the calculation value of coefficient of determination R^2 is equal to 0.67, NSE value is equal to 0.865 and PBIAS was equal to 30. The performance of both experimental and simulated data was satisfactory. Various parameters which shows fluctuation in the sediments yield was found in satisfactory manner from comparison. The comparison bar chart between discharge and sediment was shown below in Figs. 16 and 17 respectively and blue color chart indicate experiment data and brown color indicate model/ simulated data.

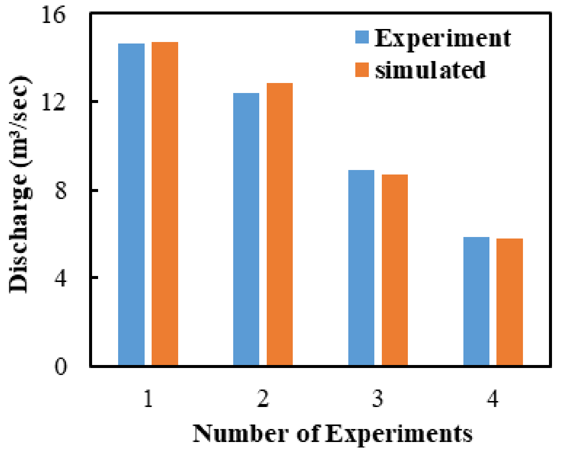

Figure 16: Comparison between experiment discharge data and simulated discharge

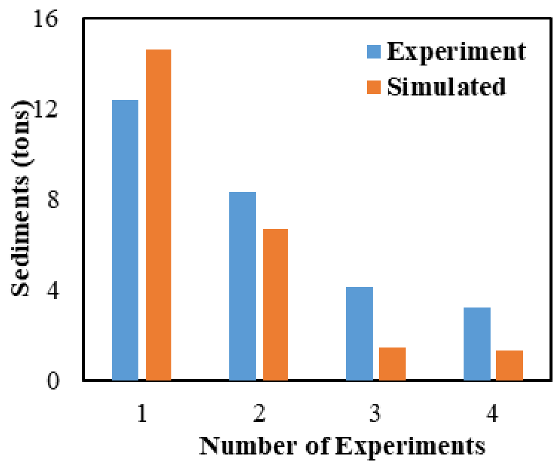

Figure 17: Comparison between experiment sediment data and simulated sediment

5. Conclusion and Recommendations:

This study focused on the comparative study between experimental and simulation method and analysis has done by experimental method using Rainfall simulator and modelling method using SWAT model. The hydrological model Soil and Water Assessment Tool (SWAT) was used to identify the sediment yield on hydrological response between 2003 and 2010 of the study area.

From the experimental and simulation method the calculation value of coefficient of determination R^2 is equal to 0.67, NSE value is equal to 0.865 and PBIAS was equal to 30 in the case of laboratory method and the values of R^2= 0.9734, NSE= 0.936 and PBIAS value= 8.82, the model performance is very good for the calibration period based on monthly time step. Similarly, the continuous model performance for the validation period was good, R^2 = 0.95, NSE = 0.903, standard deviation ratio RMSE = 0.311 and PBIAS= 12.46. The model performance very good in the validation period of 2011 to 2015. The relation between simulated and observed value of stream flow for validation period and it was decreased 2.34% in comparison with calibration period. The value of NSE was decreased 3.3% and RMSE was increased 5.8% within calibration and validation. The overall performance of both experimental and simulated data was satisfactory. Various parameters which shows fluctuation in the sediments yield was found in satisfactory manner from comparison.

This study was little bit complex because the rainfall pattern, soil use, land use and different slopes in the study area did not match in the laboratory. But the result was found in satisfactory level. Therefore, this study obtained the sediment flow pattern, sediment deposition in the outlet of Fusre basin from this information different types of water related works has to be held in this area. The data available from the simulation were used as a base data for feasibility of new events related to waters such as water supply system, hydropower projects, irrigation system etc.

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