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Sediment Yield Modeling and Evaluation of Best Management Practices Using the SWAT Model of the Daketa Watershed, Ethiopia

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Abstract

High soil erosion rates, sediment transport, and loss of agricultural nutrients have been caused by poor land-use practices and management systems. This study mainly focuses on sediment yield modeling and evaluation of best management practices of the Daketa sub-basin using the SWAT model. Calibration and validation were done using the Soil and Water Assessment Tool (SWAT) model in Daketa sub-basin. The coefficient of determination (R^2), Nash–Sutcliffe efficiency coefficient (ENS), and percent bias (PBIAS) were used to evaluate the model performance. During the calibration and validation, monthly sediment yield R^2 values of 0.80 and 0.85, ENS values of 0.74 and 0.81, and PBIAS values of 0.0829 and 0.124 were obtained. The mean annual sediment yield of the Daketa watershed is 14.43 t/ha/year. Basin management scenarios were applied to reduce sediment production in the sub-basins. Four scenarios were developed such as (i) baseline, (ii) 5 and 10 m wide filter strip, (iii) waterway grass, and (iv) terraces to select the best management practices in the basin. The result shows that grassy waterway reduces sediment yield with an efficiency of 74.6% relative to the baseline scenario. Generally, the results indicated that grass waterways have a high potential for reducing the volume and velocity of runoff, sediments, and agrochemicals from agricultural catchments.

Keywords Soil erosion · SWAT model · Sediment yield · Best management

Introduction

Background

Soil degradation by water is the most serious problem in Ethiopia. This is due to its rugged terrain and global climatic anomalies. Land degradation is a global environmental crisis, threatening agricultural areas at an alarming rate [15]. Land degradation occurs when natural or human-induced processes decrease the ability of the land to support crops, livestock, and organisms. One type of land degradation is soil erosion. Moreover, the current rate of agricultural land degradation worldwide by soil erosion and other factors was found to be leading to an irreversible loss in productivity ranging from 6 to 10 million hectares of fertile land per year [14]. Soil erosion is a serious global issue because of its severe adverse economic and environmental impacts. Economic impacts on productivity may be due to direct effects on crops/plants both on-site and off-site [5].

Erosion in all its forms involves the dislodgement of soil particles, their removal, and eventual deposition away from the original position. Susceptibility to erosion and the rate at which it occurs depends on land use, geology, geomorphology, climate, soil texture, soil structure, and the nature and density of vegetation in the area [12]. On the other hand, Hurni [9] estimated that soil loss due to erosion of cultivated fields in Ethiopia amounts to about 42 t/ha/year and from unproductive land 70 t/ha/year. These all indicate the need for the application of soil and water conservation practices to save the soil for future natural resources.

Sediment yield is one measure of geomorphic activity that results from soil erosion and processes of sediment accumulation, so it depends on variables that control water and sediment discharge to rivers. It is some part of the eroded materials left over and deposited as alluvial along river channels and

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across flood plains [8]. Sediment yield affects rates of soil development and influences the recovery of disturbed surfaces downslope from source areas in downstream landscapes. Surficial materials, topography, rainfall seasonality, and vegetation cover all have a significant impact on sediment yield. Typically, sediment yield reflects the influences of climate (precipitation), catchment properties (soil type, topography), land use/cover, and drainage properties (stream network form and density) [7].

The land-use practices of the study area had brought a negative impact on soil conservation and management. The indiscriminate deforestation, overgrazing, complete crop residue removal from farmlands, absence of sound crop rotation schemes, improper land-use patterns, absence of soil and water conservation measures, the torrential rains, and the extremely rugged topography are the principal causes of accelerated soil erosion and loss of water by surface runoff in the catchment. This is prone to the siltation process coupled with the erosive nature of the land that causes much amount of soil erosion carried and deposited in the stream channel [4].

The periodic evaluation of the sediment yield pattern and assessment of the occurrences of available runoff in the area is very essential not only to sustain river sedimentation reduction but also for watershed management. Therefore, a comprehensive understanding of hydrological processes in the watershed is a prerequisite for successful watershed management and environmental restoration in general and sediment reduction in particular [13].

An integrated approach to the use, management, and conservation of soil and water resources is further justified by the close relationship between soil and water quantity and quality. Applying watershed management to the natural resources has a vital role to improve the economic advantage of Ethiopian rural communities through improved land productivity, increase food security, and improved access to sufficient water. Moreover, efficient use of soil, water, and energy addressed to increased crop production, overcoming depletion, and minimizing risks of soil, water, and environmental degradation, as affected by external temporal factors such as climate, land use, and management [11]. The loss of nutrient-rich topsoil by water (soil erosion) leads to loss of soil quality and hence reduced crop yield in Daketa watershed. The proper investigation of sediment yield modeling and best management practice of the Daketa watershed is essential for the management of soil erosion in the watershed.

Description of Study Area

The Wabi Shebelle river basin is one of the twelve major river basins in Ethiopia, which is situated in the southeastern part of the country. The basin is one of the water-scarce basins in the country with the largest area coverage and low water availability. Daketa sub-basin is located in the middle part of the Wabi Shebelle river basin in southeastern Ethiopia (Fig. 1). The extent of the sub-basin ranges from 41° 15′ 04.89″ E to 42° 54′ 45.39″ east longitude from 7° 15′ 54.49″ N to 9° 25′ 35.96″ north latitude [10]. It is bounded by Erer Mojo sub-basin from the north and the west and Fafem Dinti sub-basin from the East. The area of the watershed covers around 15,182 km². The basin includes Oromia and the Somali region. Most of the sub-basin lands are the less populated area that lies in arid to semi-arid lowland areas. The economic main sources of most of the people in the sub-basin are crop production and livestock husbandry and the farming system those characterized as mixed farming and agro-pastoral. The agro-pastoralists are those who engaged in the agro-pastoral activity and derive most of their subsistence from livestock and to a small extent from growing crops mainly short maturing drought-tolerant crops.

Data Collection

SWAT model requires specific information about the watershed such as topography, land use/land cover, soil properties, weather data, and other land management practices. In general, the necessary data collected for this study can be classified as spatial and time-series data. The spatial data used for this study were the digital elevation model (DEM), the land use/cover, and the soil map of the study area. The digital elevation model (DEM) describes the representation of a digital topographic surface and its elevation of the study area at any point in a given spatial resolution. The DEM of the study basin was downloaded from ASTER for a resolution of 30*30 m. The land use/cover and soil map of the study area were collected from the Ministry of Agriculture (MoA).

The daily data of precipitation, minimum and maximum air temperature, solar radiation, wind speed, and relative humidity, were collected from Ethiopian National Meteorological Agency in the time range from 1996 to 2015. In the study area, there were six weather stations around the study area, such as Babile, Gursum, Degahamedo, Duhun, Fik, and Segag. Among the six meteorological stations, the Babile station has records of precipitation, temperature, sunshine, relative humidity, and wind speed, and the remaining stations only have records of precipitation and temperature. Therefore, the Babile stations were selected as time-generating (synoptic) stations. The streamflow and sediment load data were collected from the Ministry of Water, Irrigation and Energy office of the hydrology and water quality department in the time-series data (1996–2015) at Hammaro head gauging station for Daketa sub-basin watershed.

For this study, missing precipitation data were reconstructed using simple arithmetic mean method or a normal
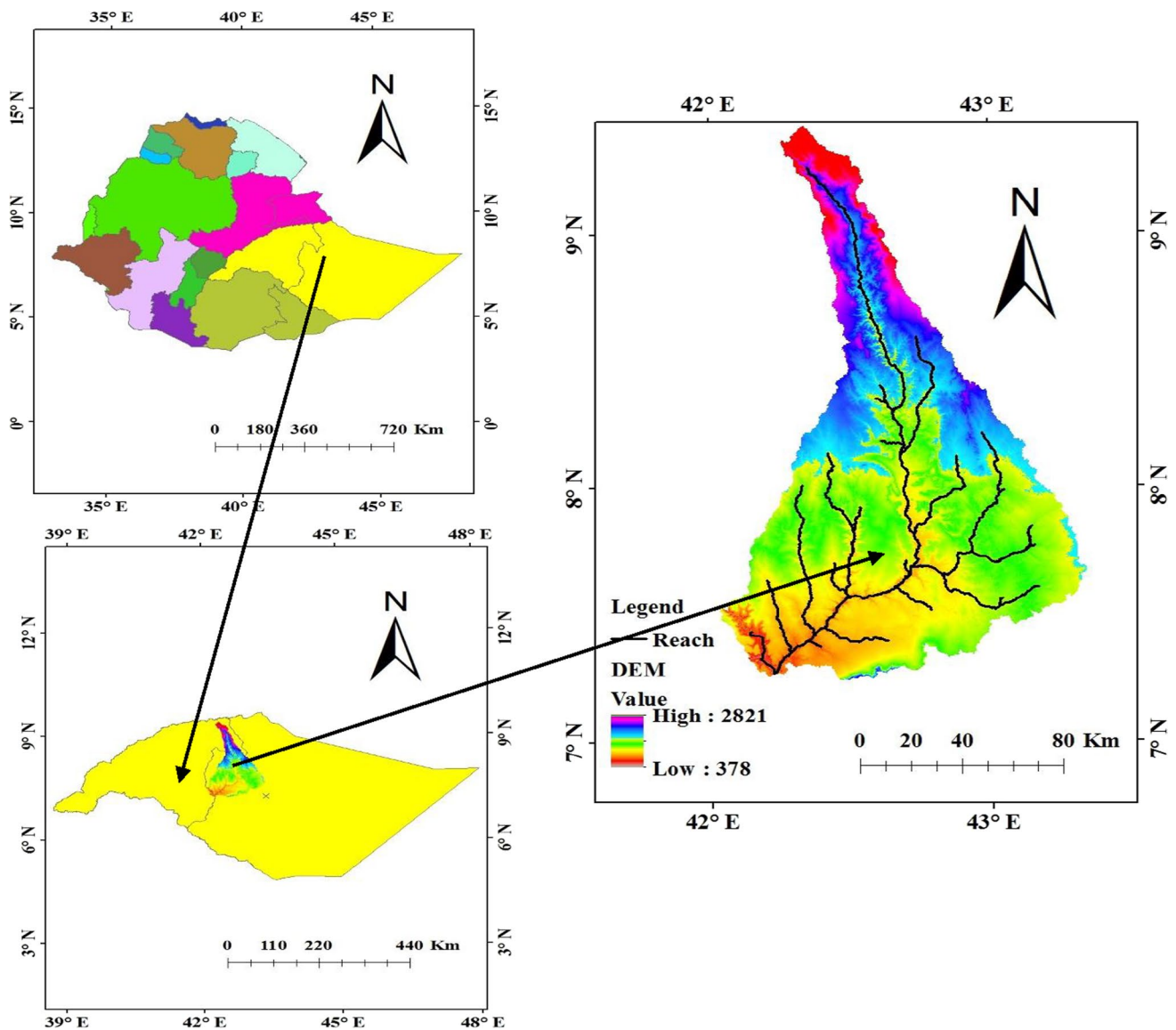
Fig. 1 Location map of the study area

ratio method. Missing values were estimated from other stations around the missing recording station considering the assumptions of at least three as close as possible and evenly spaced around the station within the missing recording station. The simple arithmetic means the method is used when the mean monthly precipitation of all index stations is within 10% of the considered station. The normal ratio (NR) method is used if the normal annual precipitation of any surrounding gauges exceeds 10% of the gauge that is under consideration. As a result, for this study, the simple arithmetic means the method is used for filling the missing data.

The non-dimensional rainfall record method is used to check the homogeneity of the selected stations in the watershed. In this method, the recorded precipitation data were plotted to compare the stations with each other. A graphical comparison of the rainfall data was done by plotting the time series of monthly rainfall data. The rainfall distribution nature of the stations in the study area is homogenous because they all have one distinct rainfall pattern almost for two stations. The maximum rainfall of the watershed occurred between June and September. However, the rainfall distribution between March and May shows a little bit peaks, especially in April which shows the maximum rainfall of the season. The consistency of rainfall records on selected stations is commonly checked by double mass curve analysis. The double mass curve is a graphical method used for identifying and adjusting inconsistency in a station's rainfall record by comparing its time trend with those of adjacent stations. The double mass curve analysis in which accumulated rainfall data was plotted against the mean value of all

neighborhood stations. The result shows the rainfall is consistent throughout the catchment and it is possible to use the data for future research.

Sediment Rating Curve Preparation

The Daketa rivers at the Hammaro gauging station were not on a continuous record of time steps; so by using streamflow and measured sediment load data was generated in a continuous-time step data by developing a sediment rating curve**.** The sediment rating curve plotted shows average sediment concentration or load on the Y-axis and that of discharge averaged on the X-axis over daily, monthly, or other times (Fig. 2). Therefore, using the rating curve the records of discharges are transformed into records of sediment concentration or load and the general relationship can be written as Eq. (1).

$$Qs = a^* Q^b \qquad (1)$$

where Qs is the sediment load in (ton/day), Q is daily streamflow in m^3/s, and a and b are the regression constants.

SWAT Model

SWAT is a hydrologic or water quality model developed by the United States Department of Agriculture—Agricultural Research Service (USDA-ARS) [1]. The model was developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large, complex watersheds with varying soils, land use, and management conditions over long periods. SWAT model is a physically based semi-distributed model,it is one of the most widely used and scientifically accepted tools for assessing water quality, sediment transport, and streamflow in a watershed. In SWAT, a watershed is divided into multiple sub-watersheds, which are further subdivided into hydrologic response units (HRUs) that consist of homogeneous land

use, management, and soil characteristics. The HRUs represent percentages of the sub-watershed area and are not identified spatially within a SWAT simulation. SWAT models allow the user to delineate the watershed and sub-watershed using downloaded DEMs. The delineation of watersheds and sub-watersheds was carried out using several steps including flow accumulation, flow direction, selection of the watershed outlet, delineation of the watershed, and finally calculation of the sub-watershed parameters. In SWAT, a watershed is divided into 43 sub-watersheds, which are further subdivided into 251 hydrologic response units (HRUs) consisting of homogeneous land use, management, and soil characteristics (Fig. 3).

Sensitivity Analysis, Calibration, and Validation

The sensitive parameter in SWAT is helpful to model users in identifying parameters that are most influential in governing streamflow, sediment yield, or water quality response. In addition, sensitivity analysis can provide a better understanding of which particular input parameters have a greater effect on model output. Therefore, to minimize parameter discrepancy, it is necessary to determine the parameters, which are affecting the results and the extent of variation. Sensitivity analysis identifies the input uncertain variables that have the highest contribution to the uncertainty in output variables. After the most sensitive parameters are identified in the model, the next step is the calibration process. Calibration is an effort to better parameterize a model to a given set of local conditions, by reducing the prediction uncertainty. Model calibration is performed by carefully selecting values for model input parameters (within their respective uncertainty ranges) by comparing model predictions (output) for a given set of assumed conditions with observed data for the same conditions [2].

In the study area, model calibration is the modification of parameter values and the comparison of the predicted output of interest with measured data until a defined objective

Fig. 2 Sediment rating curve of Daketa sub-basin at Hammaro head gauge station
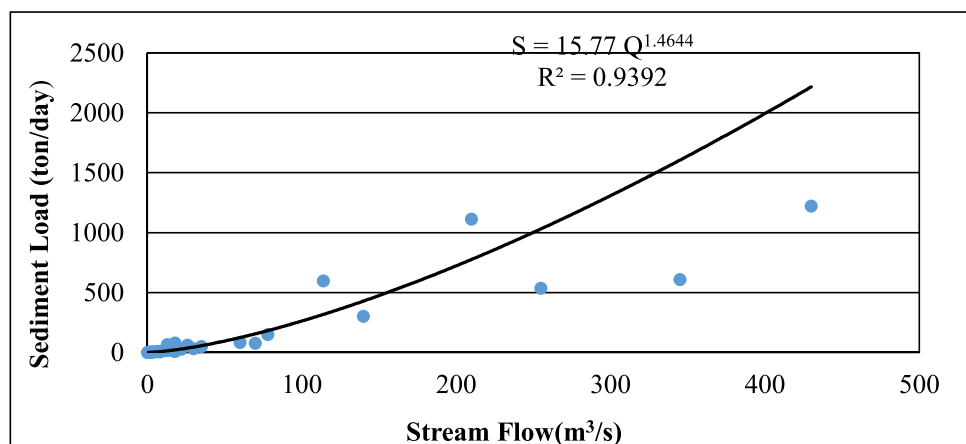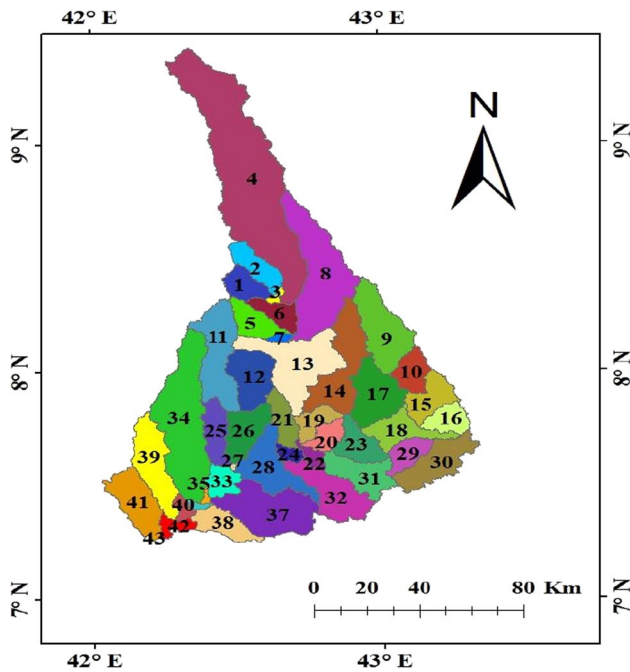
Fig. 3 Spatial distribution of sub-basins of the Daketa watershed

function is achieved. Manually adjust the parameter values before and after the calibration processes until they more closely match the behavior of the model with that of the study area. Model calibration was performed over 5 years, from January 1, 1997, to December 31, 2001, excluding the 2-year warming periods. For this study, the calibration process was carried out for streamflow and sediment. Once the calibration process is complete, the validation process follows. Validation is the comparison of the model results with an independent data set without further adjustment of the parameter values. The validation period of this study was from 1/Jan/2002 to 31/Dec/2005.

Evaluation of Statistical Performance of the Model

The overall model calibration and validation performance of different statistical indicators were evaluated to determine the quality and reliability of the prediction compared to the observed values. For this study, coefficient of determination (R^2), Nash–Sutcliffe modeling efficiency (NSE), mean square error (RSR) observation standard deviation ratio, and percent bias (PBIAS) were used to verify the performance of the model.

Developing Scenarios for Watershed Management in SWAT Mode

After well evaluating the model performance, the sub-basin of the watershed with high sediment yield is identified to

apply sediment reduction methods or management operations. In the study area to preserve the potential of water resources, practical measures are needed to prevent soil erosion. Comprehensive land and water management planning are adapted to local conditions. It is important to formulate measures that involve vegetation planting, engineering practices, conservation tillage, and sheet and gully erosion control, to ensure the best-integrated benefits of various conservation measures Chekol [6]. Based on the recommendations given by OWWDSE [10], sediment reduction methods such as physical measures and vegetation covers were selected and applied in the SWAT model sub-basin in the editing model input tables management operations directory.

Developing Scenario's Input Analysis

The scenario is the consideration of possible alternative outcomes. In order to develop strategies for planning and managing water resources and assessing the impacts of environmental change, they are often guided by the analysis of multiple future scenarios. They are different scenarios that were developed to manage the effect of human activities on sediment production in the study watershed.

Scenario 1: Baseline Scenario

The current limit of the existing conditions that were initially present before performing the scenario simulations is considered. This corresponds to current land management practices without applying conservation measures or being used as a reference point.

Scenario 2: Filter Strip

In the SWAT model, the simulated filter strip by programming the year, month, and day for the parameter. Management operation (MGT_OP), for simulation filter strips (FILTER_I) and VFSI, the ratio of field area to filter strip area (FILTER_RATIO) most common values 30–60, fraction of HRU draining 10% more area filter strip concentrate (FILTER_CON). Ten percent of the filter strip can receive between 0.25 and 0.75 runoff from the entire field. Fraction of flow within the most concentrated 10% of the filter strip, which is completely channeled (dimensionless). For this study, 5 m and 10 m wide filter strips were placed for all the HRUs.

Scenario 3: Grass Waterways

The simulation step was performed based on the adjusted parameters, such as grass waterway simulation (GWATI), manning value for overland flow (GWATN, default 0.35), sediment calculation in the pathway grassy waterway

(GWATSPCON), the depth of the grassy waterway from the top of the bank to the bottom (m) (GWATD), the average width of the grassy waterway (m) (GWATW), length of the grassy waterway (km) (GWATL), and mean channel slope of the grassy waterway (m) (GWATS).

Scenario 4: Terracing

The terraces in the SWAT model are simulated by adjusting the erosion parameters. The USLE practice factor (TERR_P), slope length (TERR_SL), and curve number (TERR_CN) are adjusted to simulate the effect of terraces. The appropriate curve number (CN) was established for this study according to the type of cover, the hydrological condition, and the hydrological soil groups [2]. On the other hand, the USLE cultivation practice factor (P) was also selected based on the slope range. TERR_SL should be the maximum distance between terraces Arnold et al. [3]. For this study, a 45% reduction in slope length was used.

Results and Discussions

Sensitivity Analysis for Sediment Yield

The average slope steepness, USLE support practice factor, channel erodibility factor, linear factor for channel sediment routing, and exponential factor for channel sediment routing as the most sensitive parameters that significantly affect sediment yield. From sediment simulation results, five parameters were identified in Table 1.

Sediment Yield Calibration

Calibration for sediment yield was carried out over 5 years from January 1, 1997, to December 31, 2001, excluding the 2-year warming periods. Default sediment parameters were adjusted by iteratively varying over recommended ranges up to the acceptable limit of the statistical performance of the optimized appraisers. Model calibration was performed by comparing the simulated sediment yield with the observed yield. Sediment yield of the gauging station in the Daketa sub-basin based on the developed sediment rating curve. After adjusting all the values of the initial sediment

parameters, the following final results were accepted. USLE support practice factor (USLE_P) was set to 0.062, and average slope (HRU_SLP) was set to 0.025. The performance of the model between measured and simulated sediment yield was determined by using R^2, NSE, RSR, and PBIAS (Table 2). The observed and simulated monthly sediment load in the calibration period shows that the model slightly overestimated some of the monthly basin sediment yields that were observed during the high flow period (Fig. 4).

Sediment Yield Validation

The validation period for sediment performance was from January 1, 2002, to December 31, 2005. It was carried out with independently measured sediment data that was not used during the calibration period. During validation, a good agreement between simulated and observed sediment is shown in Fig. 5. The observed and simulated sediment yield in the monthly time step of the validation period showed that the model slightly underestimates the sediment yields of high flow periods.

In general, the study area's average annual value of the soil loss was estimated by WWDSE and WAPCOS (2004) using the sub-divisions of the Daketa sub-basin catchment, which considers meaning annual sediment yield of 5.0 M tons. The estimated mean annual sediment yield of the Daketa sub-basin watershed was 14.43 t/ha/year.

Sediment Yield in Sub-basin

The Daketa watershed is classified into 43 sub-basins; then each sub-basin is divided into 251 HRUs. The HRU analysis tool in the Arc SWAT model helped load land use, soil layers, and slope. HRU analysis in SWAT includes HRU divisions by slope classes in addition to land use and soils. The slope of the study area was classified into five slope

Table 2 Model performance test for calibration and validation period of sediment parameter

Months	Simulation	R^2	ENS	RSR (%)	PBIAS (%)
1997–2001	Calibration	0.83	0.81	44	8.29
2002–2005	Validation	0.75	0.72	45.2	12.4

Table 1 Sediment parameters and degree of sensitivity for Daketa watershed

Sediment parameters	SWAT_code	Range
USLE support practice factor	USLE_P	0.0–1.0
Linear factor for channel sediment routing	Spcon	0.0001–0.01
Average slope steepness	HRU_SLP	0.0–0.2
Exponential factor for channel sediment routing	Spexp	1.0–2.0
Channel erodibility factor	Ch_Erod	0–1

classes 0–2% (flat), 2–8% (smooth to undulating), 8–15% (undulating/steep), 15–30% (moderately steep), and > 30% (steep slopes).

The contribution of sediments to the reach of each sub-basin was not uniform due to the distribution of rainfall, runoff, soil, and slope erosion. The sediment hotspot area of the sub-basin was identified using model output. In the Daketa basin, the sub-basins that produced the most sediment were 8, 24, 26, 29, 37, 38, 42, and 43; the remaining sub-basin produced minimal sediment (Fig. 6). These sub-watersheds were covered by scrub, agricultural land,

forest, grassland, and bare land of land use/cover types. The slope of these high sediment-producing sub-basins is greater than 15% slope area coverage or steep and moderately steep slopes. These slopes cover about 6219 km² of the total area of the basin or cover about 42% of the total basin; high sediment is produced. According to Fig. 6, the result shows that the relation between slope and sediment yield had a direct relation in some of the sub-basins. The slope is steep; there is high sediment production. Sub-basin 37 and 38 are the hotspot area in the Daketa watershed.

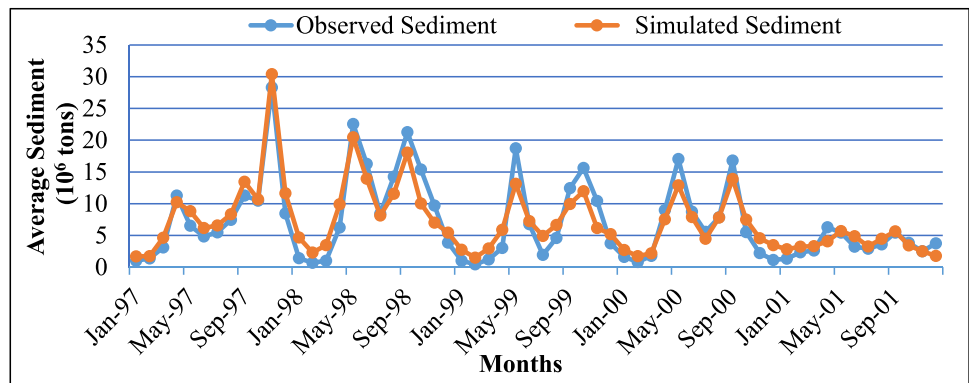**Fig. 4** Sediment yield calibration at Daketa sub-basin gauging station
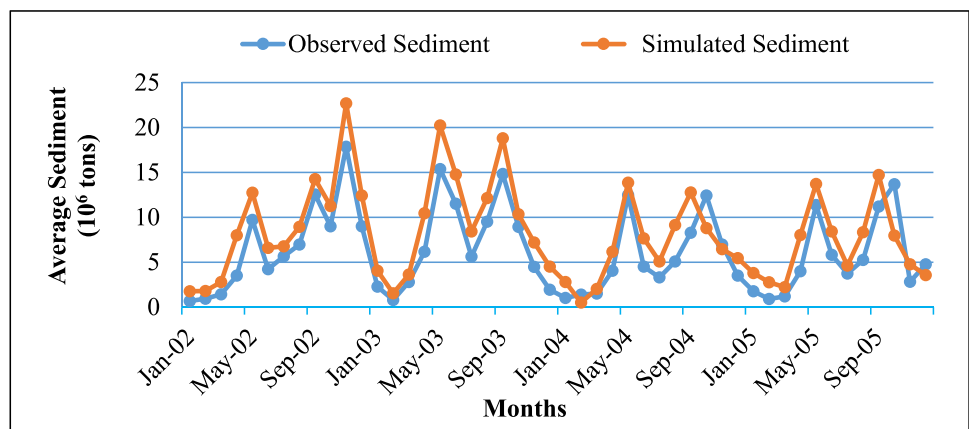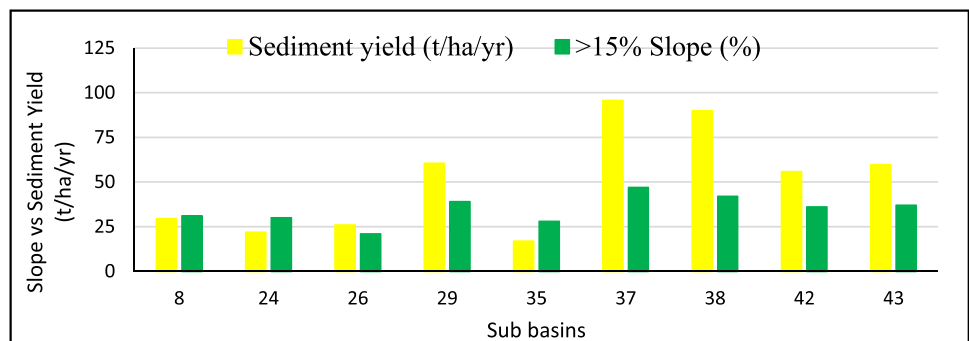

Fig. 5 Sediment yield validation graph

Fig. 6 Critical sub-basin slope-sediment yield relationships

Scenario Development Analysis

There is an effect of soil erosion and sediment production from the critical sub-watershed of the study area, which needs conservational practices. The management operations were simulated in the SWAT model to observe the reduction change from the output sediment yield of the model by selecting the high sediment yielding sub-basins. Therefore, to use the model as a tool for analyzing the effects of different activities in the study area, an alternative scenario analysis was developed. The following four management scenarios were considered and simulated.

Scenario 1: Baseline Scenario

The baseline scenario was considered only the existing conditions of the study area. The baseline scenario corresponds to the current land management practices without conservation measures. The sediment yield is maximum in 8, 24, 26, 29, 37, 38, 42, and 43 sub-basins in the existing conditions of the study area (Fig. 7).

Scenario 2: Filter Strip

The width of the filter strip has a significant effect on reducing sediment production. The 5-m width of the filter strip reduces the average sediment yield by 16.22 t/ha/year compared to the reference condition, which is 32%. On the other hand, the 10-m width of the filter strip reduces the average sediment yield by 22.96 t/ha/year compared to the reference condition, which is 45.3% (Table 3). The 5-m width of the filter strip is good for reducing sediment reduction compared to the 10-m width of the filter strip.

Scenario 3: Grass Waterway

The mean annual sediment production at the baseline is 50.68 t/ha/year and after applying the grassy waterways, the sediment production is reduced to 12.87 t/ha/year (Table 4). The grassy waterway reduces sediment yield with an efficiency of 74.6% relative to the baseline scenario. Grassed waterways are an effective best management practices method in Daketa watershed to reduce sediment yields.

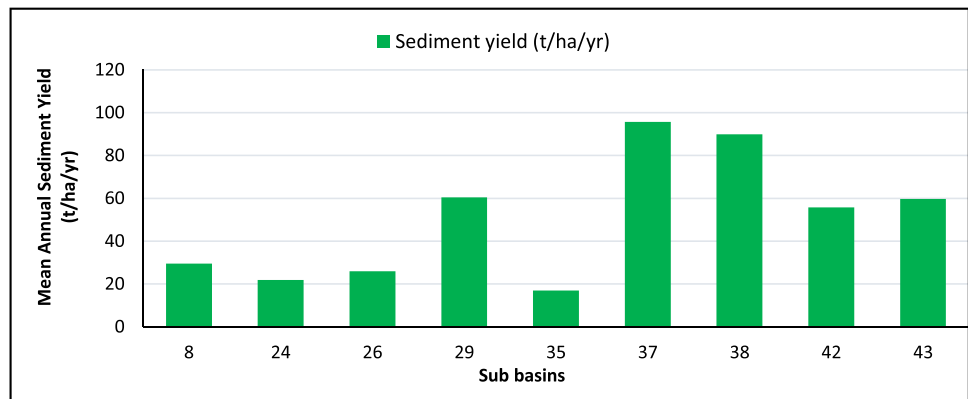**Fig. 7** Scenario 1 critical sub-basin mean annual sediment yield

Table 3 Mean annual reduced sediment yield due to filter strip 5-m and 10-m width

Critical sub-basins	Mean annual sediment yield (t/ha/yr)	Mean annual sediment yield reduction (t/ha/yr)	
		Reduced sediment yield due to filter strip (5 m)	Reduced sediment yield due to filter strip (10 m)
8	29.53	9.45	13.38
24	21.92	7.01	9.93
26	25.99	8.32	11.77
29	60.48	19.35	27.4
35	16.97	5.43	7.69
37	95.76	30.64	43.37
38	89.89	28.76	40.72
42	55.83	17.84	25.29
43	59.72	19.11	27.05

Table 4 Reduced mean annual sediment yield due to scenario 3

Critical sub-basin	Mean annual sediment yield (t/ha/yr) for baseline	Grass waterway (t/ha/yr)
8	29.53	7.5
24	21.92	5.57
26	25.99	6.6
29	60.48	15.36
35	16.97	4.31
37	95.76	24.32
38	89.89	22.83
42	55.83	14.18
43	59.72	15.17

Table 5 Reduced mean annual sediment yield due to scenario 4

Critical sub-basin	Mean annual sediment yield (t/ha/yr) for baseline	Terracing 45% slope
8	29.53	10.4
24	21.92	7.72
26	25.99	9.15
29	60.48	21.29
35	16.97	5.97
37	95.76	33.71
38	89.89	31.64
42	55.83	19.65
43	59.72	21.02

Scenario 4: Terracing

The application of terraces in watershed management is an option to reduce runoff and soil erosion, considerably reducing the production of sediments from sub-watersheds. Mean annual sediment yield was reduced from 50.68 to 17.84 t/ha/ year and the terraces effectively reduce sediment by 64.8% from baseline (Table 5). Soil erosion is one of several major

deterioration processes in Ethiopia that leads to soil degradation and lower agricultural productivity. As a result, numerous attempts have been made to control soil erosion by implementing soil and water conservation measures at various periods and locations across the country. Terracing is the most widespread and productive of these soil and water conservation strategies in Ethiopia.

Scenario Comparison

In the Daketa watershed, the sub-basins that produced the most sediment were 8, 24, 26, 29, 37, 38, 42, and 43; the remaining sub-basin produced minimal sediment. The mean annual sediment was calculated for selected sub-basins for each scenario. According to Table 3, the grass waterway is the best sediment reduction method as compared to other methods. The 5 m wide filter strip is the second best method to reduce sediment production in the catchment (Table 6).

The best management practice is applied in the model to see the effectiveness of sediment reduction methods. The effectiveness of the best management practice scenario was computed by calculating the percentage change in the SWAT model outputs using Eq. (2).

$$Effectiveness\ of\ BMP = \left(\frac{PreBMP - PostBMP}{PreBMP} \right) * 100 \tag{2}$$

According to Table 4, the result shows that the grass channel is the best scenario to reduce sediment production in the Daketa watershed compared to other scenarios. The functions of grass waterways include reducing the volume and speed of runoff and retaining sediment and noxious substances from adjacent fields. The grassy waterway reduces sediment yield with an efficiency of 74.6% relative to the baseline scenario. Overall, the results indicated a high potential for grass waterways to reduce the volume and velocity of runoff, sediments, and agrochemicals from agricultural catchments (Table 7).

Table 6 Reduced mean annual sediment yield (t/ha/year) due to applied scenarios

Critical sub-basin	Baseline scenario	Filter strip (5 m)	Filter strip (10 m)	Grass waterway	Terracing 45% slope length reduction
8	29.53	9.45	13.38	7.5	10.4
24	21.92	7.01	9.93	5.57	7.72
26	25.99	8.32	11.77	6.6	9.15
29	60.48	19.35	27.4	15.36	21.29
35	16.97	5.43	7.69	4.31	5.97
37	95.76	30.64	43.37	24.32	33.71
38	89.89	28.76	40.72	22.83	31.64
42	55.83	17.87	25.29	14.18	19.65
43	59.72	19.11	27.05	15.17	21.02

Table 7 Mean annual sediment yield (t/ha/year) reduced in percent

Scenarios	Scenario 1	Scenario 2		Scenario 3	Scenario 4
	Baseline	Filter strip (5 m)	Filter strip (10 m)	Grass waterway	Terracing
Total mean annual sediment yield (t/ha/yr)	50.68	16.22	22.96	12.87	17.84
Mean annual sediment reduction from baseline	–	34.46	27.72	37.81	32.84
Mean annual sediment reduction from baseline (%)	–	68	54.7	74.6	64.8

Conclusions

The main purpose of this study is sediment yield modeling and evaluation of best management practices using the SWAT model of the Daketa watershed. The mean annual sediment yield of the Daketa watershed is 14.43 t/ha/year. The average annual sediment yield during the baseline is 50.54 t/ha/year after applying the management scenarios; this result was reduced to 34.46 t/ha/year and 27.72 t/ha/year due to the width of the filter strip 5 m and 10 m, respectively. The mean annual sediment reduction was 37.81 t/ha/year due to grass waterway and 32.84 t/ha/year due to terracing from the baseline. Generally, the grassy waterway reduces sediment yield with an efficiency of 74.6% relative to other scenarios. This study recommends watershed management options as an important method of sediment reduction based on the comparable result of the previous study in various watersheds. As a result, the grassy waterway is a cost-effective technique and it must be applied in the area of the erosion hotspot in the watershed.

Declarations

Consent for Publication We have submitted the manuscript entitled "Sediment Yield Modeling and Evaluation of Best Management Practices Using the SWAT Model of the Daketa Watershed, Ethiopia" to be considered for publication. We declare that this is our original research work.

Conflict of Interest The authors declare no competing interests.

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