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Original Article

Assessing the Impact of Land Cover Change on Streamflow and Sediment Yield Using the SWAT Model and GIS in the Srepok River Basin, Vietnam

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Abstract: The Srepok River Basin is part of the major river system in the Central Highlands, playing a crucial role in irrigation, hydropower generation, and sustaining cross-border flows to Cambodia. In recent years, the basin has been significantly affected by land cover changes and land use conversion, which have altered flow regimes, increased erosion and sedimentation. This study applied the SWAT (Soil and Water Assessment Tool) model in combination with a geographic information system (GIS) to simulate discharge and sediment in the Srepok River Basin, aiming to assess the impacts of land cover change on hydrological processes during 2010-2020. The results indicate that surface flow (SUR_Q) in 2020 increased compared to 2010 (Ban Don station: +9.1%; Cau 14: +7.21%; Giang Son: +5.33%; Duc Xuyen: +6.67%). In contrast, Groundwater flow (GW_Q) decreased over the same period (Ban Don: -21.65%; Cau 14: -15.68%; Giang Son: -16.59%; Duc Xuyen: -17.69%). Sediment load also rose markedly in 2020 relative to 2010 (Ban Don: +8.5%; Giang Son: +4.65%). The main driver of these changes was the reduction in forest cover, which increased erosion and sediment load in the river. Overall, the results demonstrate that integrating the SWAT model with GIS is an effective approach for assessing the impacts of land

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cover change on discharge and sediment dynamics in the Srepok River Basin. The findings provide a scientific basis for basin management, land use planning, and sustainable utilization of natural resources, while supporting socio-economic development goals.

Keywords: SWAT, GIS, land cover changes, discharge, Srepok River Basin.

1. Introduction

Climate change and unsustainable land use activities are increasingly intensifying flow variability in many river basins. One of the main drivers of flow and sediment variability is human disturbance of land cover through land use practices, which strongly affects surface flow (SUR_Q), evapotranspiration, and soil permeability [1]. Concerns about overexploitation of natural resources for economic development in river basins have grown due to their negative environmental consequences. Vietnam is considered a country with degraded water resources, with the Central Highlands being among the most severely affected regions. Here, human activities such as deforestation, slash and burn practices, conversion of forest land to agriculture, hydropower development that reduces soil water retention, and downstream urbanization have significantly altered discharge and sediment regimes [2, 3]. In Vietnam, various approaches have been used to assess water resources in river basins. Among these, hydrological modeling has become the most widely applied method in recent studies, as it allows the development of future scenarios for land and water resources at multiple scales, at the same time consistent with global research trends [4, 5]. This study employs the Soil and Water Assessment Tool (SWAT) integrated with GIS to examine the characteristics and governing processes of basin hydrology.

SWAT has been extensively applied in watershed studies and offers several advantages over earlier models, including the ability to simulate hydrological processes in ungauged basins and to assess the impacts of changes in inputs, such as land use, management practices, and climate [6-8]. The integration of SWAT with GIS also facilitates the delineation of watershed boundaries and the processing of spatial and attribute data. SWAT has been widely applied in discharge forecasting [9, 10], in evaluating the impacts of climate change on river basin flow [11, 12], in simulating the effects of land use and land cover change [13], and in assessing basin water balance under different land cover scenarios [14]. These applications demonstrate that SWAT is effective, versatile, and highly applicable for hydrological simulation.

In the Srepok River Basin, SWAT has been used to assess the individual and combined effects of climate change and land use change on sediment dynamics in its two main tributaries, Krong Anna and Krong Kno [15, 16]. Although numerous studies worldwide have applied the SWAT model to investigate hydrological processes and sediment dynamics, most have focused on individual drivers such as climate change or localized land use changes. However, there remains a significant knowledge gap regarding how large-scale land cover transitions affect both discharge (surface flow and Groundwater flow) and sediment transport in transboundary basins like the Srepok, particularly in the Central Highlands of Vietnam. This study aims to fill this gap by using the SWAT model with GIS to simulate and quantify the impacts of land cover change on hydrological and sedimentary processes during the period 2010–2020. The findings are expected to support evidence-based water resource management and sustainable land use planning in the region.

2. Study Area

The Srepok River Basin is one of the four major river systems in the Central Highlands of Vietnam. Originating from the high terrain of the Truong Son mountain range, the river extends about 450 km before joining the Mekong River.

The basin covers a total area of 18.230 km², flowing through Gia Lai, Dak Lak, and Lam Dong provinces, crossing into Cambodia, and finally discharging into the Mekong. As an transboundary river system, it plays a vital role in socio-economic development, security, national defense, environmental protection, and foreign relations, not only for the Central Highlands but also for Vietnam as a whole (Fig. 1).

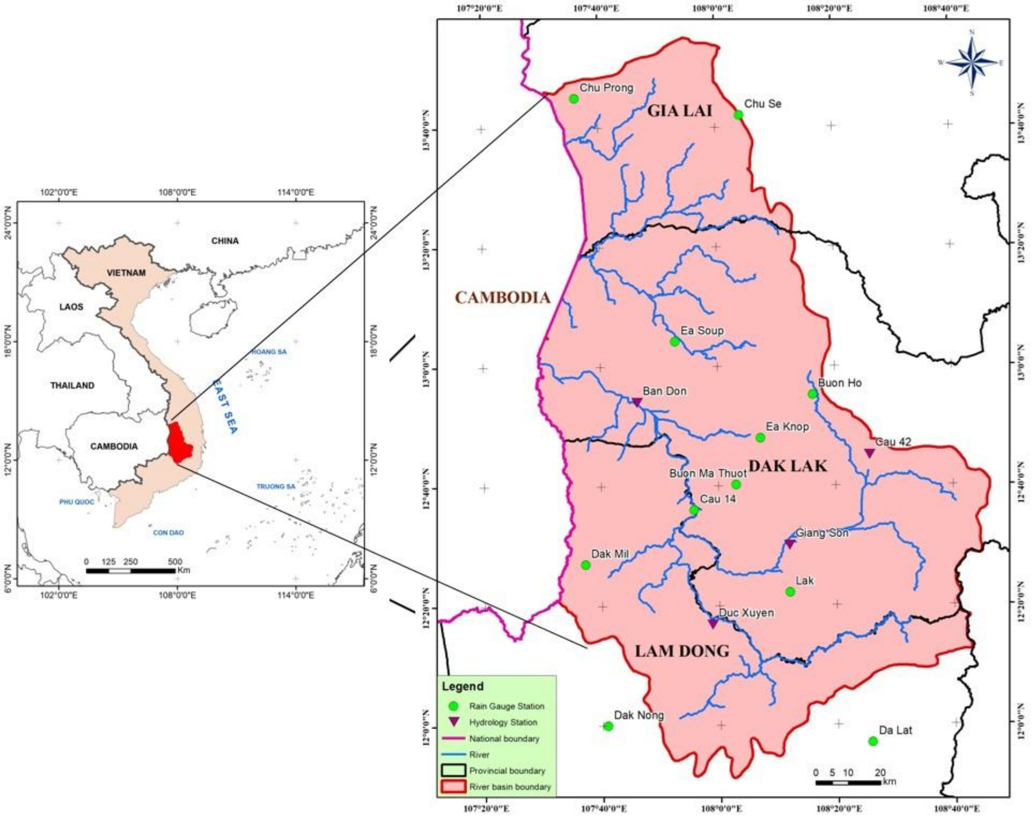

Figure 1. Srepok River Basin.

The basin is located in the tropical monsoon climate zone of the plateaus, consisting of two separate basins: the Ia Drang – Ea Hleo River in the North and the Srepok mainstream. The average annual temperature ranges from 20 °C - 25 °C, with high solar radiation intensity and about 2,337 hours of sunshine per year. Evaporation is higher than in neighboring plains, while the average annual relative humidity ranges from 80–85%. The average annual rainfall exceeds 1,800 mm, distributed in two distinct seasons: the rainy season (accounting for 84–88% of the total annual rainfall) and the dry season (accounting for only 12–16% of the annual rainfall), the flood season starts from June – November with the total flow in the flood season accounting for 65–80% of the total annual flow.

In recent decades, land cover change, particularly the conversion of forest land for agricultural expansion, has become increasingly severe. These changes have altered discharge and intensified riverbed erosion and sedimentation across the basin. This study therefore aims to assess the impacts of land cover change during 2010-2020 on discharge and sediment, providing a scientific basis for sustainable basin management and planning.

3. Methodology

3.1. Mapping and Geographic Information System (GIS) Methods

GIS applications enhance spatial analysis, support the identification of watershed characteristics, and enable watershed delineation using digital elevation models (DEMs) as input. They also provide a systematic framework for watershed analysis through DEMs and standardized datasets such as land cover, soil properties, gauging station locations, and meteorological variables.

In this study, GIS was applied to analyze land cover changes at two periods from 2010 to 2020. Land cover maps and related factors were used to detect changes, and the results were then incorporated into the SWAT model to construct two scenarios corresponding to the 2010 and 2020 land cover conditions.

3.2. Modeling Method Using the SWAT Model

This study applies the SWAT model to two land cover scenarios of the Srepok River Basin, corresponding to the years 2010 and 2020. Based on these scenarios, changes in land cover, weather, and hydrological data were analyzed to evaluate the impacts of land cover change on discharge and sediment. The SWAT model simulates discharge, sediment load, and nutrient loads from each sub-basin and hydrological response unit (HRU), and then routes these outputs through channels, ponds, and reservoirs to the basin outlet [17].

SWAT provides several options for simulating hydrological processes depending on available data. For example, surface flow from HRUs can be estimated using either the Curve Number (CN) method of the United States Soil Conservation Service (USDA-SCS, 1972) [18] or the Green-Ampt infiltration method (Green and Ampt, 1911) [19]. Peak discharge is calculated using the modified rational method. Potential evapotranspiration can be estimated using one of three methods: Hargreaves [20], Priestley-Taylor [21], or Penman-Monteith [22]. The model is based on the physical principles of natural processes and uses correlation and regression equations to describe the relationships between input parameters (e.g., land use/cover, soil, topography, and climate) and output variables (e.g., discharge, sediment, and water quality). The simulation process in SWAT is divided into two main phases [4, 23]: i) The land phase of the hydrological cycle-controls the movement of water, sediment, nutrients, and pesticides from each sub-basin to the main channel; and ii) The routing phase of the hydrological cycle-controls the transport of water, sediment, nutrients, and pesticides through the river network to the basin outlet.

The hydrological cycle is simulated using the water balance equation [18]:

$$SW_t = SW_0 + \sum_{i=1}^{n}\left(R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw}\right) \quad (1)$$

where: SW_t is the soil water content at time t (mm), SW_0 is the initial soil water content (mm), t is time (days), R_{day} is rainfall (mm), Q_{surf} is surface flow (mm), E_a is evapotranspiration (mm), w_{seep} is water percolation into the unsaturated zone (mm), and Q_{gw} is groundwater contribution to discharge on day ith (mm).

Surface erosion in each HRU is estimated using the Modified Universal Soil Loss Equation (MUSLE) [24]:

$$sed = 11.8\left(Q_{surf} \times q_{peak} \times area_{hru}\right)^{0.56} \times K_{USLE} \times C_{USLE} \times P_{USLE} \times LS_{USLE} \times CFRG \quad (2)$$

where: *sed* is the daily sediment load (t), Q_{surf} is surface flow volume (mm/ha), q_{peak} is peak runoff rate (m^3/s), $area_{HRU}$ is the HRU area (ha), K_{USLE} is the soil erodibility factor, C_{USLE} is the cover management factor, P_{USLE} is the support practice factor, LS_{USLE} is the topographic factor (slope length and steepness), and *CFRG* is the coarse fragment factor.

Sediment transport within the river network results from both erosion and deposition processes. At the beginning of each time step, SWAT calculates the maximum sediment concentration in a channel segment. Whether erosion or deposition occurs depends on the actual sediment concentration relative to the river's transport capacity.

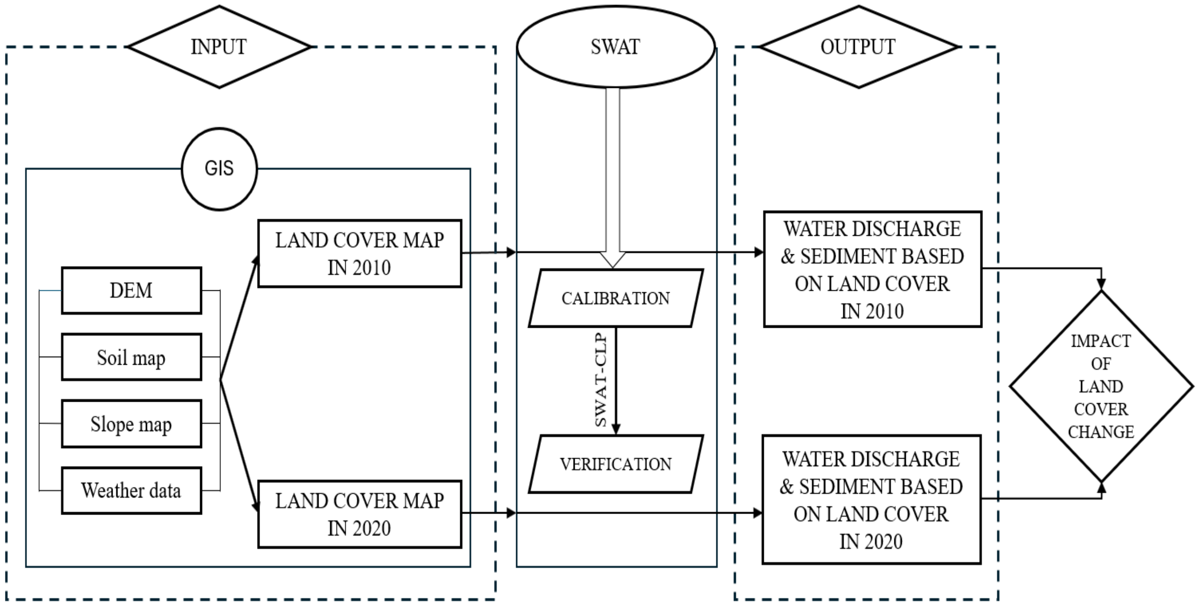

Figure 2. The methodology of research.

3.3. Input Data Processing Method

The input data for the SWAT model consists of multiple spatial and temporal datasets, including basin, sub-basin, and HRU characteristics in Tab. 2, 3. Specifically: i) Spatial data: digital elevation model (DEM), soil map, slope map, and land cover map; and ii) Attribute data: meteorological variables such as maximum and minimum temperature and rainfall. ArcGIS software was used to support data analysis and preprocessing.

DEM data was collected from the United States Geological Survey (USGS): https://earthexplorer.usgs.gov/ Digital Elevation Model (DEM) data with a resolution of 30 m × 30 m. The elevation separated five levels: <300m, 300–600 m, 600–900 m, 900–1,200 m, 1,200–2,400 m (Fig. 3).

Slope map was edited from SWAT model base on Project code 05/HĐ-KHCN-NTM under the National Science and Technology Program on building new rural areas for the period 2016-2020, [25]. It has five groups: under 5%, 5%–10%, 10%–15%, 15%–20%, upper 20% (Fig. 4).

Soil map was collected from Project code 05/HĐ-KHCN-NTM under the National Science and Technology Program on building new rural areas for the period 2016-2020 [25] (Fig. 5).

Meteorological data was collected from National Center for Hydro-Meteorological Data and Information throughout a period from 1980 to 2020 (Tab. 2).

Land cover maps for 2010 and 2020 collected from Project code TN3/T02 under the Program *"Science and Technology for Socio-Economic Development in the Central Highlands"* (KHCN-TN3/11-15) and project code TN17/T05 under the Program *"Science and Technology for Socio-Economic Development in the Central Highlands in the Context of Regional Linkages and International Integration"* (KHCN-TN/16-20) [26, 27] (Fig. 6, 7).

Hydrological data at Ban Don, Giang Son, Cau 14, Duc Xuyen station was used to calibrate and validate model. The period of calibration was from 1991 to 2000 and verification was from 2001 to 2009. Although study had observed data from 2010 till 2020, it was not used to validate because it has four reservoirs which have activated in this period on Srepok river.

Model calibration and validation: SWAT depends on variations in multiple spatial and temporal parameters. Sensitivity analysis is therefore a key step to identify parameters that strongly influence simulation results. Focusing on these sensitive parameters improves the efficiency and accuracy of model calibration. SWAT-CUP was set up to calibrate the model with some parameters and five hundred times iteration. The calibration result was showed in (Tab. 3).

To compare simulated and observed values, two statistical indices were applied: the Nash-Sutcliffe Efficiency (NSE) and the coefficient of determination (R^2). These indices were used to evaluate the accuracy of SWAT simulation results.

$$NSE = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \bar{O})^2} \quad (3)$$

$$R^2 = \left(\frac{\sum_{i=1}^{n}(O_i - \bar{O})(P_i - P)}{\sqrt{\sum_{i=1}^{n}(O_i - \bar{O})^2}\sqrt{\sum_{i=1}^{n}(P_i - P)^2}} \right)^2 \quad (4)$$

where: O_i is the observed discharge at time i, $\bar{O}$ is the mean observed discharge, P_i is the simulated discharge at time i, and $\bar{P}$ is the mean simulated discharge, and n is the number of registered flow discharge data. The simulating quality of model is assessed in (Tab. 1).

Table 1. Evaluation of the SWAT model using NSE and R^2 criteria

Criterion/Level	Acceptable	Good	Very good
NSE	0.5-0.65	0.65-0.75	> 0.75
R^2	0.5-0.64	0.65-0.81	> 0.82

Table 2. Sources of Collected Data

No.	Data Type	Source
1	Topographic map (*.dgn)	United States Geological Survey (USGS): https://earthexplorer.usgs.gov/ Digital Elevation Model (DEM) data with a resolution of 30 m × 30 m.
2	Land cover maps for 2010 and 2020	Project code TN3/T02 under the Program “Science and Technology for Socio-Economic Development in the Central Highlands” (KHCN-TN3/11-15) and project code TN17/T05 under the Program “Science and Technology for Socio-Economic Development in the Central Highlands in the Context of Regional Linkages and International Integration” (KHCN-TN/16-20) [26, 27].
3	Soil map	Project code 05/HĐ-KHCN-NTM under the National Science and Technology Program on building new rural areas for the period 2016-2020 [25].
4	Rainfall and temperature data (1980-2020); Discharge and suspended sediment data (1980-2020)	National Center for Hydro-Meteorological Data and Information.

Table 3. List of data collection stations

TT	Station Name	Data Collection period	Collected Data				Coordinates $(^0)$	
			Rainfall	Temperature	Discharge	Suspended Sediment Data	Longitude	Latitude
1	Chu Prong	1980-2017	v				107°53"	13°45"
2	Chu Se	1981-2017	v				108°05"	13°42"
3	Ban Don	1980-2020	v		v	v	107°46"	12°54"
4	Buon Ho	1980-2020	v	v			108°16’	12°55’
5	Buon Ma Thuot	1980-2020	v	v			108°03’	12°41’
6	Cau 14	1980-2020	v		v		107°36"	12°57"
7	Cau 42	1980-2020	v				108°23'	12°46'
8	Ea Knop	1985-2017	v				108°27'	12°48'
9	Ea Sup	1980-2017	v				107°53'	13°04'
10	Giang Sơn	1980-2020	v		v	v	108°12"	12°30"
11	Lak	1980-2020	v				108°11’	12°22’
12	Dak Mil	1980-2020	v				107°39’	12°27’
13	Duc Xuyen	1980-2020	v	v	v		107°59'	12°17'
14	Dak Nong	1980-2020	v				107°41'	12°00'
15	Da Lat	1980-2020	v	v			108°26'	11°57'

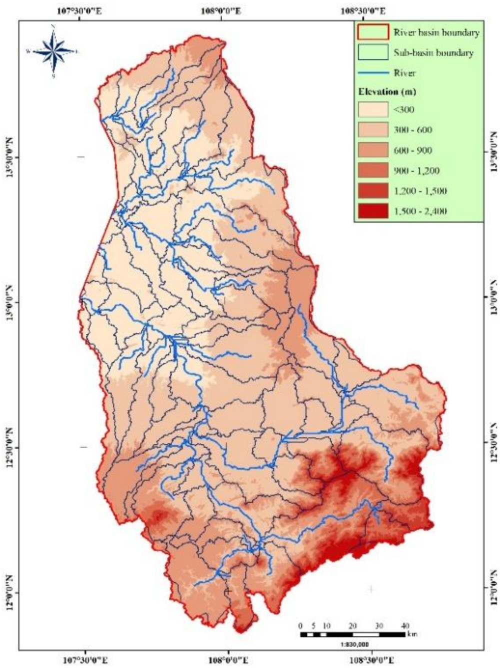

Figure 3. Digital Elevation Model (DEM) of the Srepok River Basin.

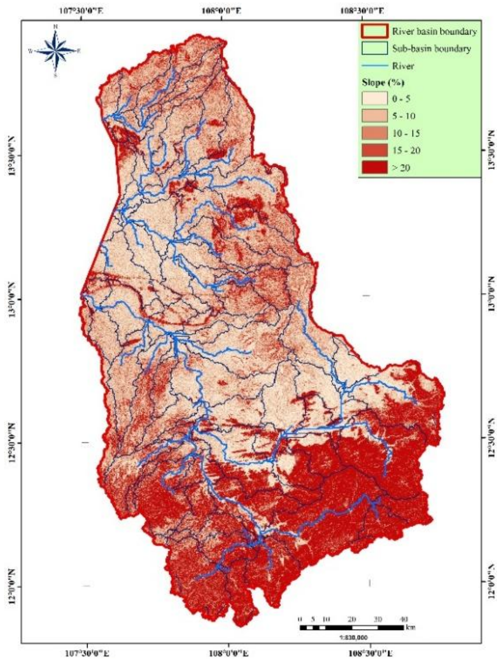

Figure 4. Slope map of the Srepok River Basin.

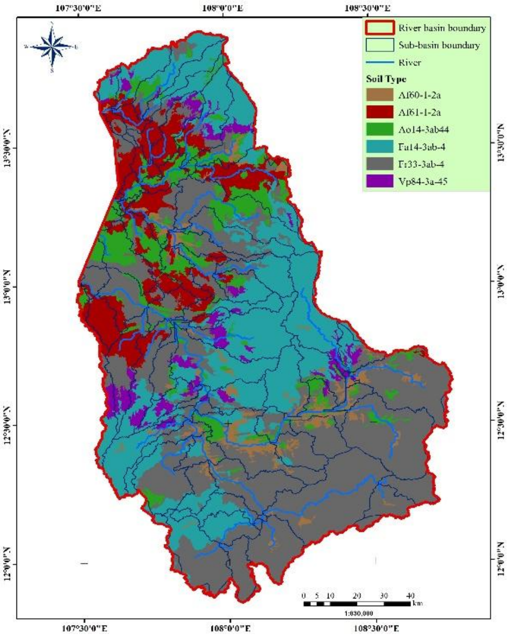

Figure 5. Soil map of the Srepok River Basin.

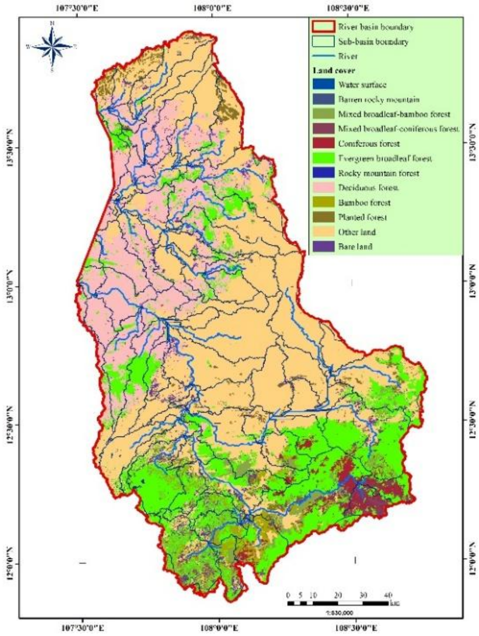

Figure 6. Land cover map of the Srepok River Basin in 2010.

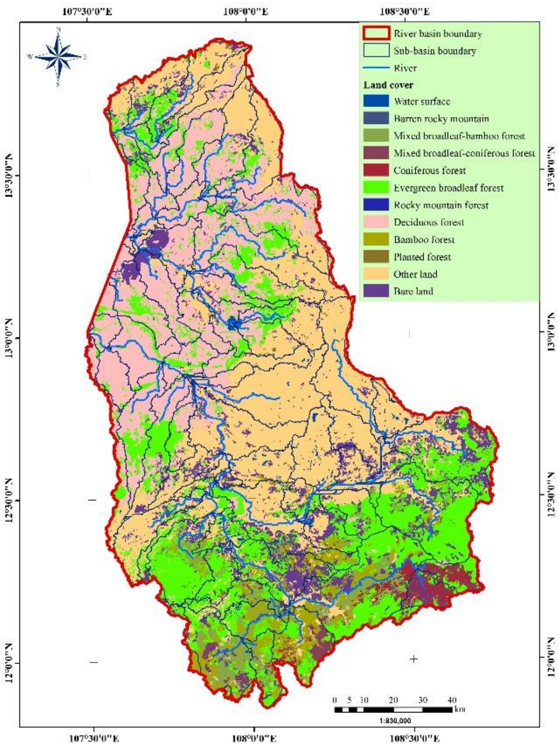

Figure 7. Land cover map of the Srepok River Basin in 2020.

4. Result and Discussion

4.1. Model Calibration and Validation

SWAT model was set up to simulate discharge and sediment in the Srepok River Basin with land cover in 2000. It simulated discharge at 76 sub – basins from 1991 to 2010 and used measured discharge at Ban Don, Giang Son, Duc Xuyen, Cau 14 stations, used measured sediment at Ban Don, Giang Son stations which was simulated on Srepok river to calibrate the calculated runoff of model. The period of calibration was from 1991 to 2000.

In this study, sensitivity analysis was conducted to identify parameters influencing surface runoff. The results indicate that four parameters had the greatest impact on discharge variation: the curve number (CN2), the groundwater flow alpha factor (ALPHA_BF), groundwater delay (GW_DELAY), and the threshold water level in the shallow aquifer for flow generation (GWQMN). For sediment load, the most influential parameter was the soil erodibility factor (USLE_K.sol). SWAT-CUP was set up to calibrate the model with some parameters and five hundred times iteration. The calibration result was shown in (Tab. 4).

As a result, the Nash-Sutcliffe efficiency (NSE) and the coefficient of determination (R^2) reached very good levels, with values of 0.75 and 0.82, respectively. The correlation between the observed and simulated discharge is illustrated in (Fig. 8) and (Fig. 9).

After calibration, the model was validated to evaluate the suitability of the fixed parameter values. Simulated runoff is presented in (Fig. 10)

Table 4. Parameters influencing discharge and sediment load in the Srepok River Basin

Parameter type	Parameter name	Unit	Sensitivity rank	Default range	Optimal range	Optimal value
Parameters influencing discharge	CN2	-	1	30-98	35-85	81
	ALPHA_BF.gw*	-	2	0-1	0-1	0.031
	GW_DELAY.gw	Days	3	0-100	410-472	150 (198.68)
	GWQMN.gw	mm	4	0-5000	3600-4700	4372
	SOL_AWC	mm H_2O/mm soil	5	0-1	0.31-0.46	0.42
	CH_N2.rte	-	6	-0.01-0.3	0.001-0.045	0.037
Parameters influencing sediment load	USLE_K.sol	-	1	0-0.65	0.15-0.58	0.25
	OV_N.hru	-	2	0.01-30	9-22	21.6
	LAT_SED.hru	-	3	0-5000	85-1568	825
	SPEXP.bsn	-	4	1-1.5	1.098-1.36	1.189
	SPCON.bsn	-	5	0.001-0.01	0.002-0.0065	0.0056

Table 5 showed the simulated water discharge were calibrated against monthly observed data from 1991-2000 and it was validated from 2001 to 2009 at Ban Don, Giang Son, Duc Xuyen and Cau 14 stations. The calibration process was conducted using monthly monitoring data from 1990 to 1999, and validation was performed for the period 2000-2009 at Ban Don, Cau 14, Giang Son, and Duc Xuyen stations. The validation results of the model were assessed as good and highly reliable. For discharge simulation, during the calibration period, R^2 values ranged from 0.77 to 0.81 and NSE values from 0.80 to 0.82 across the Duc Xuyen, Giang Son, Cau 14, and Ban Don stations. During the validation period, the model maintained good performance, with R^2 values between 0.76 and 0.8 and NSE values between 0.80 and 0.82. These results indicate that the model reasonably reproduced monthly flow fluctuations as well as major flood peaks in the basin. For sediment load, calibration and validation also showed high consistency. At Giang Son and Ban Don stations, R^2 values ranged from 0.76 to 0.79 and NSE values from 0.75 to 0.84 during calibration. In the validation phase, R^2 values ranged from 0.75 to 0.77 and NSE values from 0.79 to 0.81, respectively.

Table 5. Calibration and validation results at stations in the Srepok River Basin

Variable	Station	Calibration		Validation	
		R^2	NSE	R^2	NSE
Discharge	Duc Xuyen	0.79	0.8	0.76	0.81
	Giang Son	0.8	0.81	0.78	0.82
	Cau 14	0.77	0.8	0.79	0.80
	Ban Don	0.81	0.82	0.8	0.81
Sediment	Giang Son	0.76	0.75	0.75	0.79
	Ban Don	0.79	0.84	0.77	0.81

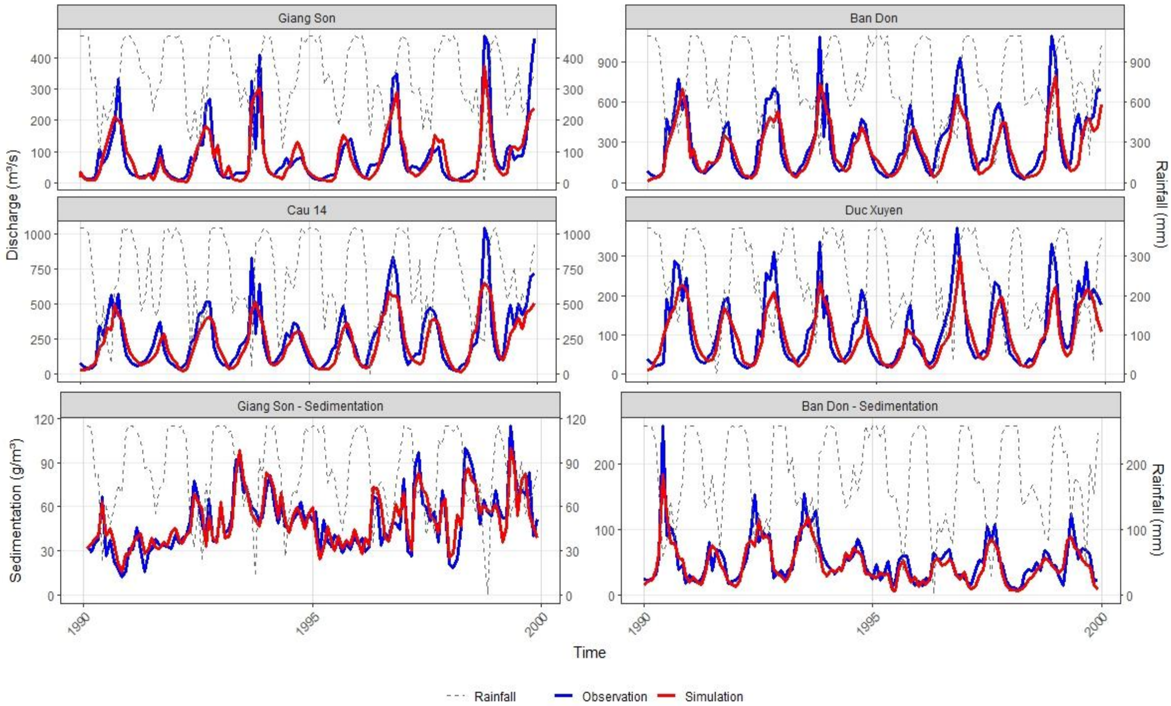

Figure 8. Comparison for the period 1990-1999 of observed and simulated mean monthly discharge at Giang Son, Ban Don, Cau 14, Duc Xuyen stations; observed and simulated mean monthly sediment load at Giang Son and Ban Don stations.

The simulation results indicate that discharge in the Srepok River Basin exhibits strong seasonal variability, with flood peaks concentrated in the rainy season and flows declining during the dry season. Suspended sediment concentration follows a similar pattern, rising sharply during flood events and maintaining a relatively high baseline towards the end of the time series. These findings highlight the influence of climate and land use on the hydrological sediment regime and confirm that the SWAT model is not only reliable in reproducing current hydrological and sediment conditions but also an effective tool for analyzing changes in water resources under the impacts of climate variability, hydropower development, and land use change in the basin.

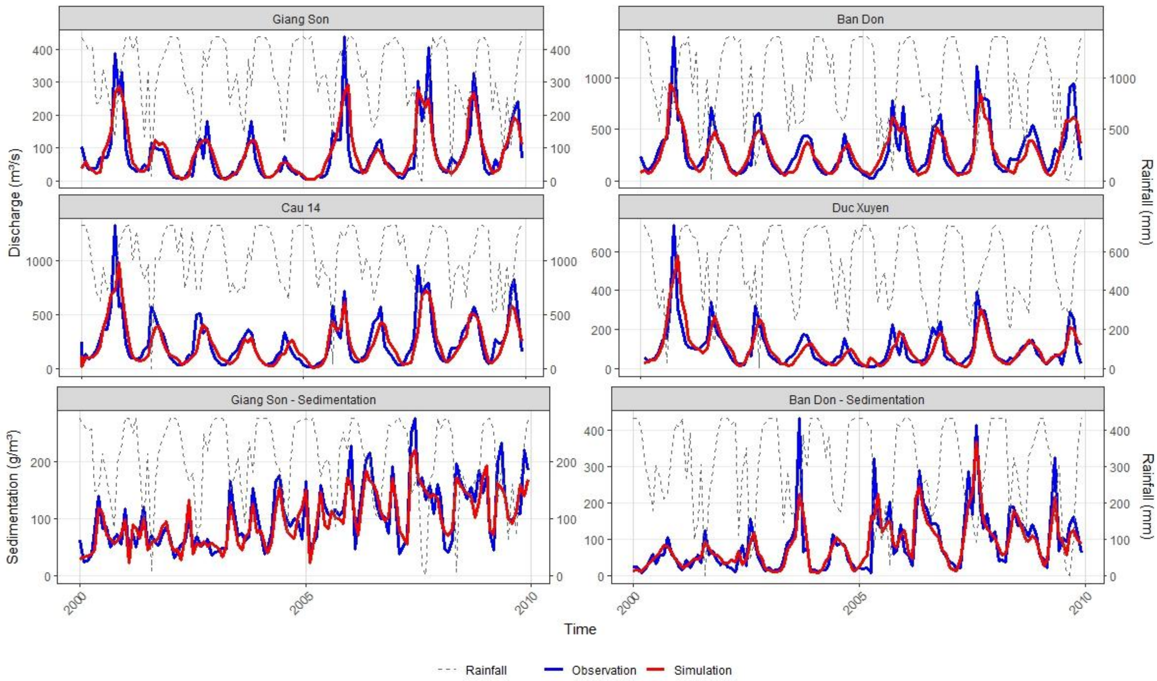

Figure 9. Comparison for the period 2000-2010 of observed and simulated mean monthly discharge at Giang Son, Ban Don, Cau 14, Duc Xuyen stations; observed and simulated mean monthly sediment load at Giang Son and Ban Don stations.

4.2. Assessment of Changes in Land Cover in the Srepok River Basin (2010-2020)

To define the change of land use types of two different land cover maps, one in 2010 and the other in 2020 by ArcGIS software. Table 6 showed the change of land use types between 2010 and 2020.

The SWAT model was run under two different land cover maps to evaluate the impacts of land use change on water discharge in the Srepok watershed. In both Land cover maps, Dem, Soil map and weather data were kept constant, while land cover maps was the only variable: land cover data from the year 2010 were used to simulate water discharge and sediment. It simulated at 76 sub-basins from 2011 to 2020, then land use in 2020 was replaced by land cover 2010.

The study reveals that land cover in the Srepok River Basin underwent substantial transformations between 2010 and 2020, with land cover types shifting back and forth among different categories. By 2020, most natural forest types including evergreen broadleaf forests, deciduous forests, bamboo forests, and mixed broadleaf-coniferous forests-had decreased in area compared to 2010. Only planted forests showed an increase during this period. The area of land for industrial crops expanded sharply in 2020 relative to 2010, while bare land and surface water areas declined significantly. This reduction was partly due to the expansion of construction land, including areas converted for water intake and storage facilities.

Overall, the comparison of land cover maps between 2010 and 2020 highlights notable changes in land cover groups. Industrial crop land, residential areas, and planted forests all increased markedly, while mixed forests, evergreen broadleaf forests, deciduous forests, bamboo forests, and surface water decreased considerably. In general, forested areas declined, whereas industrial crop land, settlements, and urban land expanded, with a substantial reduction in bare land.

Table 6. Changes in Land Cover Types in the Srepok River Basin, 2010-2020

No.	Land cover type	Code	2010 Area (ha)	2010 Percentage (%)	2020 Area (ha)	2020 Percentage (%)	Change (ha)	Change (%)
1	Industrial crops	AGRL	607,115.5	33.4	801,728.2	44.1	+194,612.7	+10.7
2	Residential land	URBN	5,223.0	0.3	48,878.0	2.7	+43,655.5	+2.4
3	Mixed broadleaf-conifer forest	FRSD	57,573.8	3.2	60,774.2	3.3	+3,200.4	+0.2
4	Broadleaf-conifer transitional forest	FRSD	19,521.2	1.1	13,219.7	0.7	-6,301.5	-0.35
5	Coniferous forest	FRSE	18,198.8	1.0	31,824.1	1.8	+13,625.3	+0.75
6	Evergreen broadleaf forest	FRSE	411,987.3	22.7	364,920.9	20.1	-47,066.5	-2.6
7	Deciduous forest	FRSD	429,885.4	23.7	349,146.2	19.2	-80,739.2	-4.5
8	Planted forest	FRSD	7,803.3	0.4	37,227.6	2.0	+29,424.3	+1.6
9	Bamboo forest	FRSD	73,867.9	4.1	42,147.9	2.3	-31,720.05	-1.75
10	Bare land	BARR	169,600.2	9.3	65,168.1	3.6	-104,432	-5.75
11	Water surface	WATR	8,508.3	0.5	7,411.6	0.4	-1,097.1	-0.06
12	Barren rocky mountain	BARR	18.2	0.0	34.89	0.0	+16.71	+0.0009

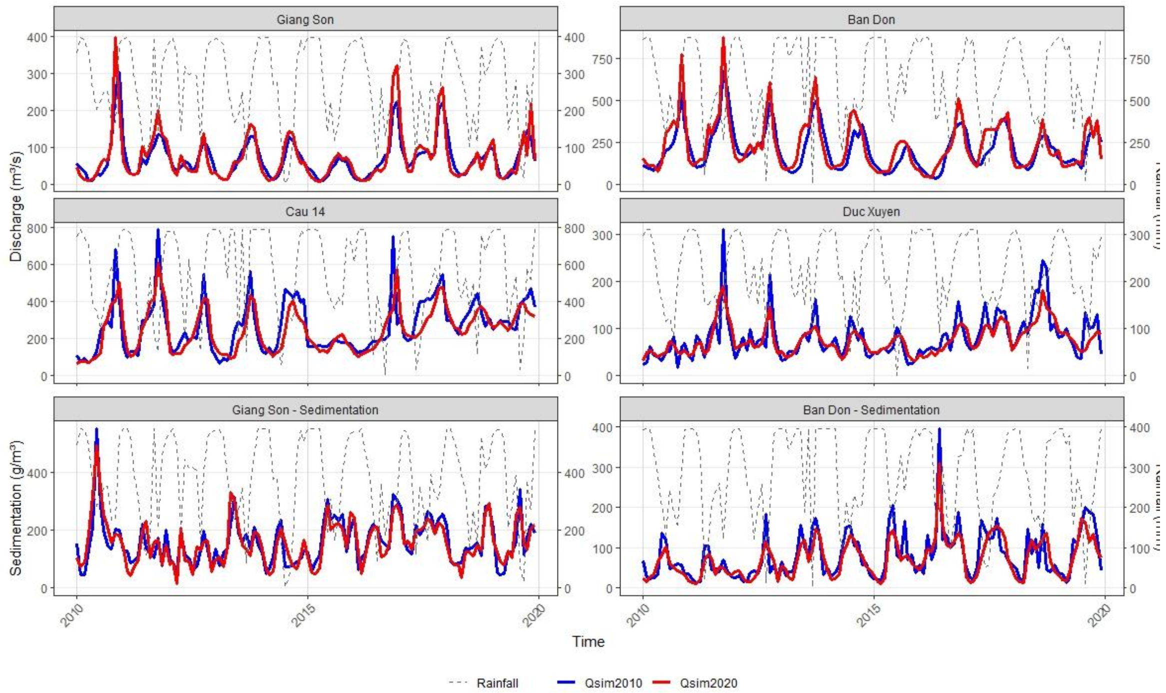

Figure 10. Simulated mean monthly discharge at Giang Son, Ban Don, Cau 14, Duc Xuyen stations under 2010 and 2020 land cover conditions; Simulated mean monthly sediment load at Giang Son, Ban Don stations under 2010 and 2020 land cover conditions.

4.3. Assessment of the Impact of Land Change on Discharge and Sediment in the Srepok River Basin

The study simulated discharge and sediment for the period 2010-2020 at Ban Don, Cau 14, Giang Son, and Duc Xuyen stations. Land cover maps were updated for two time points (2010 and 2020), while other inputs - including terrain factors (DEM), soil maps, and meteorological data - were kept unchanged.

Discharge variation depends mainly on rainfall and land cover. Simulation results for the 2010–2020 period show that flow was unevenly distributed over time. Total surface flow and sediment load associated with the 2010 land cover were lower than those under the 2020 land cover, whereas total groundwater flow under the 2010 land cover was higher than in 2020. The reduction of forest area and the expansion of residential land led to a decrease in groundwater flow and changes in surface flow, while also having a strong impact on sediment dynamics. Forest loss increased soil erosion rates and consequently raised sediment loads in the river (Fig. 10).

5. Conclusion

This study applied the SWAT model integrated with GIS to simulate discharge and sediment in the Srepok River Basin for the period 2010-2020 under two land cover scenarios (2010 and 2020). The objective was to assess the impacts of land cover change on hydrological processes and sediment dynamics. Sensitivity analysis identified four key parameters influencing discharge (CN2, ALPHA_BF, GW_DELAY, GWQMN) and one parameter affecting sediment load (USLE_K.sol). Model calibration and validation results demonstrated good reliability, with R^2 values from 0.65 to 0.81 (good level) and NSE values above 0.82 (very good level). Simulation results showed pronounced seasonal variability in discharge, with flood peaks concentrated in the rainy season and decreasing flows during the dry season. Suspended sediment concentration followed the same pattern, rising sharply during floods and maintaining a relatively high baseline towards the end of the time series.

Land cover analysis indicated that total forest area in 2020 was 899,260.6 ha, a reduction of 119,577.1 ha (11.7%) compared to 2010. This forest loss, along with the expansion of agricultural and residential land, reduced Groundwater flow and increased surface flow and sediment load, thereby intensifying erosion risks. Specifically, surface flow in 2020 increased compared to 2010 (Ban Don: +9.1%; Cau 14: +7.21%; Giang Son: +5.33%; Duc Xuyen: +6.67%), while Groundwater flow decreased markedly (Ban Don: -21.65%; Cau 14: -15.68%; Giang Son: -16.59%; Duc Xuyen: -17.69%).

Sediment load in the river varies across space and time. The reduction of forest area in 2020 compared to 2010 led to a significant increase in sediment load in the river in 2020 (Ban Don station: +8.5%; Giang Son station: +4.65%). Consequently, the erosion risk in the basin also increased.

Overall, the use of SWAT in this study proved to be reliable and applicable to the Srepok River Basin for determining the impacts of land cover change. The calibrated and validated parameters, together with the simulation results. Although the SWAT-GIS approach provided reasonable simulations of discharge and sediment, this study has certain limitations. The model calibration and simulations were based on fixed meteorological data and did not explicitly account for the effects of reservoir regulation or interannual climate variability. These factors may introduce uncertainties in the estimation of surface flow and sediment. Moreover, the analysis focused primarily on land cover changes between 2010 and 2020, without considering potential interactions with other drivers such as rainfall intensity or land management practices.

Future research should incorporate additional meteorological variables, reservoir operation data, and climate change scenarios to improve model robustness. Integrating remote sensing–based precipitation products and high-resolution land use datasets could also enhance spatial accuracy. Despite these limitations, the results of this study provide valuable insights into the independent effects of land use change on hydrological and sediment processes in the Srepok River Basin and serve as a foundation for more comprehensive basin-scale modeling in future studies.

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