ASSESSMENT OF SOIL AND WATER IN UPSTREAM SREPOK WATERSHED – DAKLAK PROVINCE USING GIS AND SWAT MODEL

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ABSTRACT

The Krong Ana sub-watershed locates in upstream Srepok watershed, Daklak province, Vietnam. The Krong Ana sub-watershed is an upland area with elevation varies from 400 to 2,400 m. The region occupies an area of approximately 171,673 ha. The study area is characterized by a range of hills with gentle to relatively high slopes and small valleys. Most of the land area in Krong Ana sub-watershed is slopping land. In many locations, there is high risk of erosion; particularly on land locates in hill sides with high slopes. The Soil and Water Assessment Tool (SWAT) has been widely applied for modeling watershed hydrology and simulating the movement of non-point source pollution. The SWAT is a physically – based continuous time hydrologic model with Arcview GIS interface developed by the Blackland Research and Extension Center and the USDA-ARS to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex basins with varying soil type, land use and management conditions over long periods of time. The main driving force behind the SWAT is the hydrological component. The hydrological processes are divided into two phases, the land phase, which control amount of water, sediment and nutrient loading in receiving waters, and the water routing phase which simulates movement through the channel network. The SWAT considers both nature sources (e.g. mineralization of organic matter and N-fixation) and anthropogenic contributions (fertilizers, manures and point sources) as nutrient inputs. The SWAT is expected to provide useful information across a range of timescales, i.e. hourly, daily, monthly, and yearly time-steps.
During recent years, emerging water and soil problems threaten the livelihood of local people and the sustainability of the whole watershed ecosystems in Vietnam. Day by day there are a lot of water resources is polluted and soil is lost because of degradation of forest or land use change. This study is aimed at assessing factors contributing to soil erosion, water discharge using land use factors in Krong Ana sub-watershed as case study. It is especially important in the upstream Srepok watershed where the soil is highly erodible and forest conversion for agricultural cropping is in serious condition. This study was also focused on how soil loss and surface water was impacted when land use in the watershed resource is changed. The SWAT model was applied to evaluate the effect of main input data of SWAT (land use, soil, human practices) to soil loss and surface water in upstream Srepok watershed.

Keyword: SWAT, GIS, Srepok Watershed, Daklak Province

INTRODUCTION

Watershed degradation is a common phenomenon around the world. There are several reasons for such degradation, but most important is improper utilization of watershed resources, among which land use allocation is the most important. Land use allocation has affected watershed and land degradation. The most important consequence of land degradation in Vietnam is the loss of productivity, depletion of fauna and flora and reduction of agricultural land per capita. In terms of the estimated monetary loss on account of land degradation, water erosion and leaching accounted for more than half, salinisation, acidification, drought and water logging for about one third and decline in soil fertility for the rest. (Buckton et al., 1999). The consequences of flood inundation and water logging are very serious on humans and precious natural resources. With the economic and social development and increasing population in the south of Krong Ana watershed and deforestation and land use change in the upstream of Srepok watershed have affected to groundwater in the dry season and soil erosion and sediment yield in the Krong Ana watershed. Hence, this research attempts to solve the selected Srepok watershed in context of watershed management through GIS and SWAT model.

OBJECTIVES

To formulate watershed management plan in Srepok watershed, the main aim in this investigation is how to apply GIS and SWAT model for supporting decision maker in making decisions on reservation of water and soil resources by delivering appropriate policies about land use allocation, the details of objectives as follows:

1. to assess the impact of deforestation and land use change in Srepok watershed on water discharge, soil erosion;
2. to support decision maker to make policy recommendations on land use planning in Srepok watershed.

METHODOLOGY

1. Location of the study area

The Srepok watershed locates in Daklak province and also in Mekong River Basin system. It is situated between $12^{0}17^{'}$ - $12^{0}36^{'}$ latitude and $108^{0}01^{'}$ – $108^{0}43^{'}$ longitude. The total area of the entire watershed is about 171,672 hectare as shown in Figure 1. The watershed has a relatively high amount of rain fluctuating from 1,800 to 2,500 mm annually.

2. Brief description of SWAT model

The Soil and Water Assessment Tool (SWAT) has been widely applied for modeling watershed hydrology and simulating the movement of non-point source pollution. The SWAT is a physically – based continuous time hydrologic model with Arcview GIS interface developed by the Blackland Research and Extension Center and the USDA-ARS (Arnold et al., 1998) to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex basins with varying soil type, land use and management conditions over long periods of time. The main driving force behind the SWAT is the hydrological component. The hydrological processes are divided into two phases, the land phase, which control amount of water, sediment and nutrient loading in receiving waters, and the water routing phase which simulates movement through the channel network. The SWAT considers both nature sources (e.g. mineralization of organic matter and N-fixation) and anthropogenic contributions (fertilizers, manures and point sources) as nutrient inputs (Somura, H. et.al. 2009). The SWAT is expected to provide useful information across a range of timescales, i.e. hourly, daily, monthly, and yearly time-steps (Neitsch et al., 2002).

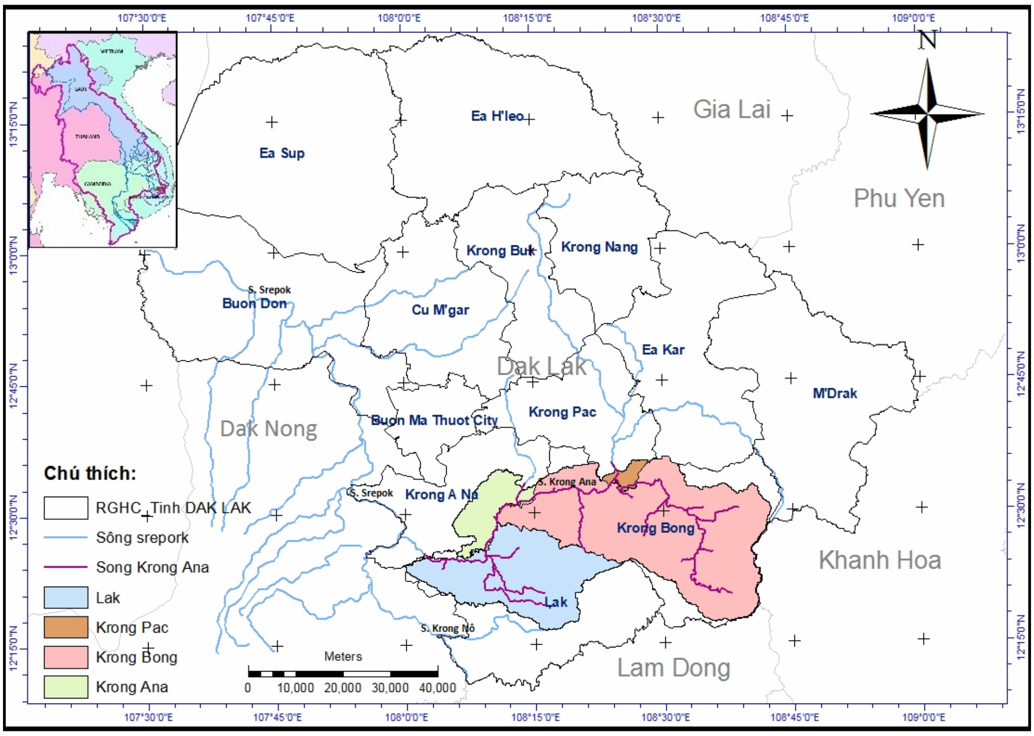

Figure 1. The Srepok watershed map

3. Data collection

Available data and information related to the SWAT modeling in Srepok watershed such as maps, statistic data, forest area, forest cover, population, soil erosion parameter, precipitation, water quality and other the related data was collected by the offices of local authorities and relevant professional institutions and our team. The types of data and their sources are shown in Table 1.

Table 1: Data collection and their sources for SWAT model

Types of data	Sources of data
1. Physical Data	Department of Land Development,Daklak Province
Topography	
Precipitation	Daklak Meteorological Department
Soil erosion	Institute of Water Resource Research in HCMC
Parameter	Department of Land Developmen, Daklak Province
2. Biological Data	
2.1. Land use maps	
2.2.Forest, Agriculture	Department of Agriculture and Rural Development,
3. Socio-economic Data	Daklak Province
Population	Daklak Statistical Department province
Income	

4. Methodology

The SWAT model requires meteorological data such as daily precipitation, maximum and minimum air temperature, wind speed, relative humidity, and solar radiation data. Spatial data sets including digital parameter layers such as parameters (R, K, C, P) and topography

(LS) was digitized from the associated maps. LS factor of the watershed is derived from digital elevation model (DEM) obtained from topography.

The SWAT model was applied in Sprekok watershed as shown in Figure 2.

To assess the sediment yield and water discharge in Srepok watershed, the input data consists of spatial data (maps) and attribute data for SWAT model was used in this research. The spatial data include Srepok digital elevation model (DEM); the streams network of Srepok watershed; Srepok watershed soil map as shown in Figure 3; Srepok watershed land use types in 2005 and 2008 as shown in Table 2 and Figure 4, 5. The attribute data include meteorological data such as average air temperature, rainfall…

Table 2. The change of area of land use and land cover types between 2005 and 2008, Srepok watershed

Unit: ha

Land use types	In 2005	In 2008	Different	% of total area
Agriculture	36,630.82	37,674.34	1,043.52	0.61
Forest	100,516.04	99,071.18	-1,444.86	-0.84
Non-agriculture	4,506.23	5,268.06	761.83	0.44
Bareland	27,361.44	27,000.95	-360.49	-0.21
Water body	2,658.30	2,658.30	0.00	0.00
Total	171,672.83	171672.83	0.00	0.00

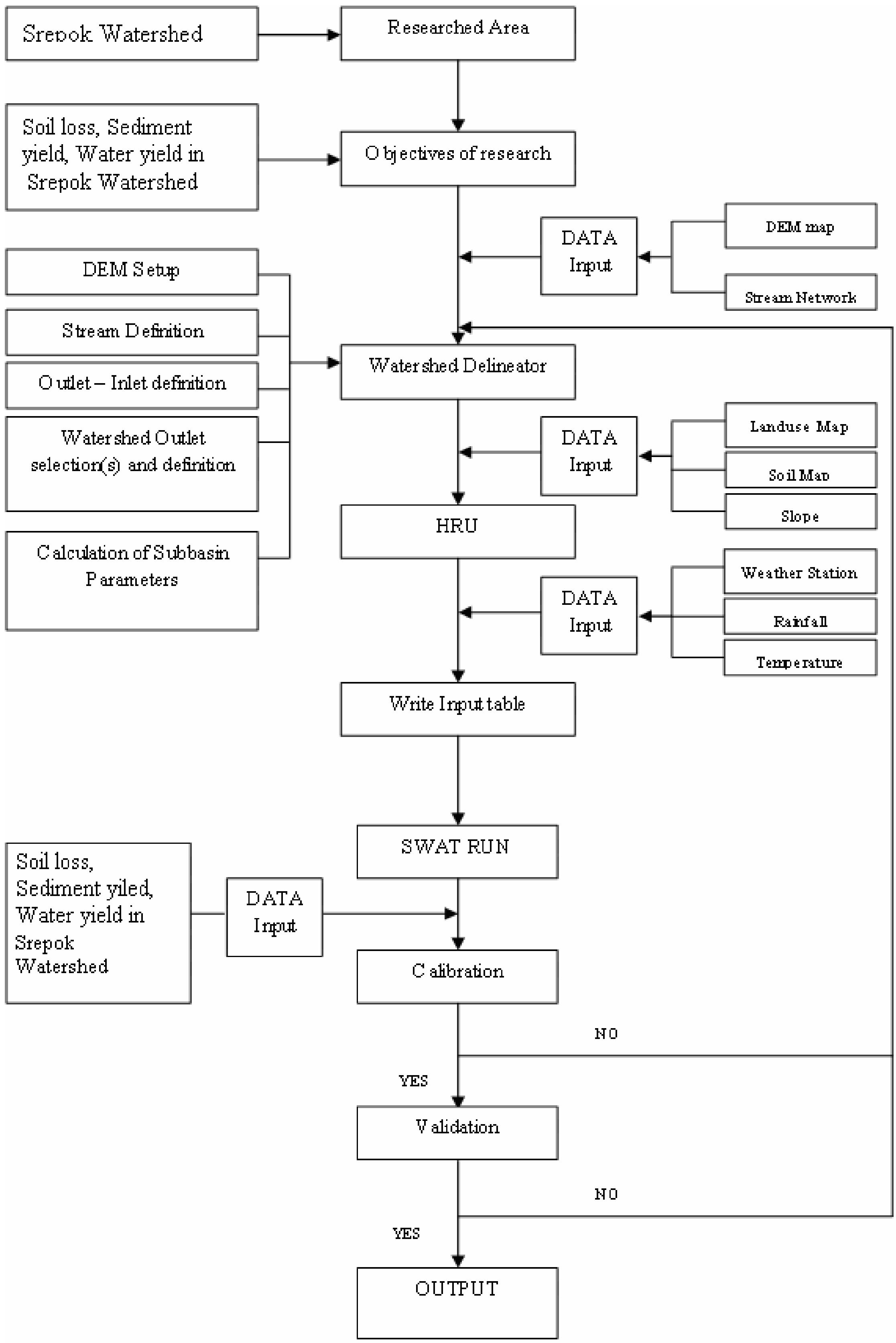

Figure 2. Application of SWAT model in Srepok watershed

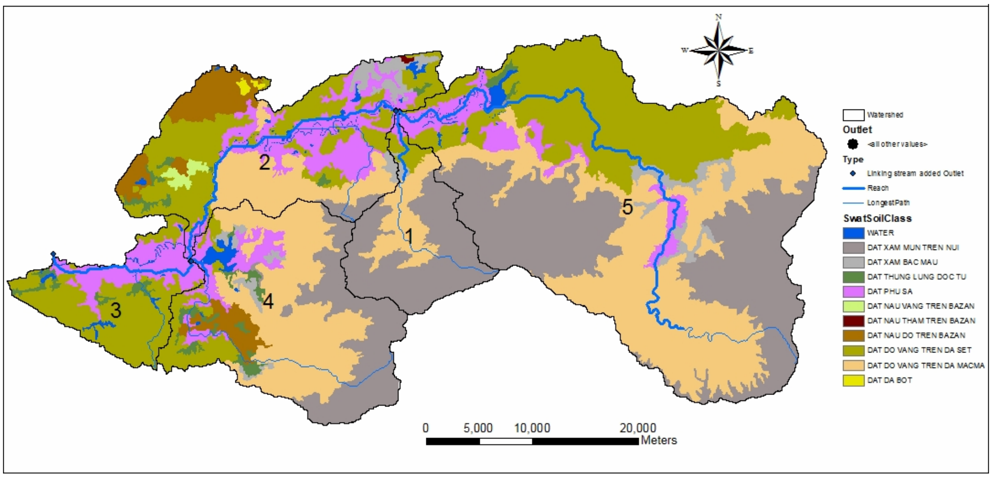

Figure 3. Srepok watershed soil map

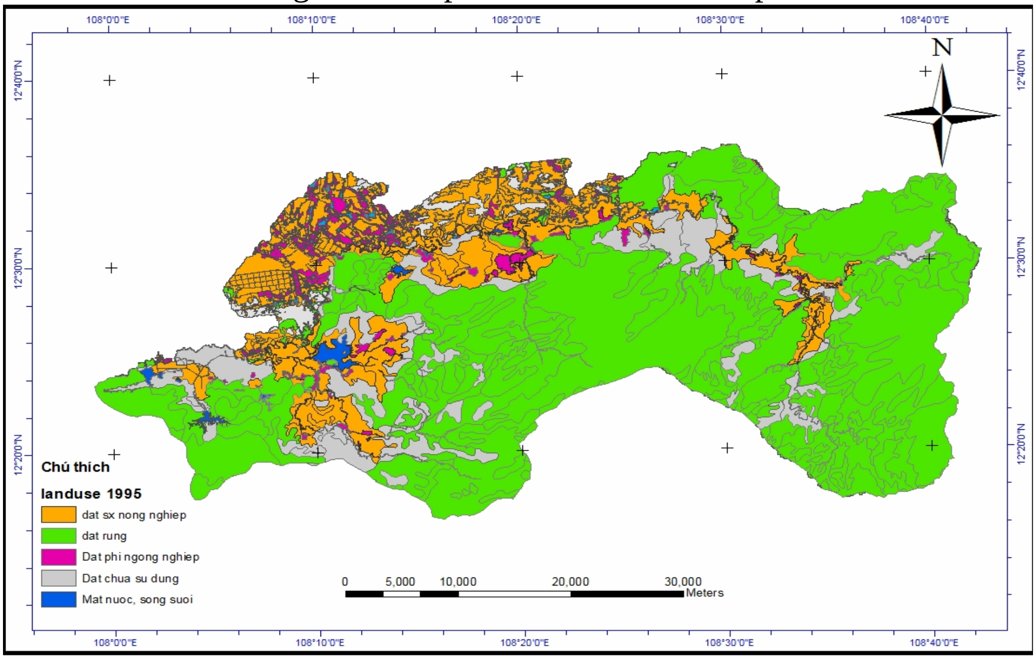

Figure 4. Land use map in Srepok watershed in 2005

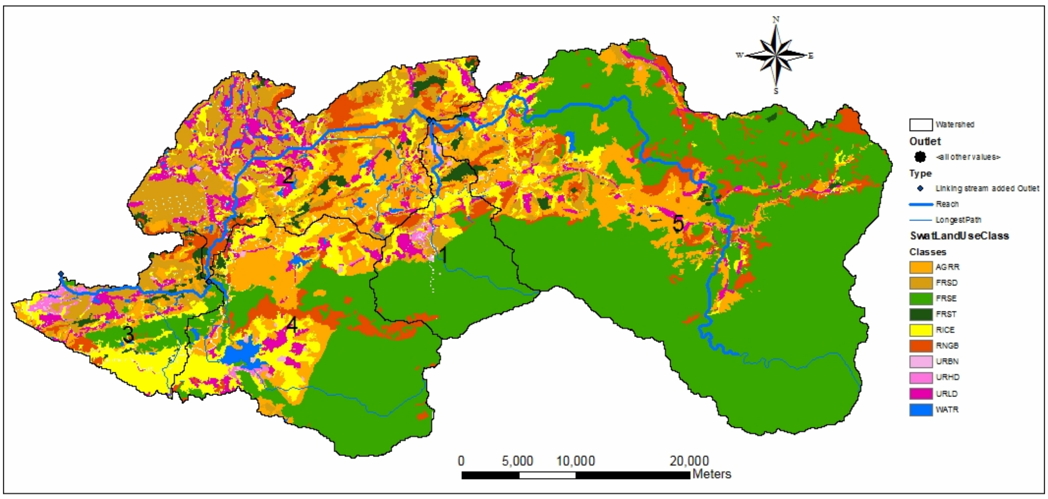

Figure 5. Land use map in Srepok watershed in 2008

RESULTS

Assessing Land use change and deforestation on water discharge and sediment yield

The output from the SWAT model presented in Table 3, we found that the total amount of surface water and soil erosion in Srepok watershed when using land use data in 2005 and 2008 as input data was 15,986 tons, 16,417 tons respectively. In Srepok watershed has two seasons, there are rainy and dry seasons. The rainy season usually starts from late April to late December. The Rainfall is one of the decisive factors to the hydrological regime of the watershed. The simulated water discharge and sediment yield in srepok watershed are shown in Figure 6, 7, 8 and 9. We also found that the water discharge and sediment yield in Srepok watershed depends on rainfall and the forest cover in upstream Srepok watershed. The rainfall is not much different in 2005 and 2008, but the surface flow and sediment yield was much different.

Table 3. The SWAT simulated statistics for Srepok watershed using land use in 2005 and land use in 2008.

Year	Rainfall (mm)	Surface flow (mm)	Sediment yield (tons/ha)
2005	1979.963	2250.776	1027.614
2008	2018.920	2684.307	1117.416

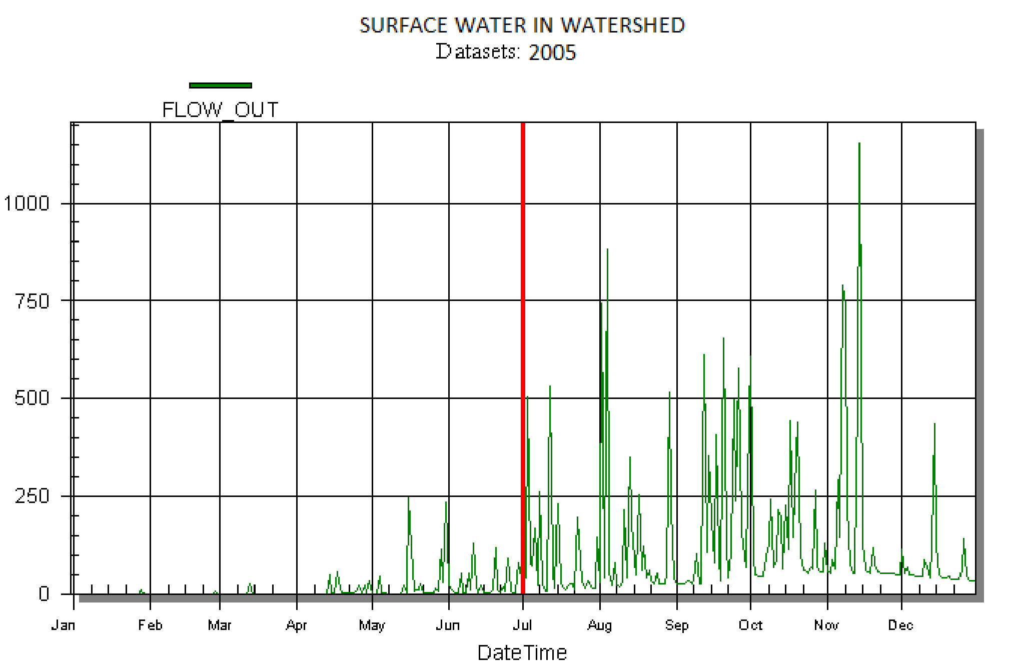

Figure 6. Simulated water discharge in Srepok watershed at year 2005

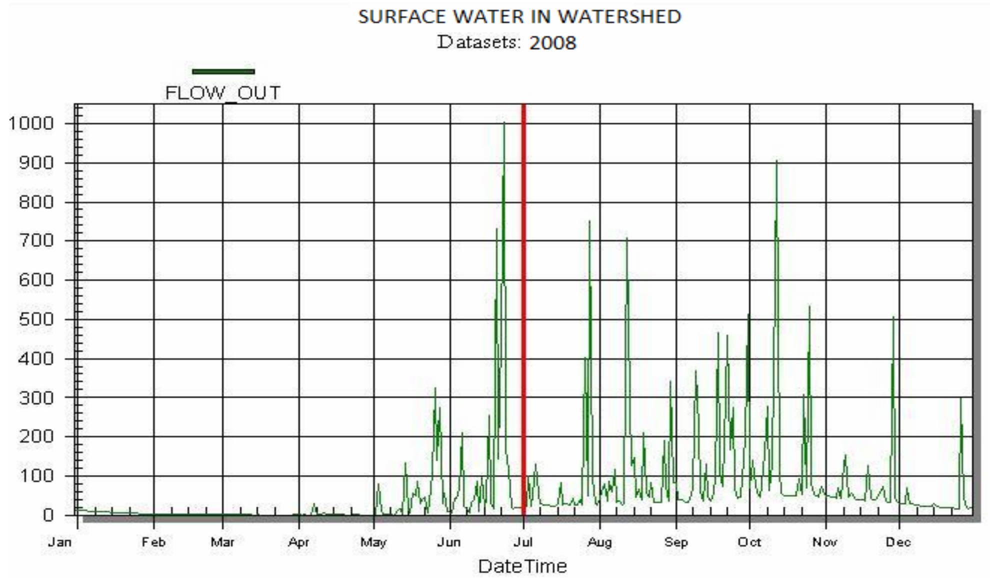

Figure 7. Simulated water discharge in Srepok watershed at year 2008

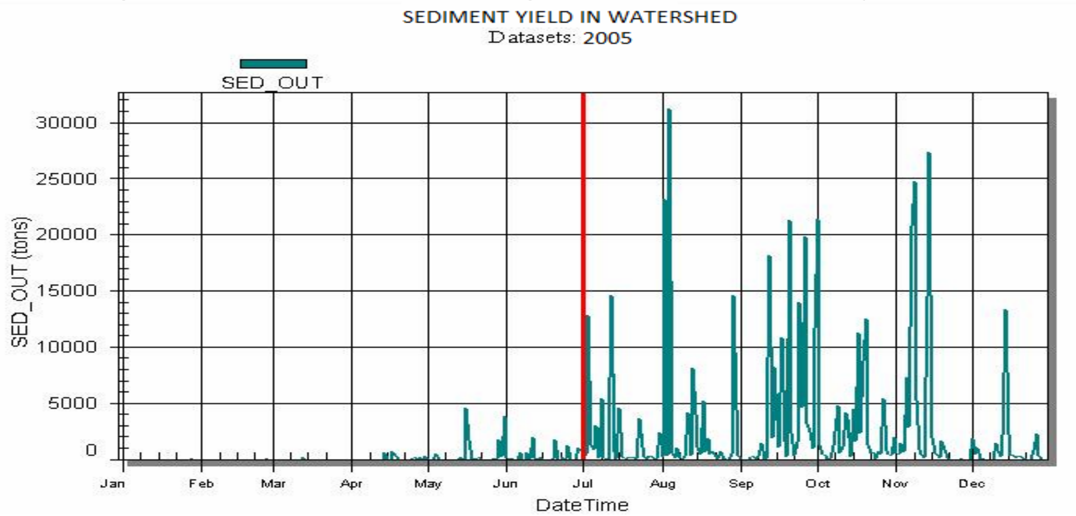

Figure 8. Simulated sediment yield in Srepok watershed at year 2005

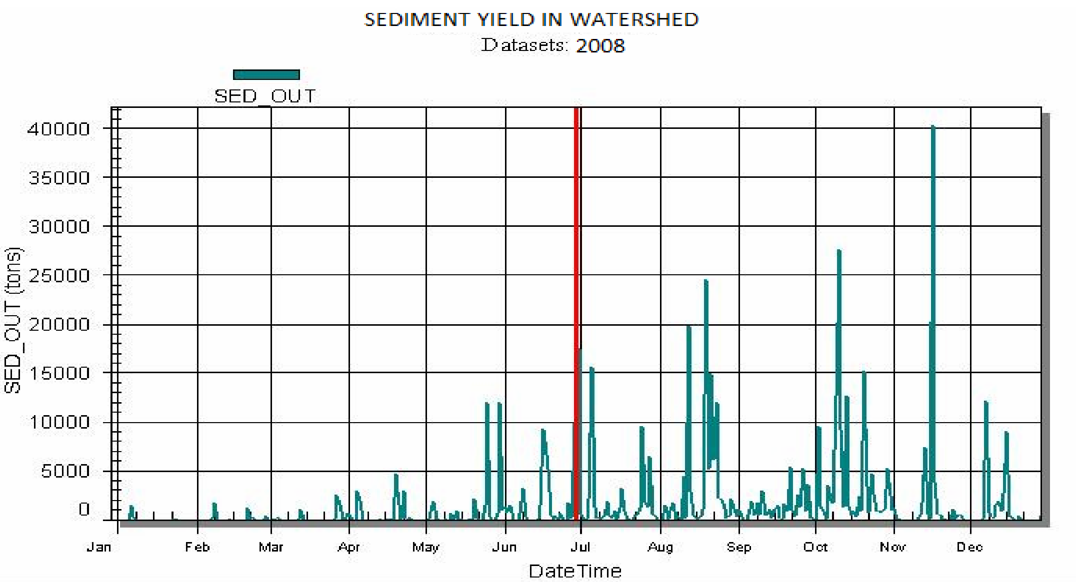

Figure 8. Simulated sediment yield in Srepok watershed at year 2008

CONCLUSIONS

The SWAT model performed well in simulating the general trend of surface flow, sediment yield, at watershed over time for daily, monthly time intervals. The results shown that the land use change and deforestation was affected surface runoff, sediment yield in Srepok watershed. Results of the simulation shown that surface runoff increase when forest converted to agricultural land. An increase about 19% in surface runoff occurs when 0.84% of the forest area converted to agricultural land. Meanwhile, sediment yield increase about 8.7% compared between 2005 (1,027 ton/ha) and 2008 (1,117 ton/ha). However, the SWAT model is a new model when we applied it to our study. In our test watershed, we recommend that policies addressing this problem should be formulated both at the local and nation level. Parallel to this, an intensive information and education campaign on the consequences of forest conversion and ways of rehabilitating the watershed should likewise be done. Finally, alternative livelihood opportunities for the upland farmers should be considered in policy implementation.

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