An evaluation of strategies to mitigate surface water quality using riparian wetland in Da Tam watershed, Lam Dong province, Vietnam: A preliminary result

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ABSTRACT: Surface runoff is caused by the rain which also carries eroded material including mud, chemicals, etc. The eroded material affects in-stream sediment levels and surface water quality. Riparian wetland zones are one of the natural methods to restrict eroded material from moving into streams, by contributing to the reduction of pollution to surface water. The Soil and Water Assessment Tool (SWAT) model was applied in this research to quantify the ability of riparian wetland zones to mitigate surface water pollution by comparing scenarios with and without riparian wetland zones. Results indicated that some water quality parameters such as nitrate (NO3), mineral phosphorus (MINP) and sediment declined from 1.6 to 2.1 times for scenarios with riparian wetland zones.
Keywords: Soil and Water Assessment Tool (SWAT), nitrate (NO3), mineral phosphorus (MINP), Stream sediment load

Introduction

Sediment is a natural occurring that is broken down by processes of weathering and erosion, and is subsequently transported by the action of wind, water or by the force ò gravity acting on the particle itself. But today, we have impacted on natural directly through our activities such as land use change, deforestation. Many researchers suggested solutions to reduce human effect. Many solutions and efforts have been made in recent years to reduce human effect on the environment. The solutions have sustainable and promote good performance. Therefore, we need to base on natural solutions to protect water quality *(Nguyen Van De, 2007).*

Riparian wetlands are typically narrow, wet areas that are adjacent to streams or rivers that support vegetation dependent upon free water in the soil. The soils are usually alluvial (water deposited). Wet areas on interstream divides are generally large and nonalluvial. They result from poor drainage in flat areas where rainfall exceeds evapotranspiration. Even though riparian and interstream divide wetlands may be equally wet, they make different contributions to water quality. In their natural state, wetlands provide habitat and food sources for hundreds of plant and animal species, and some contribute to water quality. These areas are important to fish and wildlife species, as well as to livestock. Since they dissipate water energy and filter the water flowing through them, riparian-wetland areas can affect the health of entire watersheds.

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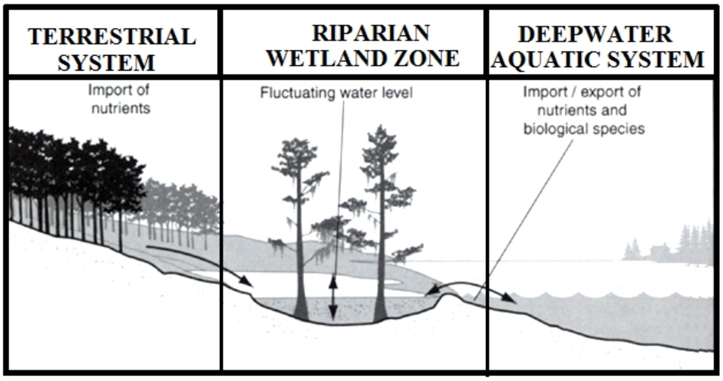

Figure 1 Location of riparian wetland zones (Source: Nguyen Van De, 2007)

We can use the actual experimental measurements to quantify the positive effect of riparian wetlands to surface water quality, but for this article we use the 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 ArcGIS interface developed by Dr. Jeff Arnold Center for Agricultural Research Service (ARS - Agricultural Research Service) U.S. Department of Agriculture (USDA - United States Department of Agriculture) to predict the impact of land management practices on water quality, sediment, and agricultural chemical yields in large complex basins with varying soil type, land use and management conditions over long periods of times. 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 and anthropogenic contributions as nutrient input. The swat is expected to provide useful information across a range of timescales hourly, daily, monthly, yearly timesteps. In addition, we also used GIS technique to process of data, and create maps.

Materials and Methods

Materials

Available data and information related to the SWAT modeling in Da Tam watershed such as maps, statistic data, forest area, population, soil texture, rainfall, and other data was collected by the offices of local authorities and relevant professional institution. The type of data and their sources are show in **Table 1**. The categories of land cover in 2005 that were interpreted form field observation processing with GIS technique.

Table 1 Data collection and their sources for SWAT modeling.

Types of data	Sources of data
Topography map	Department of natural resources and environmental, Lam Dong province, Viet Nam
Land use map	Department of natural resources and environmental, Lam Dong province, Viet Nam
Soil map	Department of Agriculture and rural development, Lam Dong province, Viet Nam
Weather (Precipitation, temperature, humidity)	Centre for Hydro-meteorological Forecasting, Lam Dong province, Viet Nam

Study area

The Da Tam watershed is the sub basin of Dong Nai basin located in the Lam Dong province of Viet Nam (**Figure 2**). The study watershed lies within 11^0 47' - $11^0$57' N and $108^0$23' - $108^0$33' E and encompasses a total area of 19391.67 ha. The watershed receives an average annual rainfall of 1729 mm with the maximum rainfall during May to October. The annual mean temperature ranges from 18 to 22^0 C and the relative humidity ranges from 75 to 82 percent. The elevation of watershed ranges from 960 m above mean sea level at its lowest point to 1810 m at its highest point. Forestry is the dominant land cover of the watershed, which comprises nearly 56.74 percent. Soils in this watershed are predominantly sandy clay loam in textur

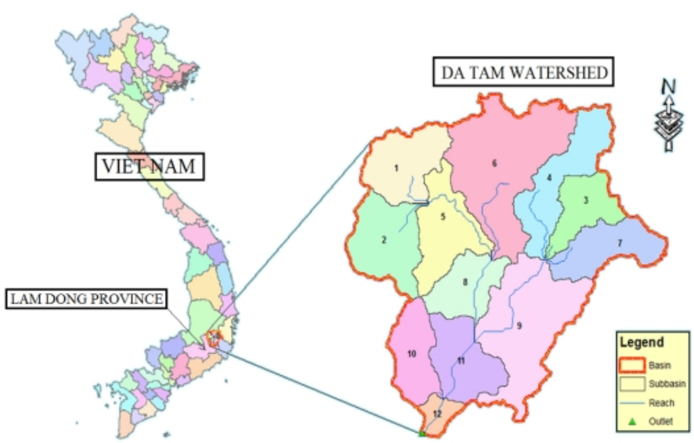

Figure 2 Location of the Da Tam watershed

Method

Rain causes surface runoff and soil erosion. Eroded material were transported by streams, it was created irresolute matter and pile up on good position such as pond, lakes, etc. Erosion material can include mud, clay, inorganic such as nitrogen, phosphorus, or some Cations such as Ca2+, Mg2+, Na+, K+. If eroded material goes into streams, it will cause sediment and pollution at streams, lakes, or ponds (Nguyen Van De, 2004).

Riparian wetlands help maintain and improve the water quality of our streams, rivers, lakes, and estuaries. Since wetlands are located between uplands and water resources, Riparian wetlands have important filtering capabilities for intercepting eroded material from higher land before the surface runoff reaches open water. As runoff and surface water pass through, riparian wetlands remove or transform pollutants through physical, chemical, and biological processes. Eroded material is going into riparian wetlands through hydrology (**Figure 3**).

Vegetation systems reduce the flow rate and filter some big eroded material such as gravel, mud, and sand. Dissolved material is transformed to bigger materials by the metabolic cycle of the system. There are so many metabolic processes in riparian wetlands such as the metabolism of phosphorus, nitrogen, and sulfur *(Le Van Khoa and et al., 2005).*

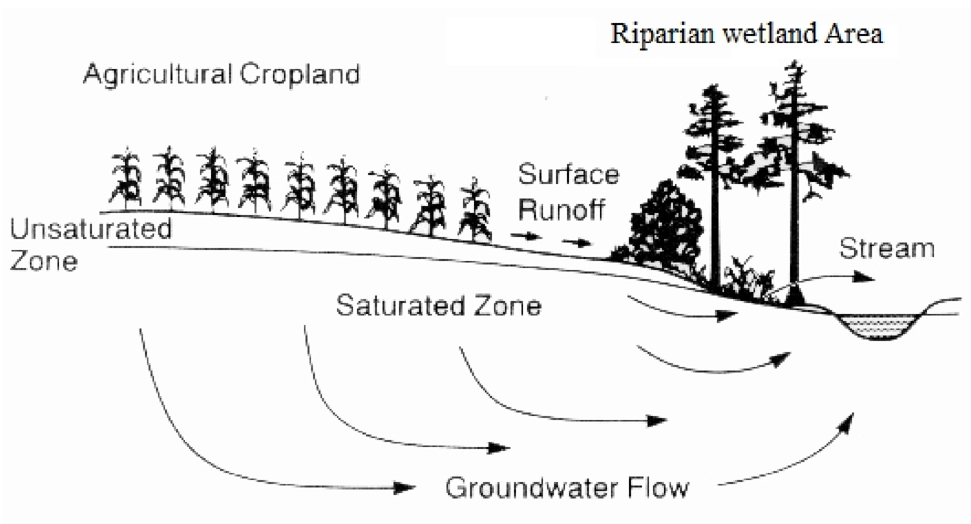

Figure 3 Surface runoff goes into the riparian wetland zones (Source: Robert Evans and et al., 1996)

We can use experiment methods or modeling methods for calculate positive effect of riparian wetlands to surface water quality. We might spend a lot of time and money with experiment methods, however. Conversely, modeling methods have more advantage than experiment methods such as save time and money, easy to practice. The swat model approach applied to the case study area of Da Tam watershed is show in **Figure 5.** In this study we used the SWAT model to run scenario A without riparian wetlands and scenario B with riparian wetlands **Figure 4.** Then, we compared output of two scenarios in some water quality parameters.

Riparian wetlands are the wetland areas along lakes, rivers and streams. In swat model, the write pond data command creates an ArcSWAT geo-database table that stores values for swat pond/ wetland input parameters (*.pnd) (**Figure** 5). We need to edit change the water body type, the parameters in the pond/ wetland parameters, SWAT input table *.pnd file, allowing us to enter the parameters for the specified water body type to get better model output. We have many values describe pond/wetland input parameters (**Table** 3).

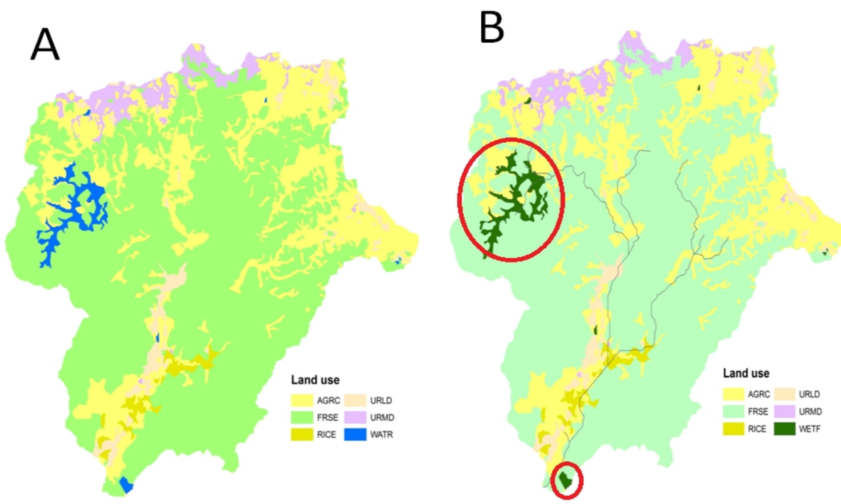

Figure 4 Map of land use with and without riparian wetlands.

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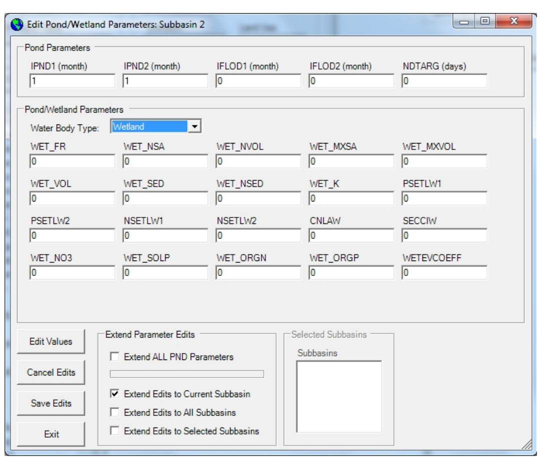

Figure 5 Pond/wetland input parameters (*.pnd) in SWAT model

Table 2 Some of wetlands parameters and description. (Source: SL.Neitsch and et al., 2005)

Name	Description
WET_FR	Fraction of sub-basin area that drains into wetlands.
WET_NSA	Surface area of wetlands at normal water level.
WET_NVOL	Volume of water stored in wetlands when filled to normal water level.
WET_MXSA	Surface area of wetlands at maximum water level.
WET_MXVOL	Volume of water stored in wetlands when filled to maximum water level.
WET_VOL	Initial volume of water in wetlands.
WET_SED	Initial sediment concentration in wetland water.
WET_NSED	Normal sediment concentration in wetland water.
WET_K	Hydraulic conductivity of bottom of wetlands.

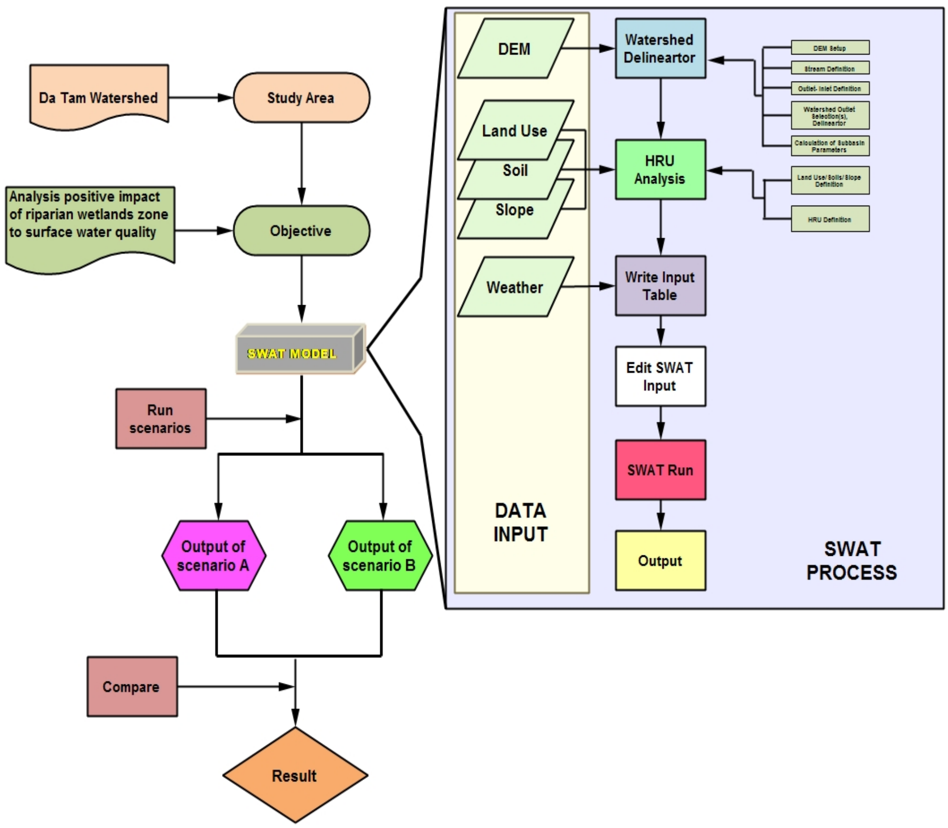

Figure 6 Methodology of study

Result and discussion

The SWAT model was applied in Da Tam watershed with two scenarios. The Da Tam watershed is divided into 12 sub-basins, according to model output. We have many parameters to represent and expressed for water quality such as dissolved oxygen (DO), nitrate (NO3), mineral phosphorus (MINP), etc., There was different about water quality between scenario A and B. Some water quality parameters of scenario A are higher than B. In this paper we focus on comparing three parameters includes sediment, NO3, MINP. We can see different of sediment, NO3, MINP in Figure 5, Figure 6, Figure 7 and Table 2.

The output of SWAT model shown that scenario B "with riparian wetlands", can reduce sediment yield and NO3, MINP loading to open water. The riparian wetlands in Da Tam watershed has only 27.52 ha about 5.8% other research area but with it sediment yield was reduced about 1.00102 times, NO3 was reduced 1.00178 times, and MINP was reduced 1.0046 times (Table 3). In addition, Output of three parameters of scenario A and B at outlet of sub-basin 2 were more different, because riparian wetlands in this areas cover 13 percent (12 ha) all sub-basin (Table 4). This figure is also indicated that human practices affected to natural ecosystems.

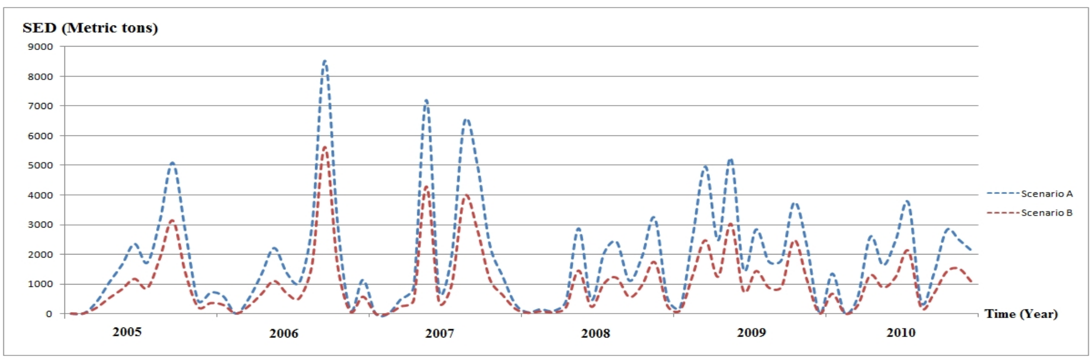

Figure 7 Sediment yield chart of scenario A and B

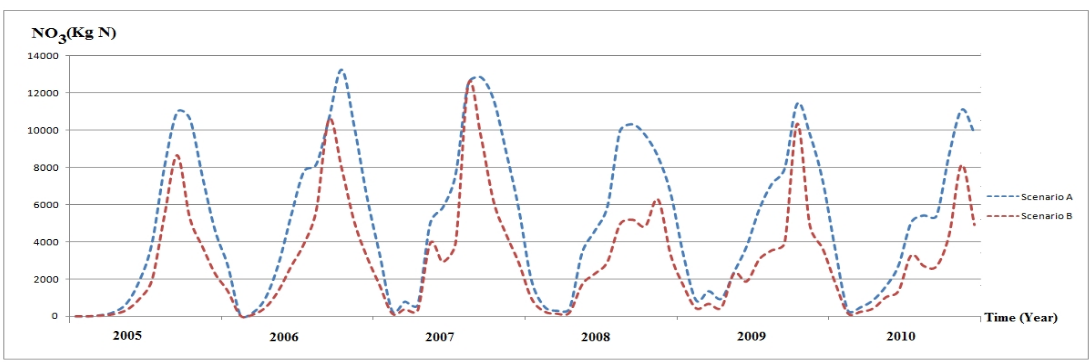

Figure 8 NO3 chart of scenario A and B

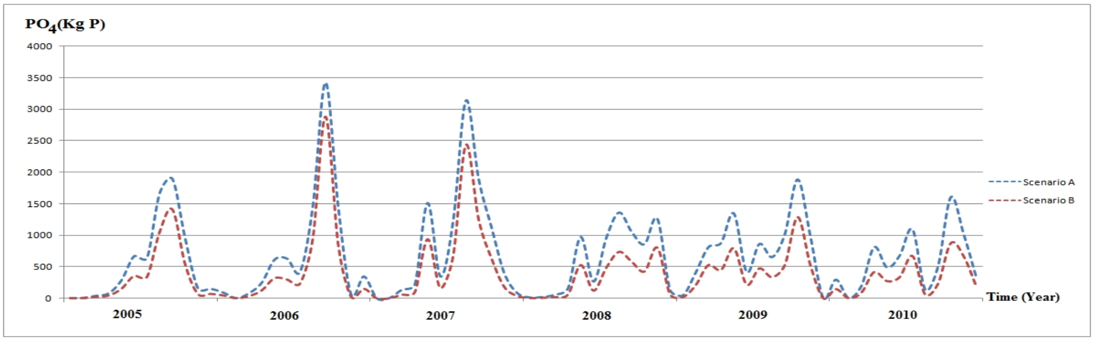

Figure 7 MINP chart of scenario A and B

Table 3 Output of three parameters of scenario A and B at output of watershed

Parameters	Scenario A	Scenario B	Rate (A/B)
Sediment (metric ton)	44199.47	44154.63	1.00102
Nitrate (Kg N)	48092.14	47748.92	1.00718
Mineral phosphorus (Kg P)	421.64	419.70	1.00460

Table 4 Output of three parameters of scenario A and B at output of sub-basin 2

Parameters	Scenario A	Scenario B	Rate (A/B)
Sediment (metric ton)	246.10	152.87	1.61
Nitrate (Kg N)	3060.076	1718.395	1.78
Mineral phosphorus (Kg P)	16.067	7.511	2.13

Conclusion and Suggestions

In summary, riparian wetlands base on their function and metabolic processes prevented eroded materials reaches to open water. Therefore, they may limit water pollution problems and unbalance ecosystems.

By using swat model we can estimate positive effects of riparian wetlands to surface water quality. However, the model has not calibrated and validate because we haven't observer and monitoring data. This makes the reliability of the model. This is one of the limitations of study.

This study is just the first step in studying potential of riparian wetlands by applying swat model. Thus, we should be continued to expand the study into practical application. We should observe more data to calibrate and validate the model.

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