Effect of Land Use Changes on the Hydrological Response in Bago River Basin, Myanmar

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1. Introduction

Land use changes affect water resources mainly through vegetation interception, evapotranspiration, runoff, surface infiltration, soil moisture status, and so forth, thereby affecting the process of watershed hydrology and water resource cycles [1].

Many previous studies were carried out in Bago River basin in Myanmar among which one of the studies focused on the flood simulation by using Integrated Flood Analysis Model (IFAS) and another was the rainfall-runoff simulation using the SWAT model in Bago river basin. The SWAT model has been demonstrated to be an effective tool for researching the impact of environmental changes on hydrology and water resources management. This research emphasizes to analyze the response of the hydrological cycle under land use change by using the process-based empirical model (SWAT).

2. Problem Statement

Changes of river flow and precipitation in Bago River basin increase floods and droughts in this watershed because of climate change impacts, and frequently floods have caused degradation of natural and water resources. In August 2011, Bago River flooded to a record level of 960 cm above the mean sea level (M.S.L). This caused damage to many paddy fields and farms in Bago township. In 2014, another high flood, peaking at 936 cm above M.S.L, struck Bago Station in Bago River basin. This disaster demonstrated that structural countermeasures are not a solution to the current flood problem. The frequency and severity of floods during rainy season has increased according to the records of Department of Meteorology and Hydrology in Myanmar. This study focuses on the effect of land use change in Bago River basin where forest had an important role. It was undertaken that land use changes would impact on the water balance components such as surface flow, base-flow and runoff in the river basin. According to this background, it is significant to have a research related to the impact of land use changes on the hydrological response in Bago River bain.

3. Study Area

In this study, Bago River basin was taken as a study area. Bago River is one of the most important and useful river located in lower Myanmar for hydropower generation, irrigation use, fisheries and navigation use. Bago River basin has a catchment area of 5,348 km^2, and the main branch of the river is approximately 331.5 km long. Bago River basin is surrounded by the most vulnerable environments in Myanmar and is a repository of biodiversity, rivers, and many ecosystem services [2]. Figure 1 shows the location of Bago River basin.

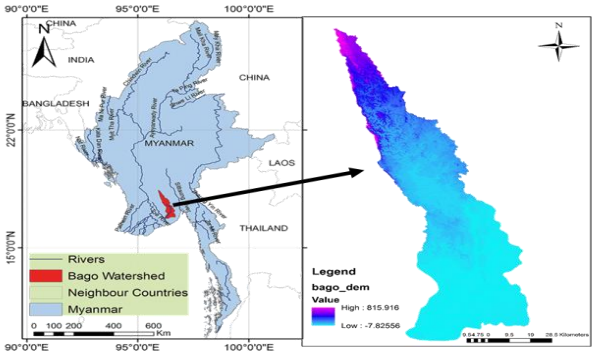

Figure 1. Location of Bago River Basin

4. Research Methodology

Soil and Water Assessment Tool (SWAT), a long-term yield model, was effectively used as a main tool in this research. The input data such as topographic, land use, soil, and hydrological and meteorological data needed by SWAT model were collected as follows: (1) Digital Elevation Model (DEM) data with resolution of 90m were achieved from United States Geological Survey (USGS); (2) the land use data of Bago River basin were produced from the SERVIR-Mekong Regional Land Cover System portal; (3) soil data were analyzed from the Food and Agriculture Organization of the United Nations; (4) the hydrological and meteorological data were obtained from Department of Meteorology and hydrology, Myanmar. All the data were analyzed for the effect of land use changes on the hydrological response in Bago River basin.

5. Results and Discussion

In this study, the SERVIR-Mekong Regional Land Cover System portal was produced the whole basin. Land use map of Bago River basin in 2000, 2010 and 2017 were categorized into six types based on SWAT code: Agriculture, Forest-Deciduous, Forest-Evergreen, Forest Mixed, Residential and Water. A calibration process in SWAT model was performed by mainly using land-use changes for three different years, 2000, 2010 and 2017. Nash-Sutcliff efficiencies (NSE) and

Root Mean Square (R^2) provided by the SWAT model are observed to check the performance of this model. As a result, the model generates for NSE 0.69, 0.75, 0.76 and also produces 0.75, 0.83, 0.85 for R^2 respectively. These aforementioned results confirm that this model can be beneficially used for evaluating the runoff mechanism in advance. Figure 2 and 3 illustrate the observed and simulated discharge in calibration and validation period.

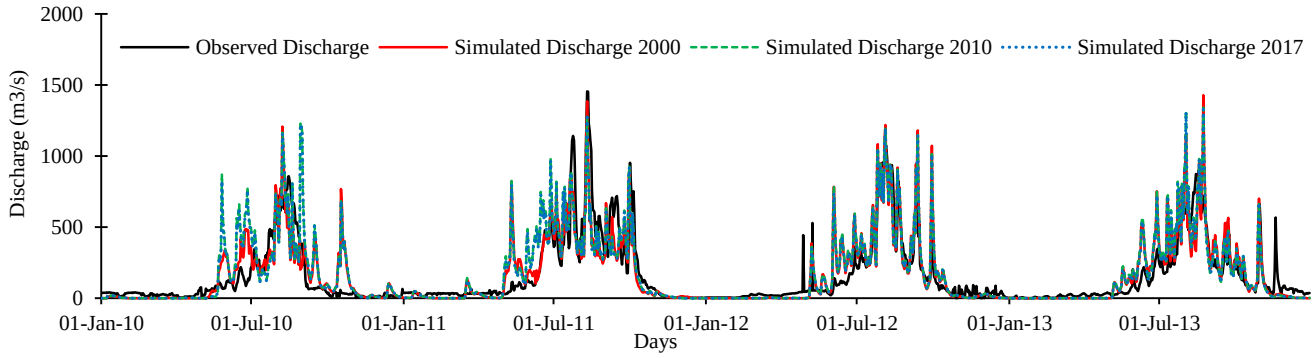

Figure 2. Observed and simulated discharge in calibration period

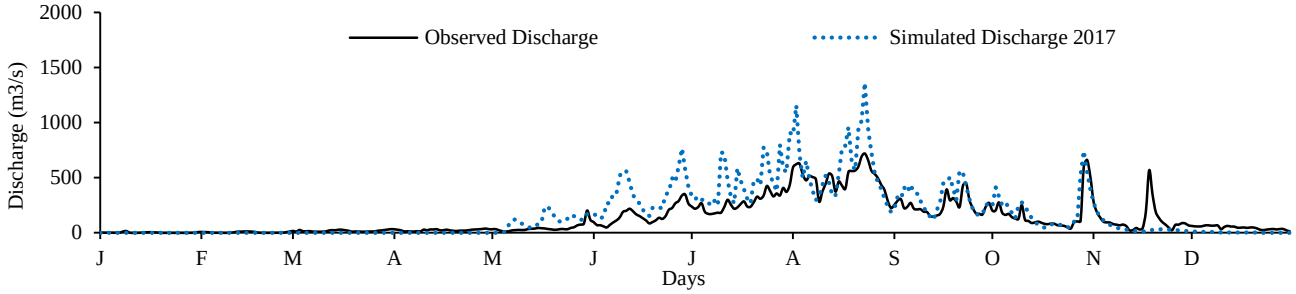

Figure 3. Observed and simulated discharge in validation period

In the prediction of hydrological response, this result also indicated that a gradual increase of the total water yield when compared to the land use in 2000. The impact of these changes resulting from the conversation of Forest-Deciduous area to Forest-Mixed area. To be more specific to the results of the hydrological response, the surface flow increased 8% in 2010 and 10% in 2017, whereas, the groundwater flow decreased 6% in 2010 and 10% in 2017 respectively. These changes occur due to an increase in forest mixed areas in Bago River basin having some influences on the hydrological cycle. Figure 4 shows the hydrological response units for land use 2000, 2010 and 2017.

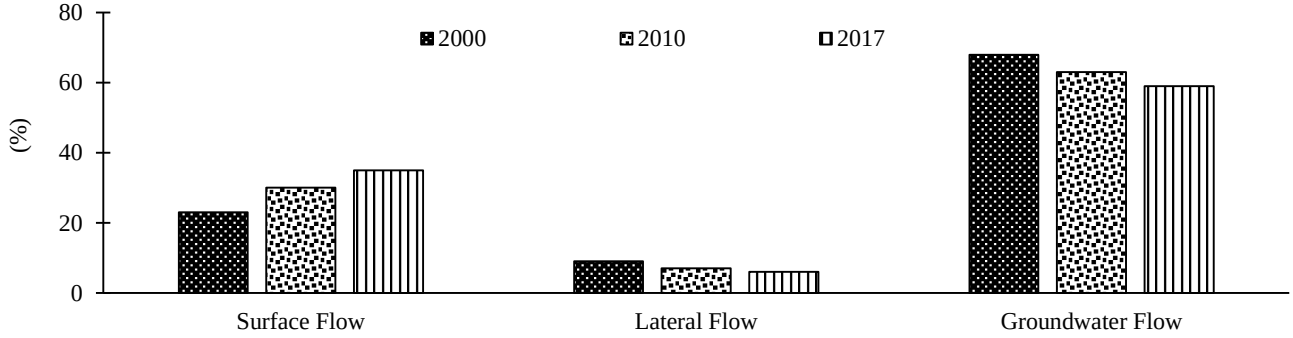

Figure 4. Hydrological response units for land use 2000, 2010 and 2017

6. Conclusions

1) A good agreement found between the observed and simulated discharges as indicated by NSE and R^2 shows that the model parameters represent the processes occurring in Bago River basin by using SWAT model.
2) A gradual increase of total water yields in 2010 and 2017 when compared with 2000. The impact of these changes occurs due to an increase in forest mixed area in Bago River basin having some influences on the hydrological cycle.

References

[1] Junfeng, C. &. (2004). Simulation of hydrological response to land-cover changes. *Chinese Journal of Applied Ecology*, (pp. 833-836).

[2] Win Win Zin, K. A. (2015). River Flood Inundation Mapping in the Bago River Basin, Myanmar. *Journal of Hydrology*, 97-102.