

Predicting the Effects of Land Use on Runoff and Sediment Yield in Selected Sub-watersheds of the Manupali River using the ArcSWAT Model

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BACKGROUND

- ❑ Driven by the growing population and increasing demand for food as well as the short-term benefit derived from productive forest lands
- ❑ Conversion of native forest to agricultural lands is very common in the Philippines



❑ **MANUPALI RIVER WATERSHED**

is a typical example that undergone land conversion and presently undergoing environmental degradation and causing off-site pollution and sedimentation of rivers, reservoirs and hydropower dams.



Agriculture has become extensive and intensive that led to ...



- ❑ conversion of forest lands and grasslands into sugarcane, corn and banana at lower altitude, and corn and vegetables at higher altitude at the expense of perennial crops
- ❑ serious soil erosion resulting to soil fertility degradation and river and reservoir sedimentation
- ❑ water pollution causing serious threats to aquatic life and health of farm families



Significance

- ❑ Developing a quantitative prediction model for assessing the environmental impacts of land use changes specifically on runoff and sediment yield in watersheds is therefore of paramount importance.
- ❑ It can serve as basis for developing policy interventions *and for developing* sound watershed management schemes, while ensuring the sustainability of the economic activities of the people.

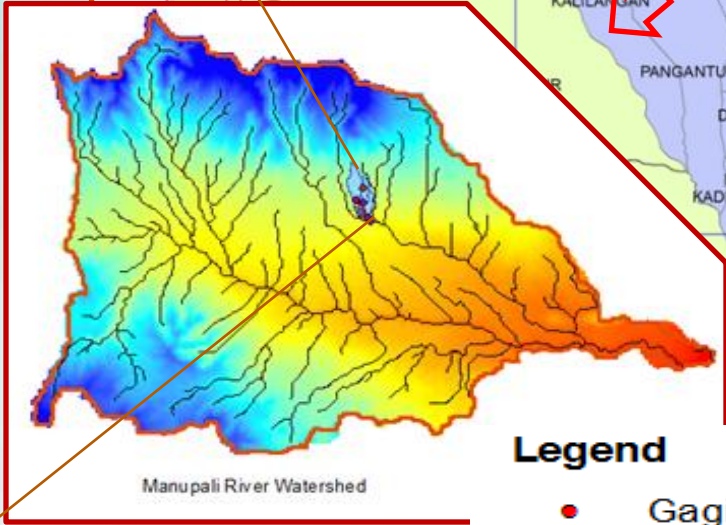
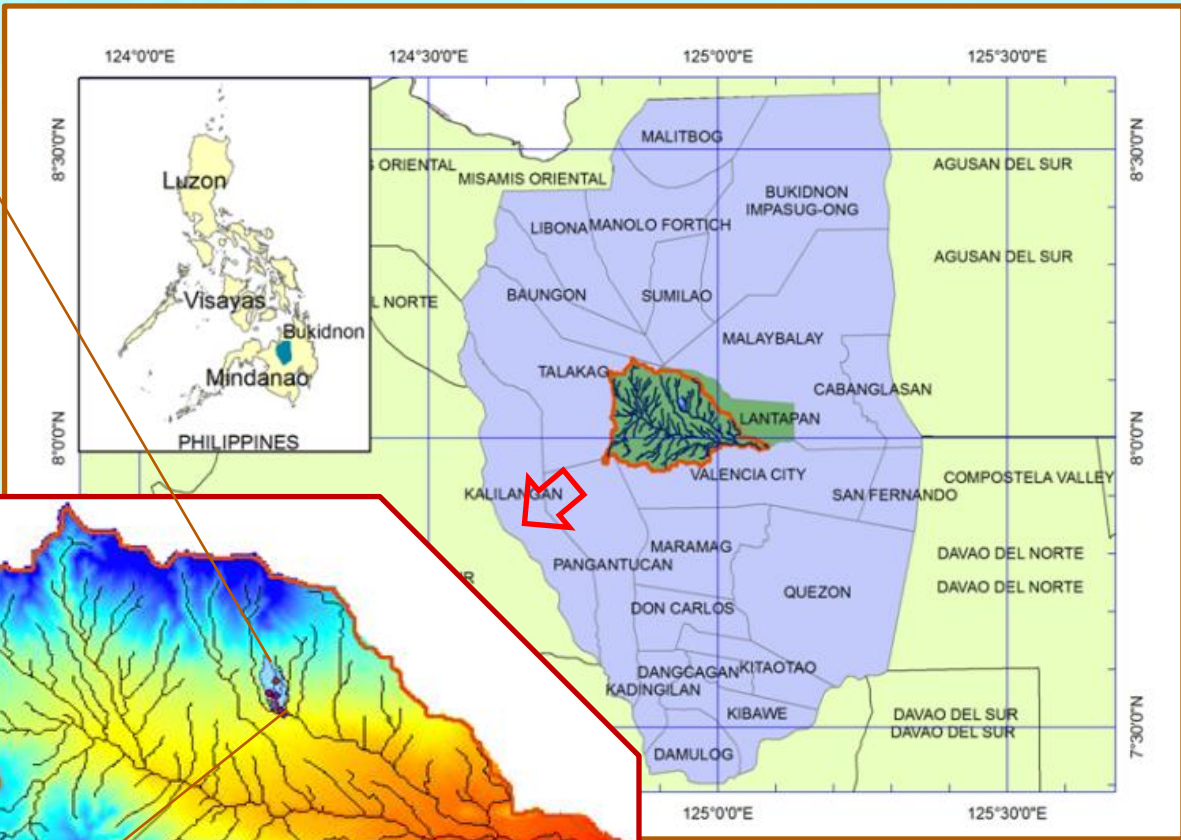
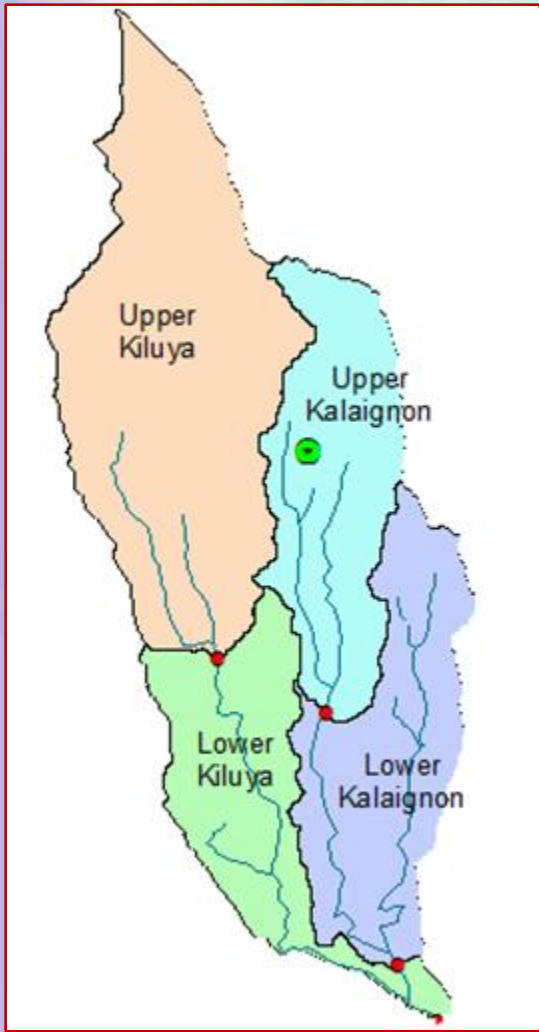


Objectives

- ❑ To determine the effects of various land use patterns on runoff and sediment yield in selected sub-watersheds of the Manupali river using the ArcSWAT model.
- ❑ Specifically, it aimed to parameterize, calibrate and use the ArcSWAT model in simulating the effects of various land use patterns on runoff and sediment yields.



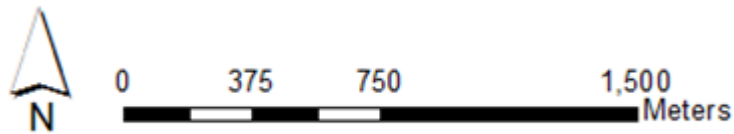
The Study Site



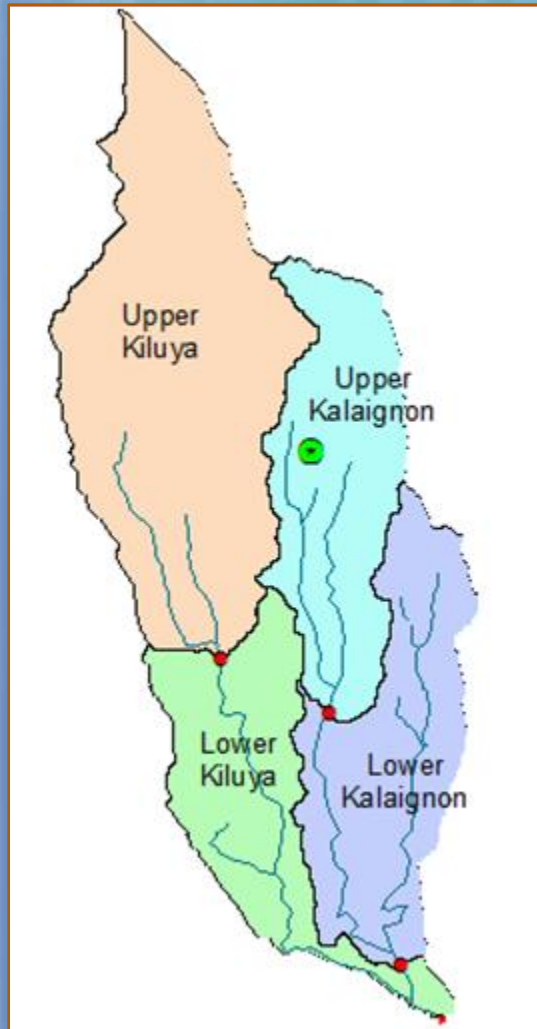
Manupali River Watershed

Legend

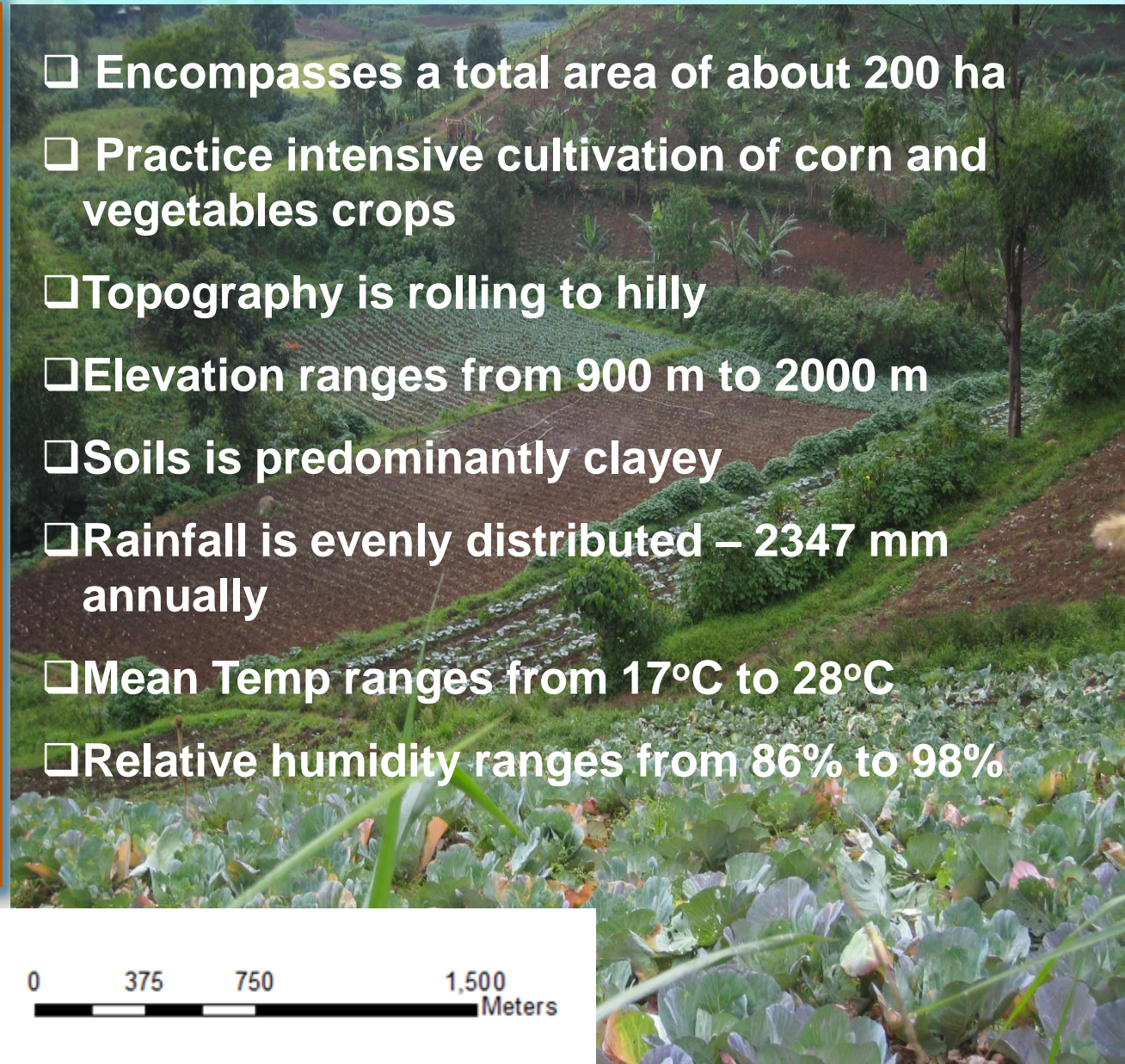
- Gaging Stations
- Automatic Weather Station (AWS)
- Rivers and tributaries
- Sub-watershed



The Study Site



- ❑ Encompasses a total area of about 200 ha
- ❑ Practice intensive cultivation of corn and vegetables crops
- ❑ Topography is rolling to hilly
- ❑ Elevation ranges from 900 m to 2000 m
- ❑ Soils is predominantly clayey
- ❑ Rainfall is evenly distributed – 2347 mm annually
- ❑ Mean Temp ranges from 17°C to 28°C
- ❑ Relative humidity ranges from 86% to 98%



Legend

- Gaging Stations
- Automatic Weather Station (AWS)
- Rivers and tributaries
- Sub-watershed



0 375 750 1,500 Meters

Model development and calibration

Precipitation and Climate



Soil Properties

Soil Type

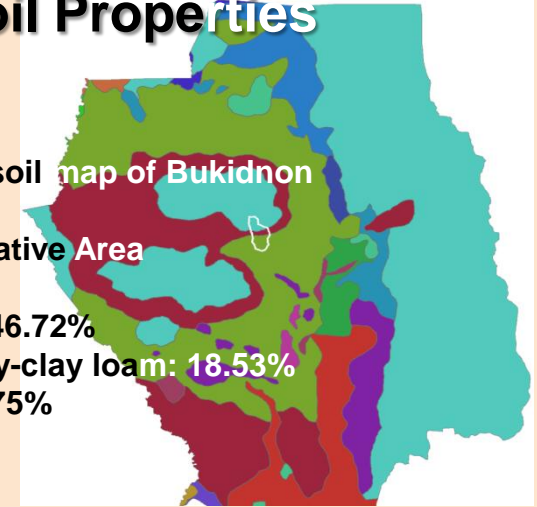
Extracted from soil map of Bukidnon

Soil Series and Relative Area

Adtuyon Clay: 46.72%

Kidaapawan clay-clay loam: 18.53%

Forest soil : 34.75%



Topography and Stream

Digital Elevation Model

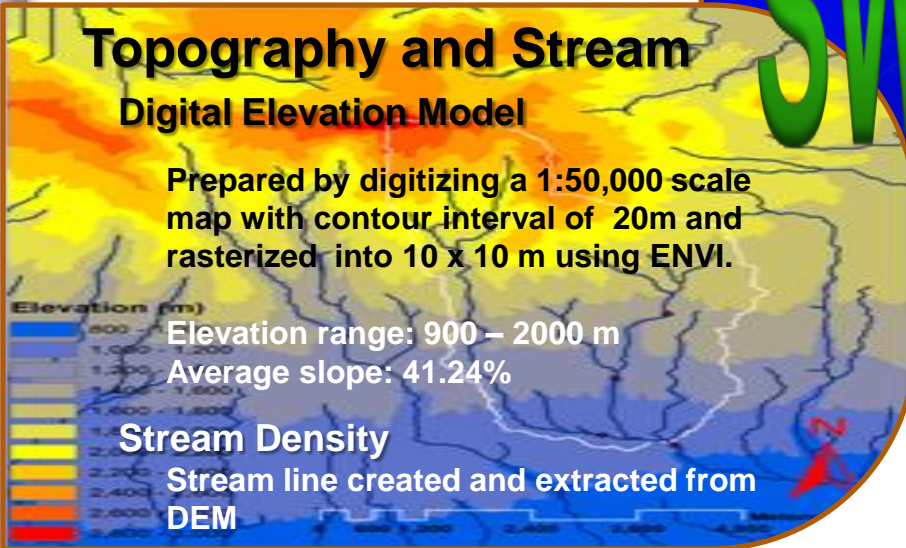
Prepared by digitizing a 1:50,000 scale map with contour interval of 20m and rasterized into 10 x 10 m using ENVI.

Elevation range: 900 – 2000 m

Average slope: 41.24%

Stream Density

Stream line created and extracted from DEM



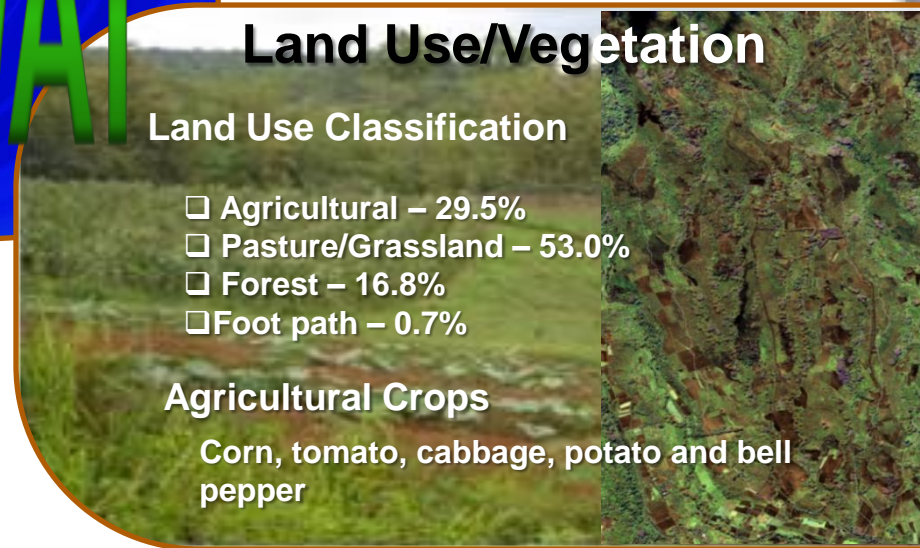
Land Use/Vegetation

Land Use Classification

- Agricultural – 29.5%
- Pasture/Grassland – 53.0%
- Forest – 16.8%
- Foot path – 0.7%

Agricultural Crops

Corn, tomato, cabbage, potato and bell pepper



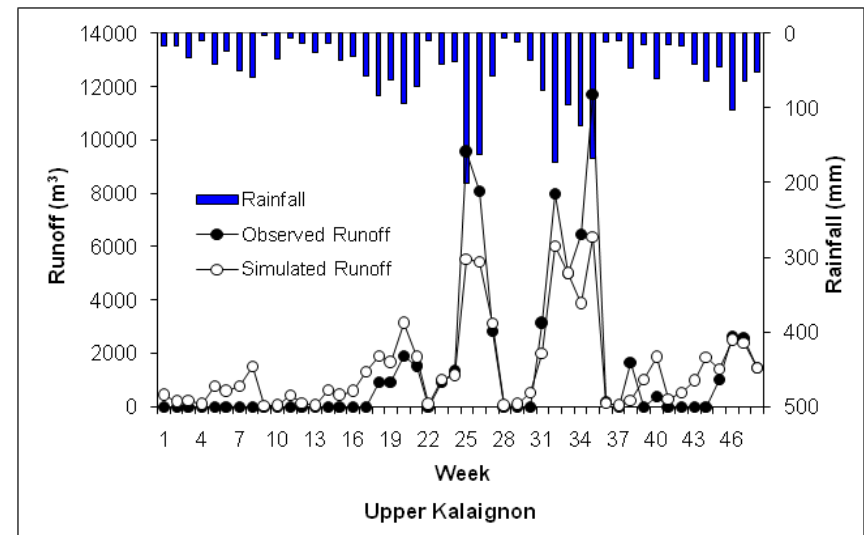
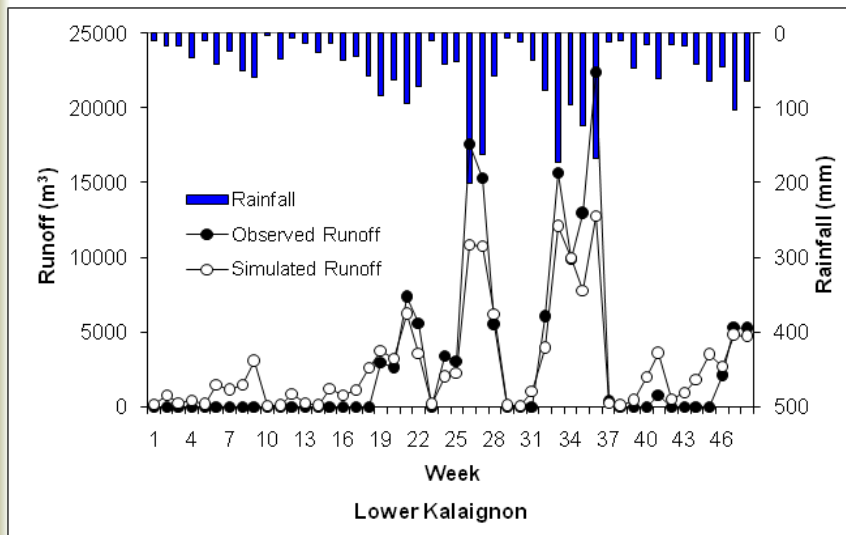
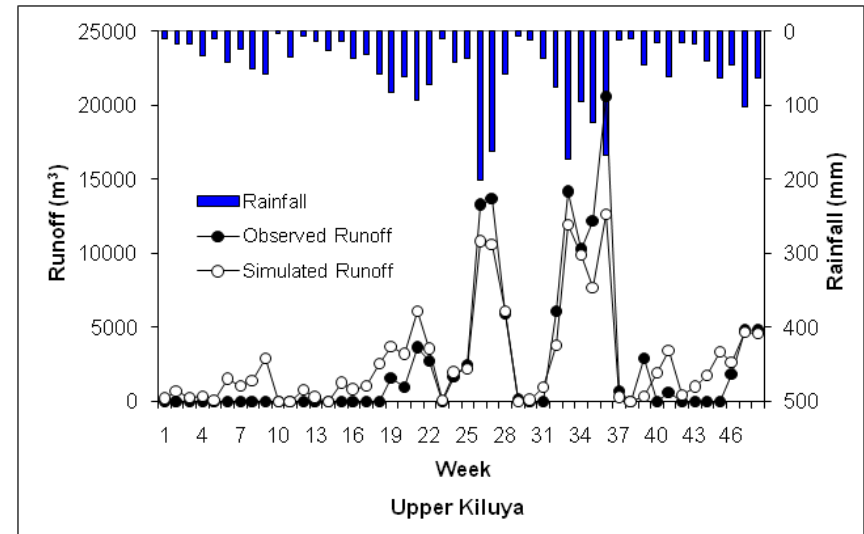
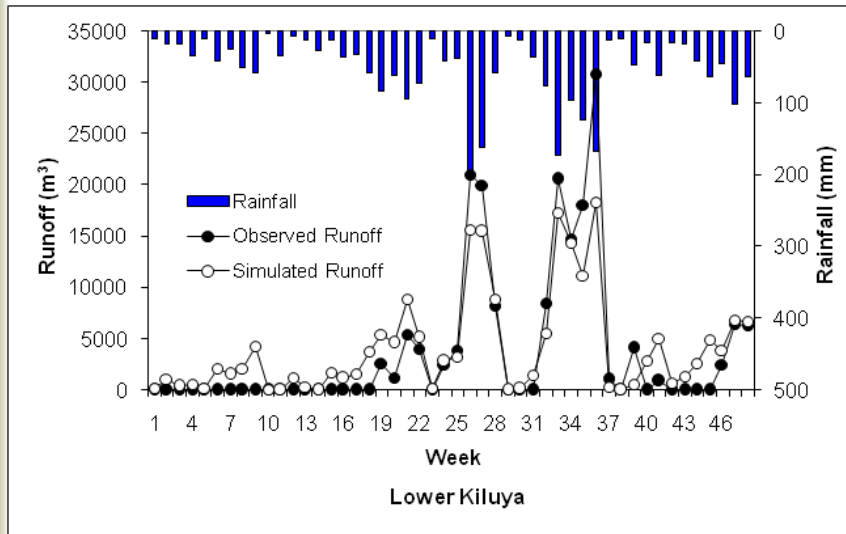
Physically-based not well-defined parameters (e.g., CN2, C factor, infiltration, SPCON, and SPEXP) were adjusted to provide better fit between the observed and simulated runoff volume and sediment yields.

Evaluation of land use change effects on runoff and sediment yield

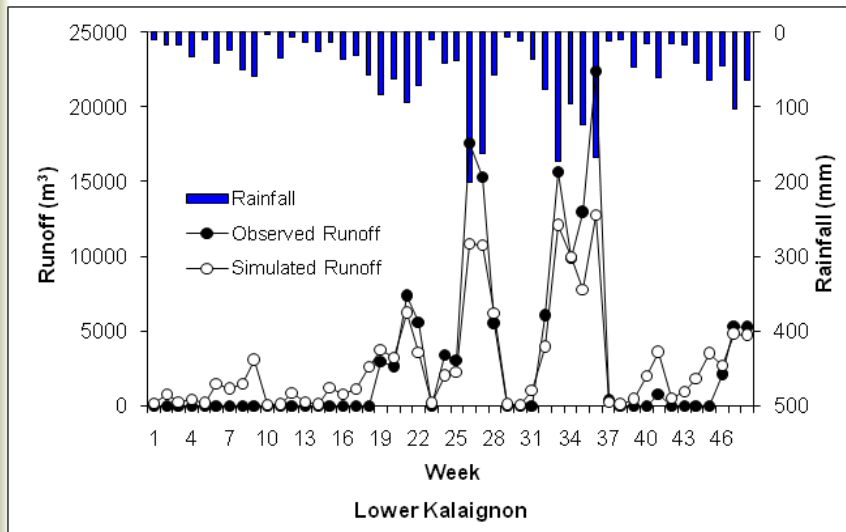
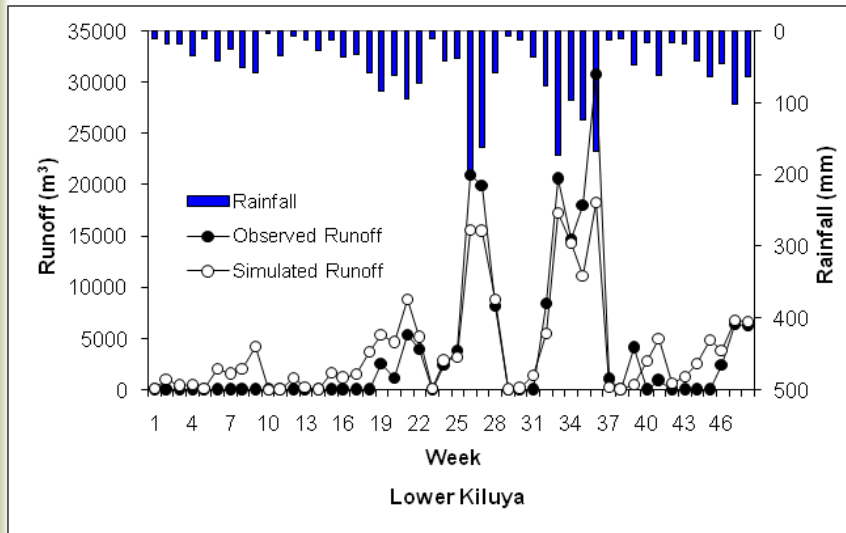
Land use change scenarios

- Scenario 1** - 50% grasslands are converted to agricultural lands with soil conservation intervention;
- Scenario 2** - 50% grasslands are converted to agricultural lands without soil conservation intervention;
- Scenario 3** - 100% grasslands are converted to agricultural lands with soil conservation intervention;
- Scenario 4** - 100% grasslands are converted to agricultural lands without soil conservation intervention;
- Scenario 5** - 100% grassland and 50% forest are converted to agricultural lands with soil conservation intervention;
- Scenario 6** - 100% grassland and 50% forest are converted to agricultural lands without soil conservation intervention;
- Scenario 7** - 100% grassland and 100% forest are converted to agricultural lands with soil conservation intervention; and
- Scenario 8** - 100% grassland and 100% forest are converted to agricultural lands without soil conservation intervention.

Prediction of runoff volume



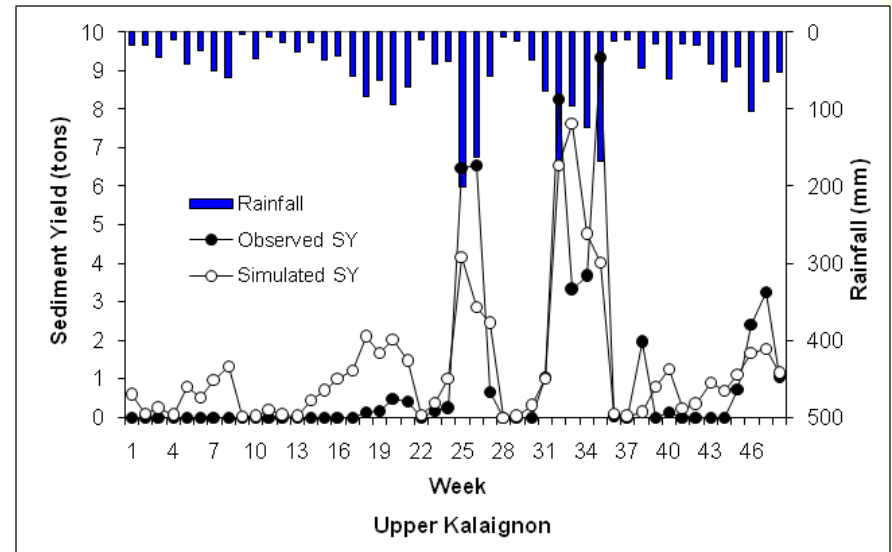
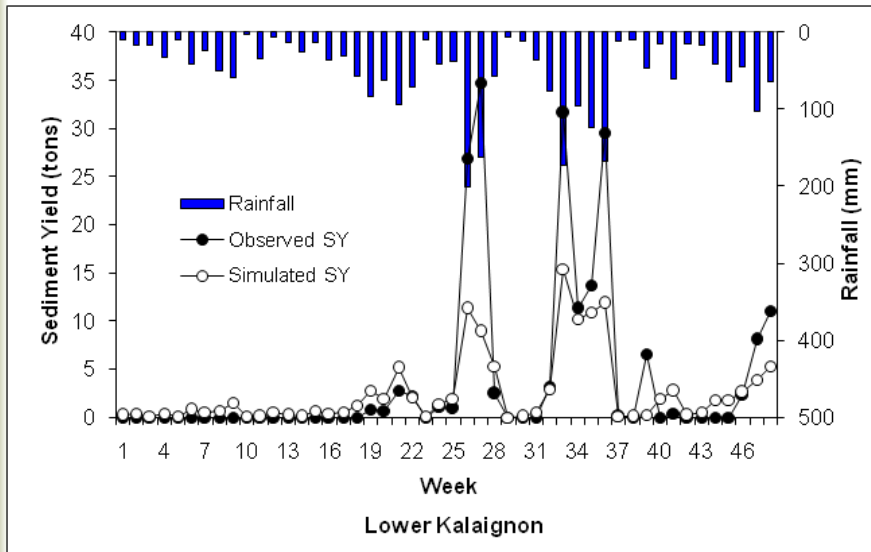
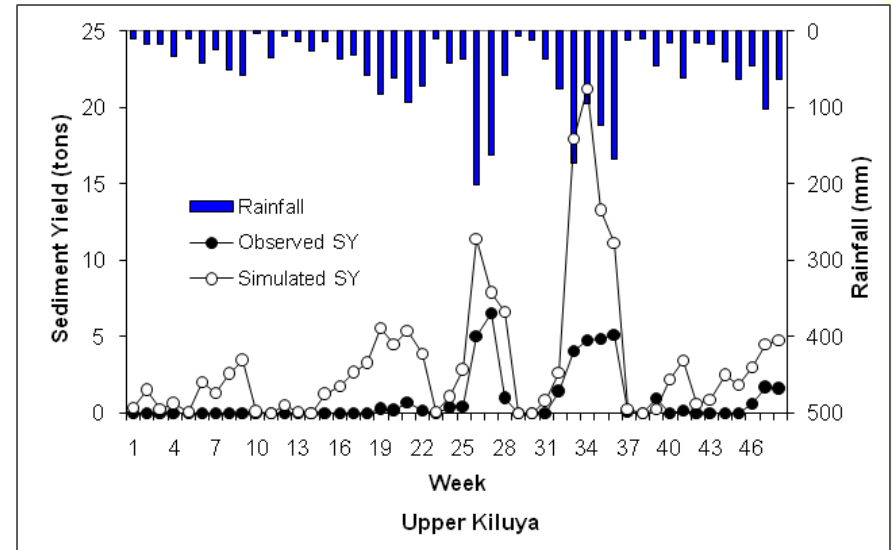
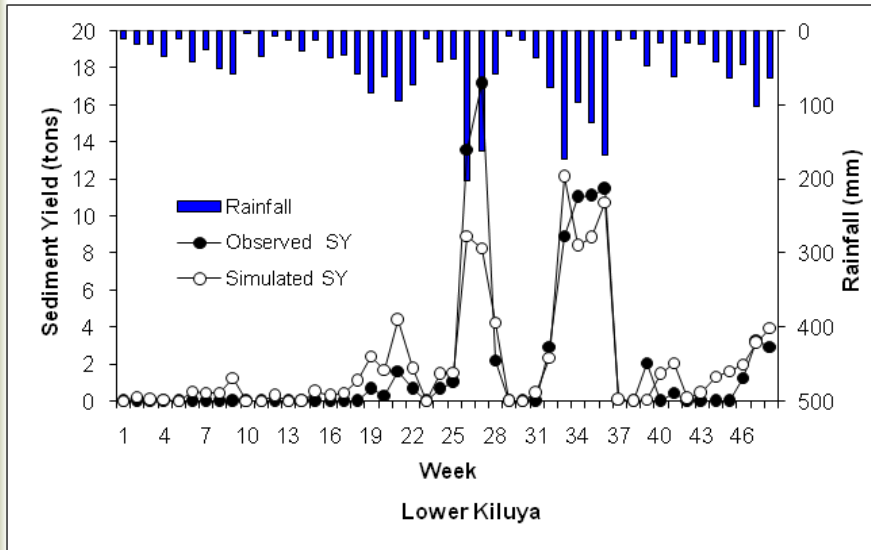
Prediction of runoff volume



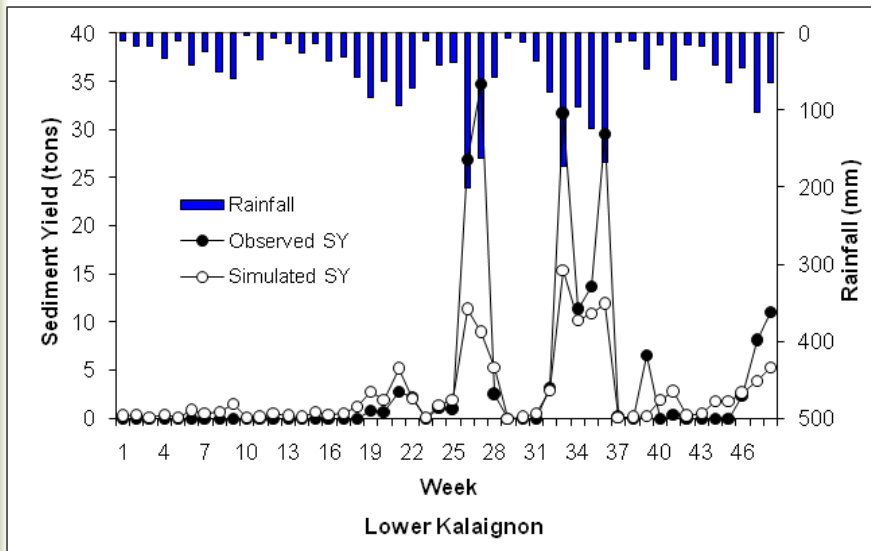
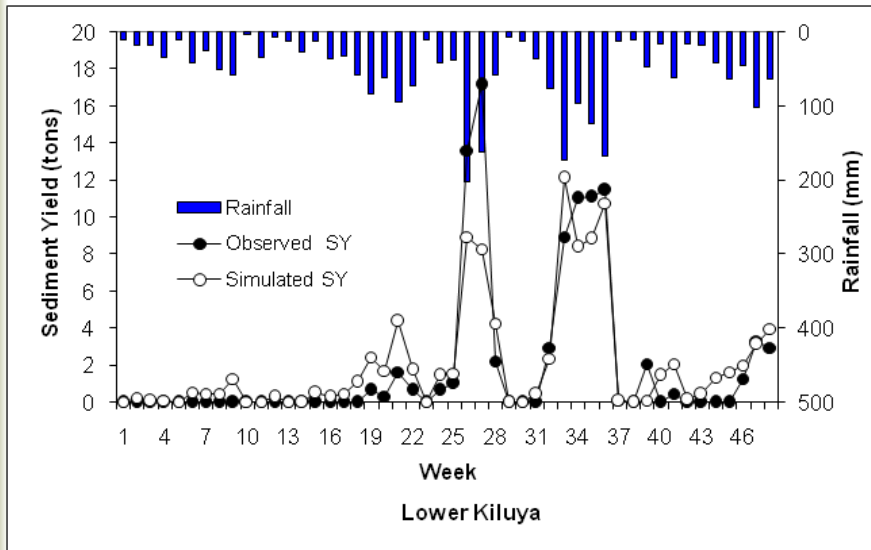
WATERSHED	WEEKLY MEAN RUNOFF VOLUME (m³)		RMSE	R ²	NSE
	Observed	Simulated			
Lower Kiluya	3809	4098	3014	0.88	0.82
Upper Kiluya	2610	2820	1977	0.88	0.83
Lower Kalaignon	2992	2848	2368	0.90	0.80
Upper Kalaignon	1470	1449	1323	0.87	0.77

- ❑ Simulated and measured runoff volumes matched well with R² ranging from 0.87 to 0.90
- ❑ ArcSWAT model showed enough adequacy to simulate runoff volumes (NSE values ranges from 0.77 to 0.83)
- ❑ The hydrologic processes were modelled realistically and can be extended to simulate hydrologic processes at various land use change scenarios

Prediction of sediment yield



Prediction of sediment yield



WATERSHED	WEEKLY MEAN SEDIMENT YIELD (tons)		RMSE	R ²	NSE
	Observed	Simulated			
Lower Kiluya	1.95	2.09	1.84	0.82	0.8
Upper Kiluya	0.84	3.39	4.17	0.7	-5.16
Lower Kalaignon	3.96	2.53	5.83	0.8	0.55
Upper Kalaignon	1.03	1.12	1.45	0.58	0.58

❑ Except for Upper Kiluya, simulated and measured sediment yield showed good agreement with R² ranging from 0.50 to 0.80

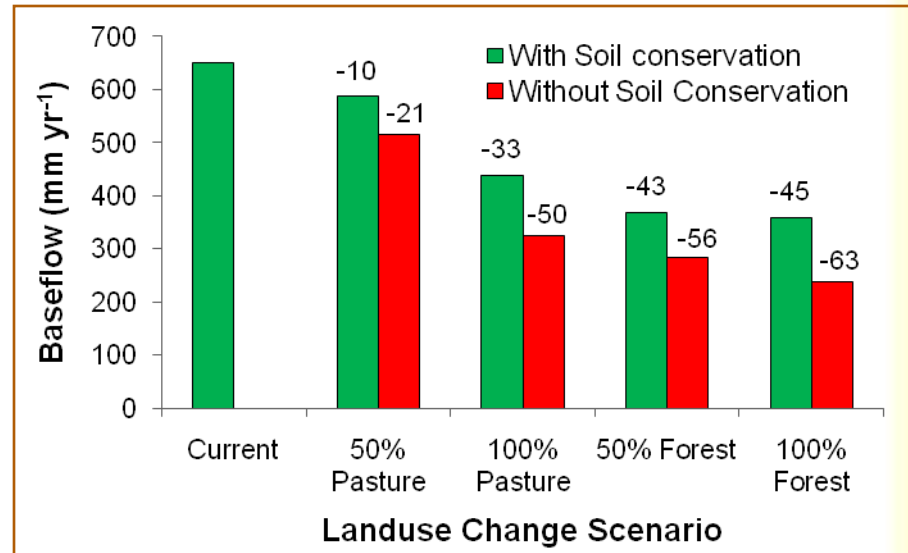
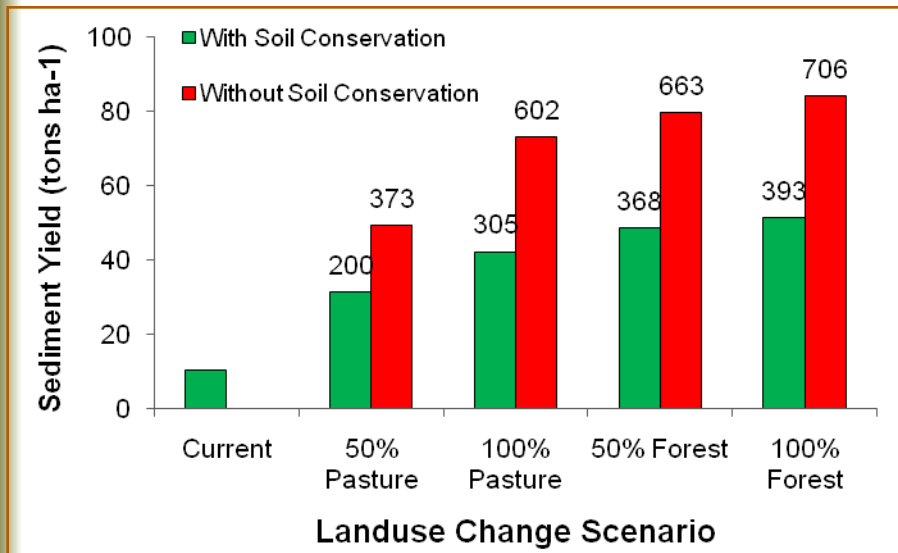
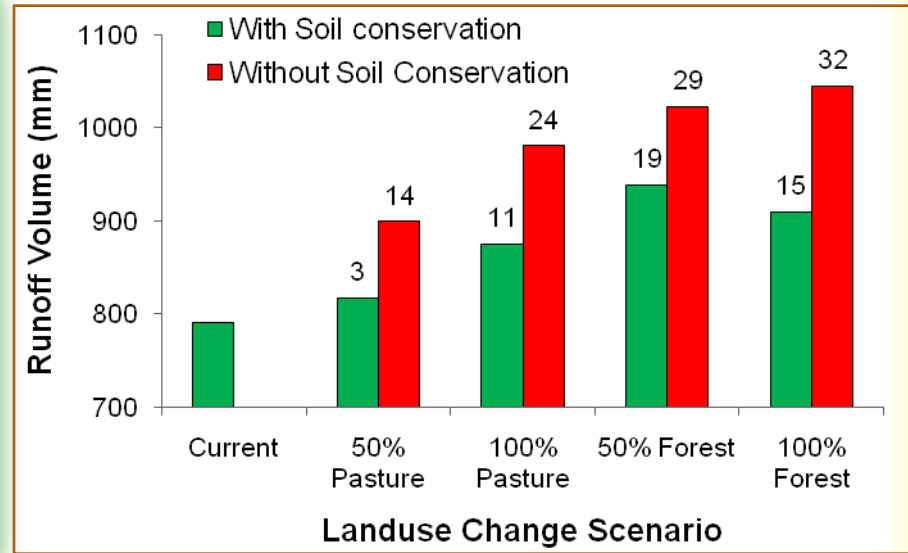
❑ ArcSWAT model showed adequacy to predict the temporal distribution of sediment yield with NSE values ranging from 0.55 to 0.80

❑ Despite the differences, the overall adequacy of the model indicates its usefulness to predict the effects of land use changes in the area.

Simulation of hydrologic impacts of land use change

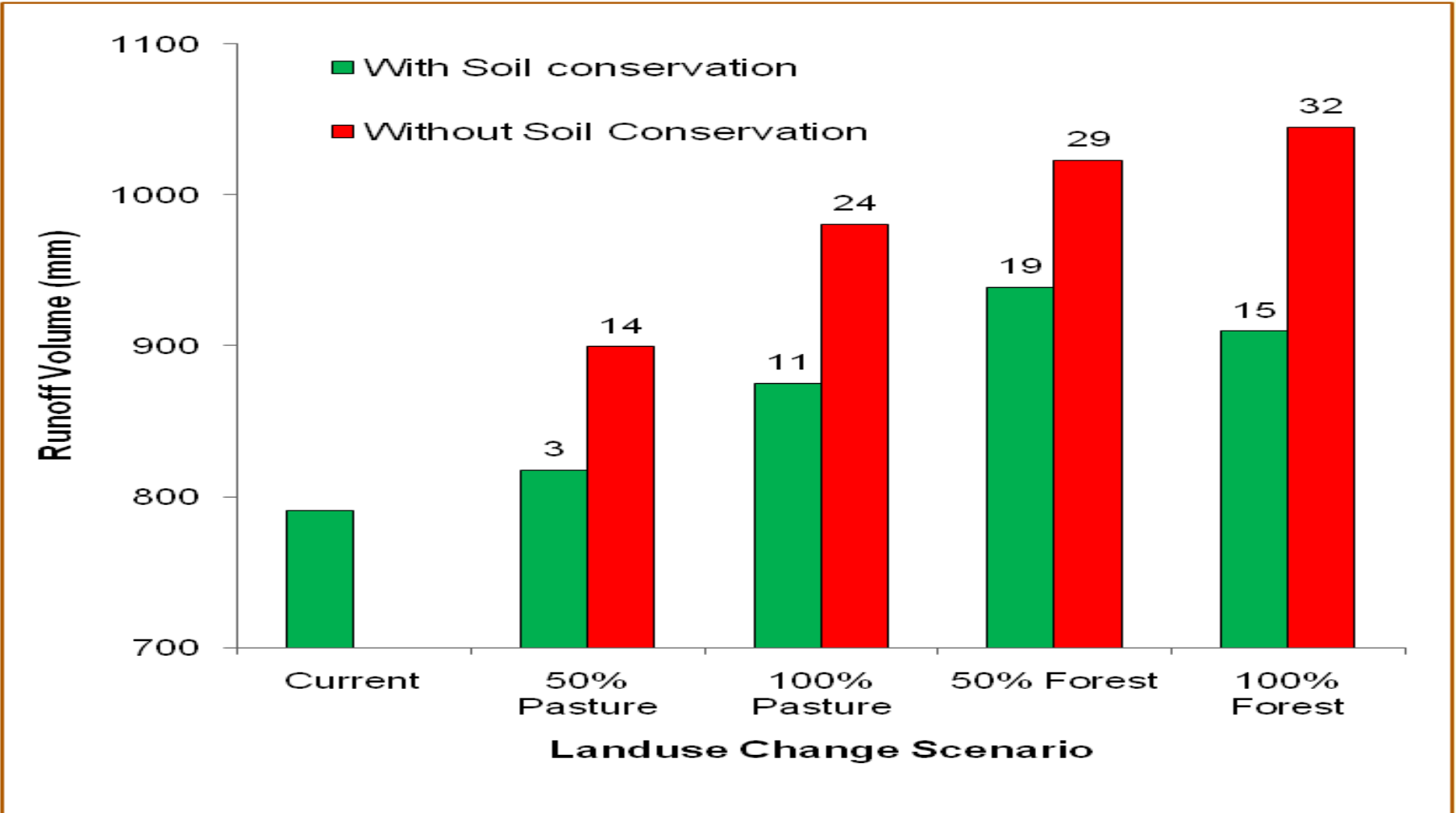
To assess the effects of land conversion in the study area, the calibrated model was run to simulate various scenarios of land use changes on

- runoff volumes
- sediment yields
- baseflows



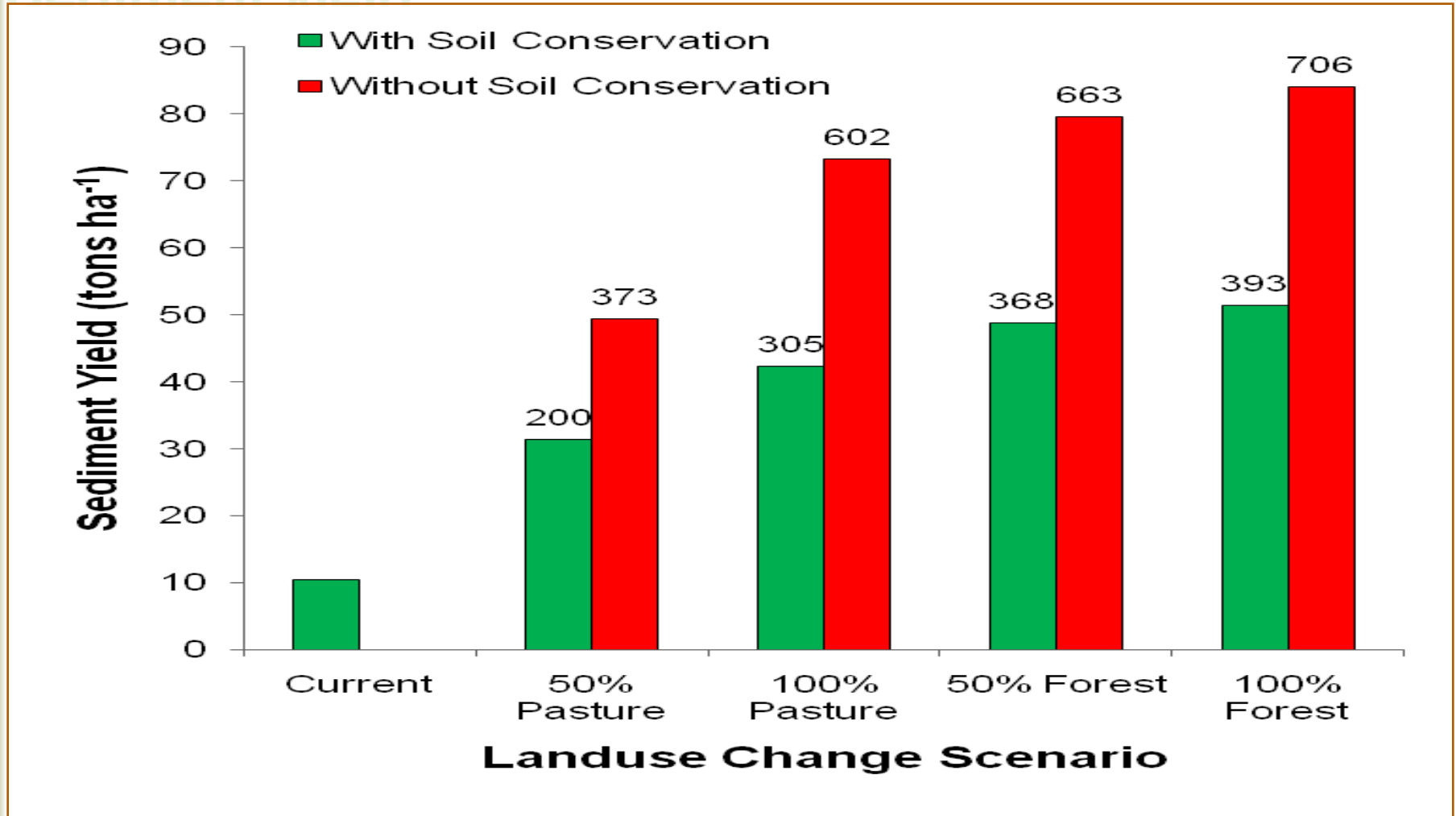
Simulation of hydrologic impacts of land use change

Runoff volume



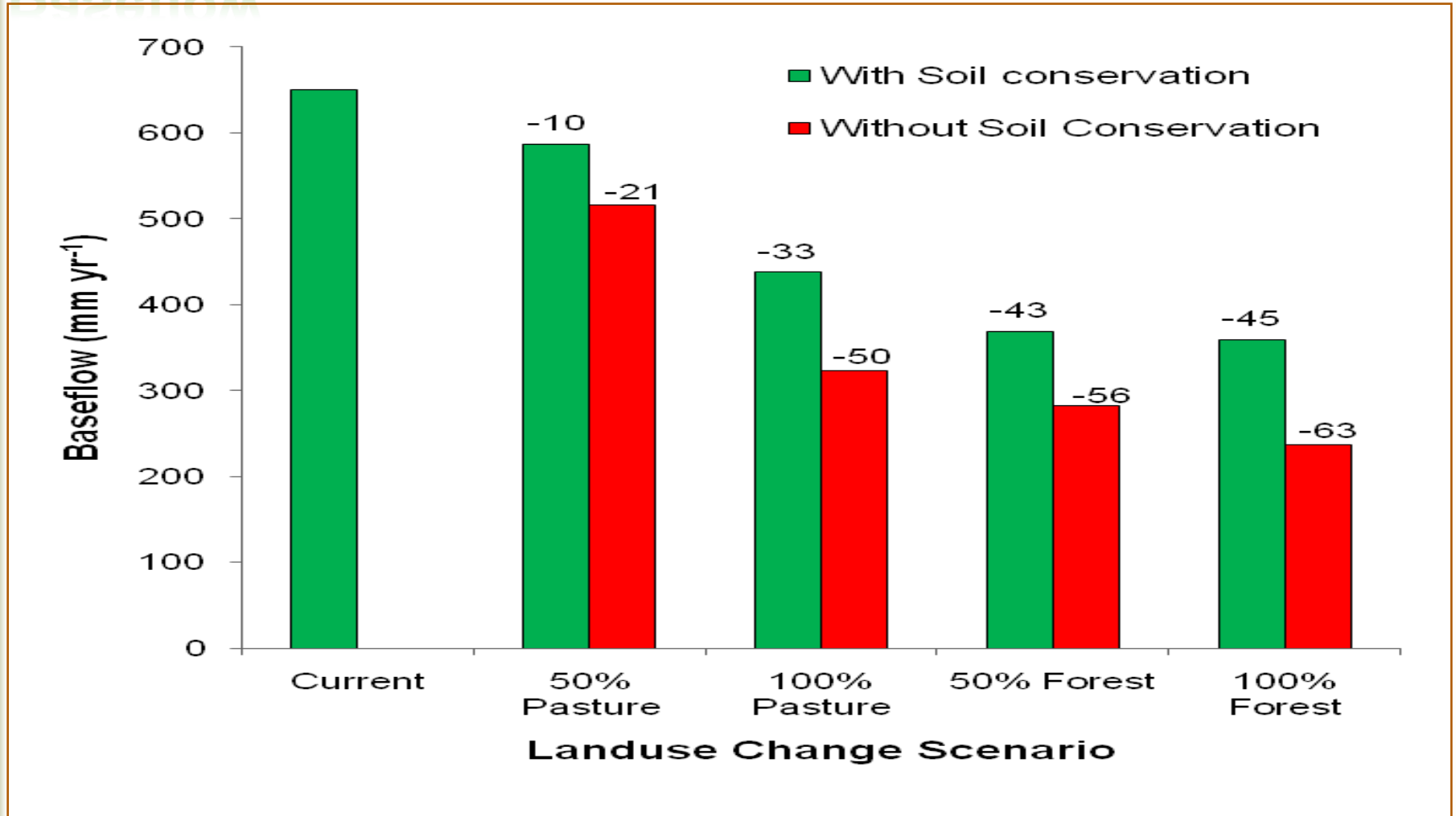
Simulation of hydrologic impacts of land use change

Sediment yield



Simulation of hydrologic impacts of land use change

Baseflow



Summary and Conclusion

- ❑ ArcSWAT can adequately predict peaks and temporal variations of runoff volumes and sediment yields with NSE ranging from 0.77 to 0.83 and 0.55 to 0.80, respectively.
- ❑ Converting pasture, grasslands and forest to agricultural crops will result to increase runoff and sediment yield and decrease baseflow.
- ❑ Increase in surface runoff will cause significant soil erosion, depleting soil nutrients, sedimentation of reservoirs, and flooding of low lying areas at the downstream.

Summary and Conclusion

- ❑ The simulate effects of pasture and forest conversion to agricultural lands is very alarming, thus efforts should be exerted to address forest conversion to agricultural crops.
- ❑ Policies addressing should be formulated both at the local and national level
- ❑ Intensive information and education campaign on the consequences of forest conversion and ways of rehabilitating the watershed should be done
- ❑ Alternative livelihood opportunities for upland farmers should be considered in policy implementation.

Acknowledgment

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Thank you

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