Photo by: Kyaw Kyaw Winn

For soil resources management

1. *Restore degraded protected forest and upland forest to decrease flooding downstream and prevent erosion in the mountainous area or saltwater intrusion in the coastal area.* The rapid growth of population, agricultural development, and urban construction and other related issues, as well as unsuitable forest management under man-made interventions, affect large areas. This impact expands the degraded forest ecosystems.

2. *In contour farming, orient crop furrows following the contour lines of the farmed area.* Furrows move left and right to maintain a constant altitude, which reduces runoff. This solution can increase crop yields.

3. *Plant short-day plants to protect top soil because the roots of trees spread out close to the surface and cling beneath the soil layer.*

4. *Alternate cover crops such as legumes with cash crops to cover the soil year-round and act as green manure that replenishes soil nitrogen.*

5. *Promote the needs, rights, interests, and responsibilities of the community related to land and water resources conservation.*

Making soil and water resources sustainable to climate variation and land use changes is not an easy task.

Therefore, to make suitable adaptation plans for soil and water resources use in this basin, decision makers need to understand the extent of the potential impact of both climate change and human activity on local soil and water resources. However, with appropriate decision systems, good policies, effective monitoring, and improved planning and execution, it is possible to manage soil and water resources sustainably.

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Assessing the Impacts of Land Use and Climate Change on Soil and Water Resources in the Srepok Watershed, Central Highland, Vietnam

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Background

Soil and water resources in the world are currently under severe pressure due to human intervention and the changing of runoff patterns caused by climate and land use changes. Population growth and human activities have accelerated the speed of land use change, that in turn affect hydrological processes. In addition, climate change may affect many aspects of natural ecosystems. Hence, understanding of impacts of climate change and land use change on hydrological conditions is essential to enable more efficient soil and water resources development. In the same light, Srepok catchment, which is situated in the Central Highlands of Vietnam, is presently being challenged by many critical issues for soil and water resources management in the Srepok river basin (Government of Vietnam 2006). However, non-linear relationships, multiple causation, lack of mechanistic understanding, and lag effects, together, limit the ability to diagnose causes. As this information is important for land use planning and water resources management, it is necessary to quantify the extent to which land use change and climate variability influence the hydrological conditions.

Data and Method

Using the Soil and Water Assessment Tool (SWAT) model, meteorological data such as daily precipitation, maximum and minimum air temperature, relative humidity, wind speed, solar radiation, and spatial data sets to include, digital elevation model (DEM), land use, and soil maps were collected. The calibration and validation of stream flow and sediment simulation also used water discharge and sediment load data. Table 1 displays the sources and types of data collected.

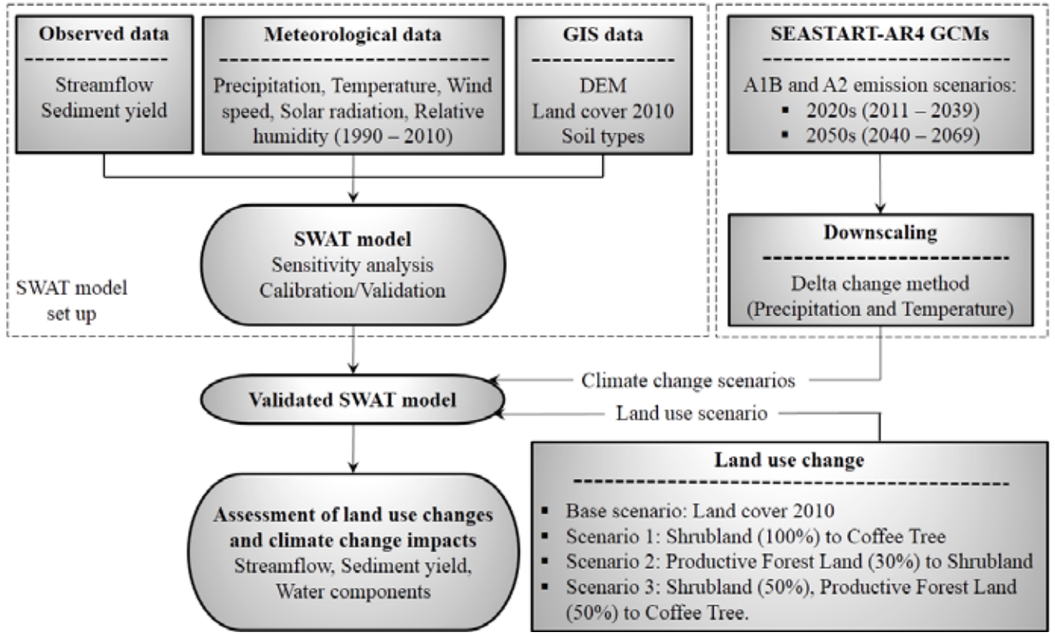
Table 1. Sources and types of data collected for SWAT simulation

Data type	Sources
Topographic map	• Department of Natural Resources and Environment Dak Lak provinces • Department of Natural Resources and Environment Dak Nong provinces • ASTER Global Digital Elevation Model (http://gdem.ersdac.jspacesystems.or.jp/)
Land use map	• Department of Natural Resources and Environment Dak Lak provinces • Department of Natural Resources and Environment Dak Nong provinces • Global Land Cover Characterization (http://www.globallandcover.com/GLC30Download/index.aspx)
Soil map	• Department of Natural Resources and Environment Dak Lak provinces • Department of Natural Resources and Environment Dak Nong provinces • Global soil data (http://www.fao.org/fileadmin/user_upload/soils)
Weather	The Central Highland Region Hydro-Meteorological Centre, Climate Forecast System Reanalysis (http://globalweather.tamu.edu)
Water discharge	The Central Highland Region Hydro-Meteorological Centre
Sediment yield	

Data on topography, land use, and soil map were collected from local government officials and the internet. This research used meteorological data for the period of 1990 to 2011.

The model utilized meteorological data from four local stations (i.e., Buon Ho, M'Drak, Buon Ma Thuot, and Dak Nong) and nine global stations in Srepok watershed.

Figure 1. Applied methodological approach in the Srepok watershed



In terms of calibration and validation model, the project used hydrological data at Ban Don Station. The period of calibration is from 1981 to 2000, while the validation is from 2001 to 2009. The data collected were processed following the SWAT model input format.

Three land use change scenarios were developed: Scenario 1 assumes that all current shrubland is to be converted to perennial cropland; Scenario 2 assumes that the productive forestland (30%) is to be replaced by shrubland; and Scenario 3 assumes that the shrubland (50%) and productive forestland (50%) are to be converted to perennial cropland.

These land use scenarios were developed based on the current trend of land use change within the basin. Baseline scenario utilizes land use in 2010.

The study uses climate change scenarios through two future periods (2010-2039 and 2040-2069) based on downscaled General Circulation Models, regional projections of climate change driven by the A1B and A2 emission scenarios obtained from SEASTART-AR4 (2009). The A1B and A2 scenarios were selected in this study because these are simulated by most GCMs in SEASTART-AR4 and the study focuses on mid-century change, in which period A1B (medium emission) and A2 (high emission) exhibit similar greenhouse gases (GHG) emission forcing.

To investigate the combined impacts of land use scenarios and climate change scenarios to the streamflow and sediment yield for the two future periods (2020s and 2050s), the research ran the SWAT model for all scenarios comparing the results to the baseline period scenario (1990-2010). Figure 1 shows the applied methodological approach in the Srepok watershed.

The results of the study show that future climate trends would differ spatially. The A1B and A2 scenarios show rise in the annual average temperature. Precipitation would decrease in an A1B scenario in 2011 to 2039 and 2040 to 2069, thus, there would be a decrease in precipitation intensity as compared with the base scenario from 1990 to 2010. All scenarios in 2011 to 2039 and 2040 to 2069 will bring about differences in distribution and quantity of annual streamflow in the dry and rainy seasons. These scenarios also show that shifts in rainy season, rainfall, and land cover had led to fluctuations in sediment yield. As regards to water components, the relationship between flow and rainfall was established. The flow availability in the Srepok watershed was over 60 percent and the amount of evapotranspiration accounted for about 36 percent. Groundwater contributed more—over 60 percent—to the total flow than did surface water. Thus, groundwater is a huge asset in the Srepok watershed.

These results would provide useful information that decision-makers need in order to promote soil and water resources planning efforts in Srepok watershed, Central Highland, Vietnam.

Policy Recommendations

Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems, and for human survival itself. It is vital for reducing the global burden of disease and improving the health, welfare, and productivity of populations. It is central to the production and preservation of a host of benefits and services for people. Water is also at the heart of adaptation to climate change, serving as the crucial link between the climate system, society, and the environment. However, climate change, as well as man-made interventions such as deforestation or infrastructure like hydroelectric power plants, affect water resources immensely. The results of the research recommends the following:

For water resources management

1. *Choosing drought-resistant crops, adding water-retaining organic matter to the soil, and installing windbreaks and fences to slow down winds and reduce evapotranspiration.* These are some simple ways to reduce the amount of water used for irrigation. These methods save money, protect the environment, and provide for optimum growing conditions
2. *Building and upgrading irrigation systems and reservoirs to serve water for production and domestic use.* This not only saves time and money more effectively, but also uses water more efficiently, such as keeping a water storage for drought or the dry season.
3. *Installing meteorological hydrology stations and water quality monitoring networks to enhance water-quality monitoring systems.* This can serve for better assessment of the variability of water resources in terms of quality and quantity.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