INTEGRATED SYSTEM FOR FLOW ASSESSMENT UNDER CLIMATE CHANGE FOR SREPOK WATERSHED, CENTRAL HIGHLAND VIETNAM

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ABSTRACT

Srepok watershed in Tay Nguyen region is planned to develop the forestry, industrial crops, agricultural process, hydroelectricity and reinforce trade, tourist and services. Application information technology and model is becoming a new trend to solve many complex problem in environment field, especially under the effect of climate change. Thus, it is necessary to integrated information technology and model to assess the influences in the past and presence of the land use types and the climate models on the surface water quality and will provide the valuable information for managing sustainable watershed. SRClim software (Srepok Climate change adaptation information system) was built with data synthesis and analysis function to make the database in Srepok watershed and provided the inputs for model, such as hydrological model MIKE, SWAT and statistic model SDSM, LARS_WG. In the paper, the data which was classified and took from SRClim software, was used to the inputs for SWAT model to assess water discharge in Srepok watershed in thirty three years (1980-2012). At the result, calibration and verification process which were compared to observed data at Ban Don station, confirmed that SWAT model was one of the potential tools to apply at highland watershed. Base on NSI index reached 0.73, R square got 0.83 in calibration period and NSI achieved 0.55, R square attained 0.64 in verification, result was the background for research about assessing the impact of land use change and climate change to natural resources in the watershed in future.

1. INTRODUCTION

Srepok basin has the total basin size 30,900 km^2, in there, of Vietnam 18,200 km^2 and of Cambodia 12,700 km^2. Srepok river system in Vietnam domain includes two main streams – the main stream Srepok from the mountain region in Southeast and Ea H'Leo river from the mountain region in Northeast of Daklak. The main stream Srepok on the region of Daklak province with the watershed size occupying 2/3 the terrain size, by two main branches Krong Ana and Krong Kno combined with total watershed size 4200 km^2, with the length 125 km. Srepok river has the potentiality for developing the hydroelectricity and most hydroelectric projects are planned for developing on this river.

This article provides the approach method to consider the effects of the climate change on the water and land resources on the Srepok watershed on the integral method base of database, GIS and math model. The main product of the research is the information system SRClim (Srepok Climate change adaptation information system). SRClim permits saving the information, data relating to the effects of the climate change to the land, water resources on the Srepok watershed. SRClim permits forming the data, script running the SWAT, Mike

models to help to provide the effects of the climate change to the land, water resources. Moreover, SRClim supports to treat the result running the scripts from SWAT, Mike supporting the decision. The information, data in SRClim are reported to ensure the information quality, preventing the excess and ability to collect. The research used data which was classified and took from SRClim software, was used to the inputs for SWAT model to assess water discharge in Srepok watershed. Moreover, and the result will be the background for continuos research in Srepok watershed in future.

2. METHODOLOGY

2.1 Approach

SRClim is constructed on the approach method stated in the project *(Bui Ta Long, 2006)* about the environment model information systems. These systems are constructed to integrate the different environment information kinds and with the math models. Matching the measurement data with the digital diagram, database and the math model create a system called GIMS *(Geographical Information Monitoring System)* to distinguish to the familiar term GIS. The important function of GIMS is to forecast the environment state with the scripts by the economic activities of people. GIMS is considered the tool with the prospect to solve the environmental problems in other ranges *(Krapivin V.F et. al., 2006).* SRClim software suggested in this research includes the modules: Web GIS model, math model bank module, module showing the simulation math result, statistic, report models concerned.

2.2 Integrated method

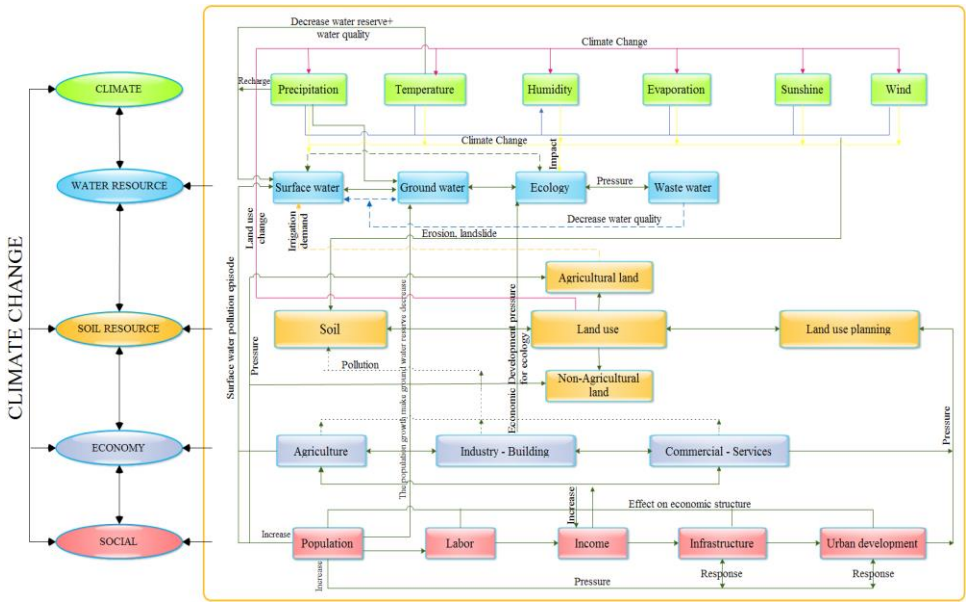

Figure 1. SRClim framework for the study.

The integrated conception in SRClim known the combination and connection for the systems *(called block)* and subsystems in the system. Four blocks suggested in the first edition include: climate, water resource, land resource, economy and society. Each block includes the sub-blocks, among the blocks, the sub-blocks get the constraint. SRClim system in this research is known the model-information system, to treat the information from many sources, various in the protection and legal use for the natural resources. SRClim must ensure the high convenient level for exchange, finding and accessing the information. The information exchange in SRClim means that the system must ensure the route for finding the

result on the queries and performing the result under the convenient form for users. The unique access means that the system must the provide the unique policy for publishing the reports, statistics from the saved data.

2.3 Database construction

Constructing database for SRClim is done on the base of researching many projects of the foreign authors, particularly from the project research *(Bui Ta Long et. al., 2012).* Forming the block diagrams for the object groups noted in the climate region, water resource, economy, society, and the mutual effect between these groups.

2.4 SWAT model

SWAT is a hydrologic quality model developed by United States Department of Agricultural-Agricultural Research Service (USDA-ARS). It is a continuous times model that operates on a daily time step. The objective in model development was to predict the impact of management on water, sediment, agricultural chemical yields in large ungagged basin. To satisfy the objective, the model is physically bases (calibration is not possible on ungagged basin); uses readily available inputs; is computationally efficient to operate on large basins in a reasonable time; and is continuous in time and capable of simulating long period for computing the effect of management change. *(Arnold, J.G., et al, 1998).*

Two statistical indexes include Nash-Sutcliffe index (NSI) and the coefficient of determination (R2) which represented the correlation between the observed value and simulated value, were utilized to evaluate the simulated results of SWAT model.

The simulating quality of model is assessed with four levels *(D.N. Moriasi, et al, 2007).*

- $0.75 < NSI \leq 1$: very good.
- $0.65 < NSI \leq 0.75$: good.
- $0.50 < NSI \leq 0.65$: satisfaction.
- $NSI < 0.50$: dissatisfaction

Moreover, if the R2 value is less than or very close to zero, the model prediction is considered "*unaccepted or poor*". If the value is one, the model prediction is *"perfect*" *(C. Santhi, et al., 2001).*

2.5 Processing data

The scope of the research is Srepok watershed which belongs to Dak Lak, Dak Nong and Lam Dong Provinces. Therefore, the input data of SWAT model version 2012 and SRClim software were collected from the relevant authorities in the three provinces and from internet sites in geographic information systems worldwide. The data include digital elevation model (DEM), soil map, land use map, slope map, meteorological and hydrology data in the study area.

DEM data was collected from global digital elevation data ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) - USGS/NASA with 30 meters resolution (http://www.gdex.cr.usgs.gov). The elevation separated five levels: 144–385 m, 385–617 m, 617–914 m, 914–1,318 m, 1,318–2,409 m; Slope map was edited from SWAT model base on The Digital Elevation Model of Srepok watershed and it has five groups: under 5%, 5–10%, 10–15%, 15–20%, and upper 20%; Soil map was collected from The Digital Soil Map of the world, a product of Food and Agriculture Organization of The United

Nations with 5000 different soils in spatial resolution of 10 kilometers (http://www.waterbase.org/download_mwswat.html). This map is separated five main soil types due to SWAT code: Ferric Acrisol, Humic Acrisol, Orthic Acrisol, Rhodic Ferrasols, and Pelic Vertisols; Land use map in 2010 was collected from Deparment of Natural Resource and Environment in Dak Lak, Dak Nong and Lam Dong Provinces. Similar to other map, land use map was divided into seven types based on SWAT code: Agricultural Land-Generic, Agricultural Land-Row Crops, Forest-Deciduous, Forest-Evergreen, Forest-Mixed, Residential - Medium Density and Water.

Meteorological data was bought from Central Highland Region Hydro-meteorological Centre throughout a period from 1980 to 2012. The model ultilized meteorological data from five local stations, including Buon Ho, M'Drak, Buon Ma Thuot, Dak Nong and Da Lat, and fifteen global stations in Srepok watershed and its neighborhood. Hydrological data at Ban Don station was used to calibrate and validate model. The period of calibration was from 1981 to 2000 and verification was from 2001 to 2009.

3. RESULTS AND DISCUSSIONS

3.1 Construct SRClim software

SRClim 2013 is researched and done in 2 years 2012-2013, in the test phase. The test edition is installed at: www.envim.net/SRClim. The SRClim software -the product of this research is constructed to manage, share the information about the land and water environment resources on Srepok watershed affected generally from many elements such as: economy-society, from the hydroelectric dams, climate change, of the economy society development plan, to help the managers active in deciding and prevention coping plan. SRClim provides the information share model between the management bodies of the central and local levels in the watershed and the information generation ability via the statistic reports suggested. SRClim model helps show the contradictions, potentialities between the economy-society and the climate change during development process. SRClim leads an integral concentration CSDL, to help the scientific researches and supports for decision.

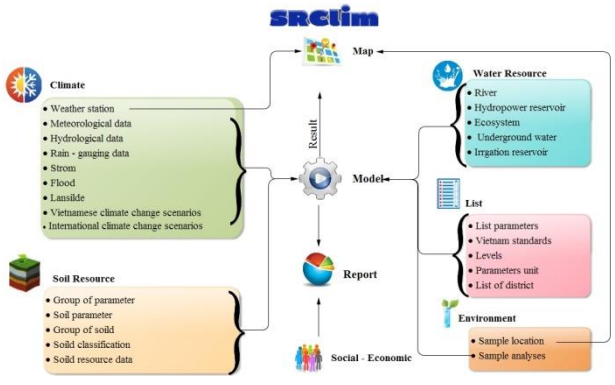

Figure. 2 Stucture of SRClim software.

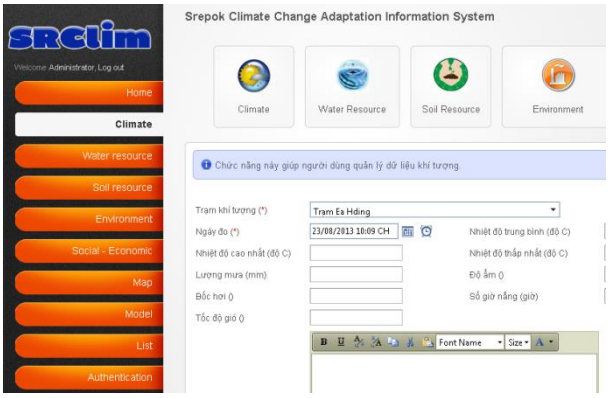

Figure. 3 Interface of SRClim software.

3.2 Simulation results of water discharge in Srepok watershed

In the first step, map and attributed data were took from SRClim software, were make the inputs for SWAT model. The observed data located in Ban Don Station which built on the main Srepok river, was used to calibrate and validate the model. The location of Ban Don Station coincided the six number outpoint. Model simulate the flow in Srepok watershed in

thirty three years (1980-2012).

Table 1 SWAT sensitive parameters and calibrated values at Ban Don Station.

Parameter	Description of parameter	Calibrated value		
		Fitted-value	New min-value	New max-value
r_CN2.	Initial SCS CN II value	-0.38	-0.58	0.19
v_ALPHA_BF	Baseflow alpha factor	0.47	0.30	0.65
v_GW_DELAY	Groundwater delay	78.38	-31.20	187.96
v_GWQMN	Threshold water depth in the shallow aquifer for flow	1.63	1.07	2.19

The automatic calibration was conducted by SWAT-CUP software with Sufi-2 algorithm (Squential Uncertainly Fitting).After we analyzed the sensitivity of twenty six elements which affect surface flow, four parameters was determined which influenced water quantity the best in Srepok watershed included Curve number (CN2), Base flow alpha factor (ALPHA_BF), Groundwater delay (GW_DELAY) and Threshold water depth in the shallow aquifer for flow (GWQMN). The calibration result was showed in Table 1 above.

SWAT – CUP model was not only provided the suitable parameters but also offered the best flow simulated result. The simulated water discharge were calibrated against monthly observed data from 1981–2000 (the observed data in 1980 was skipped to make model warm up). At the result, Nash-Sutcliffe index and the coefficient of determination reached very good level in both scenarios with 0.75 and 0.83, respectively. The correlation between the observed value and simulated value was represented via Figure 4 as below.

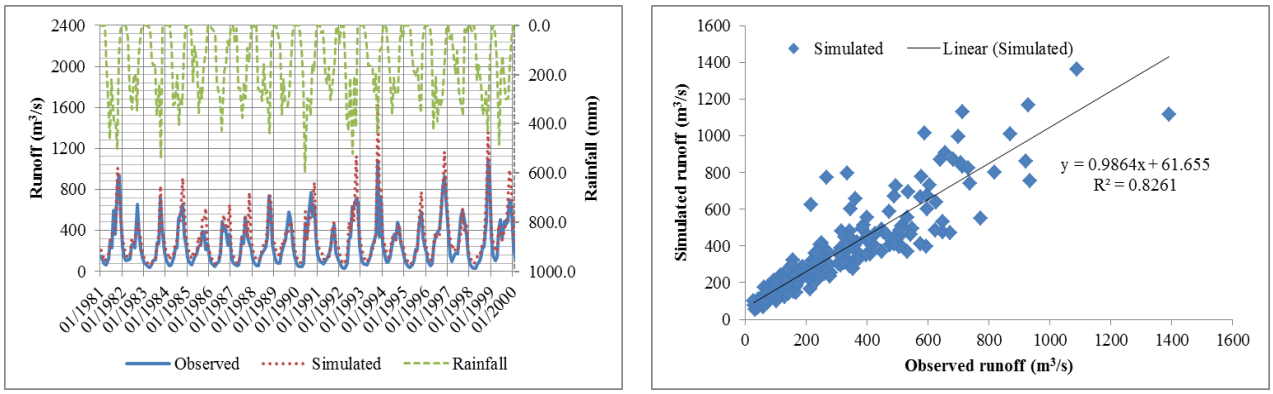

Figure 4. The correlation between the observed and simulated value at Ban Don Station after calibration (1981-2000).

Table 2 Model performance for the simulation of flow-out at Ban Don station.

Before calibration		After calibration		After validation	
R2	NSI	R2	NSI	R2	NSI
0,81	0,37	0,83	0,75	0,64	0,55

After calibration, fixed values was used to validate to estimate the accuracy of model. Runoff simulation results were shown in Figure 5 and Table 2. In validation period (20101-

2009), the NSI and R square value was acceptable at 0.55, 0.65 respectively. Therefore, this study could determine that SWAT model was one of the potential tools to simulate the water discharge in Srepok watershed.

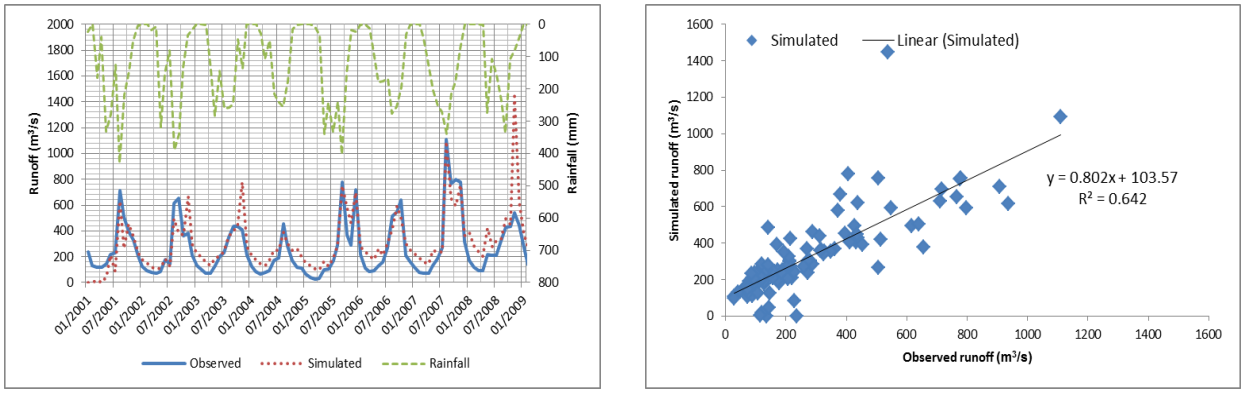

Figure 5. The correlation between the observed and simulated value at Ban Don Station after validation (2001-2009).

The correlation between the observed and simulated value was presented via charts (see Figure 4 and Figure 5). Overall, simulated values tend to higher than observed values in both calibration and validation period. However, the top of water discharge on rain season has similar trend. In summary, simulated result of model was verification and can be used the background for research else like assessing the role of land cover or climate change in the Srepok watershed.

4. CONCLUSIONS

The main result of this article was to establish SRClim tool with data synthesis and analysis function following the require of users. The data which was classified and took from SRClim software, was used to the inputs for SWAT model to assess water discharge in Srepok watershed. Base on the result, the information technology and SRClim tool were suggested to apply for managing database and supporting decision in water and land resource exploitation in Srepok watershed.

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