SWAT2009_LUC: A TOOL TO ACTIVATE LAND USE CHANGE MODULE IN SWAT 2009

Naresh Pai
Dharmendra Saraswat
Department of Biological & Agricultural Engineering

Presented at:

University of Castilla La Mancha
Toledo, Spain
June 15-17, 2011
• Simulate impact of soil, land use, and management activities on water quantity and quality\(^1\)

• Past studies mostly relied on “snapshot” approach for characterizing land use in watersheds for the entire study period

• Temporal land use changes have direct impact on hydrology, sedimentation, and nutrient losses\(^2\)

• A single land use dataset is therefore not a reasonable representation of watershed processes

\(^1\)Frankenberger (2011)
\(^2\)Miller et al. (2002), Ahearn et al. (2005), Ouyang et al. (2010)
BACKGROUND

• SWAT 2009: released January 2010

• New module: land use change (LUC)\footnote{Arnold et al. (2010)}

• Distribution of existing land use could be varied AT ANY TIME DURING the model run

• Manually updating land use distribution is time consuming

*Arnold et al. (2010)
OBJECTIVES

1. Develop a Graphical User Interface (GUI) for a desktop based, stand-alone tool to activate LUC (LUU) module in SWAT 2009

2. Assess the performance by comparing LUC tool’s output with input land use data
**LUC MODULE CONCEPT**

- **Assumption**: SWAT model for the project area has been created

- **HRU**: unique combination of land use, soil, and slope within a subbasin

- Fractional area of an existing HRU is represented by HRU_FR variable in *.hru files

- LUC module operates by updating HRU_FR variable as many times as the number of temporal land use data layers are input in the model

- **Constraints**: 1) HRUs can’t be added or deleted  
  2) Sum of HRU_FR for each subbasin = 1
LUC MODULE: CHALLENGE

- Depending on watershed size, threshold decision, and heterogeneity

1. Numerous HRUs: few 100’s to 1000’s
   LS (4) * ST (10) * SC (4) = 160 – computational time

2. Fragmented HRUs: Single HRU could consist of multiple islands

3. Area under all HRUs require labor and time (hrus1.rrd)

Mapping challenge

Fragmented HRU

Regular LULC raster grid

#Pai et al. (2011; in review)
Input Processing

• For *non-threshold SWAT models*: use 0-0-0 HRU raster that includes all unique combinations of land use, soil, and slope (hrus1.rrd)

• For *SWAT models created using threshold*: post process non-dominant (ND) HRUs with nearest dominant (D) HRUs in 0-0-0 raster using Euclidean distance allocation method*
SWAT2009_LUC TOOL

- GUI for activating LUC module developed
- Ingests multiple land use layers interactively
- Interacts with SWAT project folder
- Output: lup.dat, file1.dat, file2.dat,....

- Projection is **important**
**SWAT2009_LUC TOOL**

- **Step 1:** Identify SWAT2009_LUC folder
- **Note:** buttons sequentially enabled
- Create sub-folders:
  - Shape
  - Raster
  - Output
- **Store:**
  - hru1.shp
  - hrs1.rrd
  - lup.dat, fileX.dat
• Step 2: Identify SWAT project folder

• Copy hrus1.rrd (from Watershed/Grid folder) in Raster folder

• Copy hru1.shp (from Watershed/Shapes folder) in Shape folder (to identify HRUs that passed the threshold)

• Post-process hrus1.rrd (for thresholded projects only using Euclidean Allocation method)
Step 3: Upload LULC data and starting dates

Use starting dates to create `lup.dat` and store in Output folder

Upload lookup table to connect land use map with SWAT four-alphabet code

<table>
<thead>
<tr>
<th>No.</th>
<th>Month</th>
<th>Day</th>
<th>Year</th>
<th>FileName</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1999</td>
<td>file1.dat</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2004</td>
<td>file2.dat</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2006</td>
<td>file3.dat</td>
</tr>
</tbody>
</table>
• **Step 4**: Hit **Process** button

• Identify base LULC for each HRU using *.hru* files

• Re-classify HRU ids based on LULCs that are not part of base HRU definition

• Re-calculate HRU_FR and output in fileX.dat in Output folder

• Copy lup.dat, file1.dat, file2.dat, … to TxtInOut to **activate LUC module**
CASE STUDY: ILLINOIS RIVER WATERSHED

Drainage area: 1,963 km²

Subbasins: 27

LULC: 2006

Soil: SSURGO

Slope: 4 classes

HRUs: 1,126
(Thresholds: 5%, 10%, 0%)

Study period: 1999 - 2006
**Land Use Change**

**Illinois River Watershed – Temporal Land Use**

- **Pasture**
- **Urban**
- **Forest**

The graph shows the percentage change in land use over the years 1999, 2004, and 2006. The red arrow indicates a decrease in pasture areas and an increase in forested areas over the years.
Results - Tool Performance

- Land use calculated by SWAT2009_LUC closely matched LULC layer for all years
CONCLUSIONS

✓ Objective 1: SWAT2009_LUC, a GUI driven, desktop-based tool was developed to activate the LUC module in SWAT 2009

✓ Objective 2: LUC module output was comparable to actual LULC data

✓ Tool useful for modelers wanting to evaluate impact of land use change (LUU)
Financial support: Arkansas Natural Resources Commission (ANRC)

Purdue: Dr. Indrajeet Chaubey and his team, Purdue University

ArcSWAT technical support: Dr. Raghavan Srinivasan, Texas A & M University

SWAT Team: Jeff Arnold, Mike White and Nancy Simons at USDA-ARS, Temple, TX
Dr. Dharmendra Saraswat
Assistant Professor - GeoSpatial
Department of Biological & Agricultural Engineering
University of Arkansas

Email: dsaraswat@uaex.edu

Website: http://baegrisk.ddns.uark.edu/geospatial