Application of the SWAT model for the sensitivity analysis of runoff to land use change

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Introduction

- Land use changes, biophysically or artificially based, have significant effects on the surrounding environment and consequently on the hydrological cycle.

- Empirical knowledge of the consequences is common (i.e deforestation causes increase in discharge).

- Difficult to make an explicit quantification of these consequences.

Introduction

– This study presents a method for quantifying the impacts of *specific* land use changes, on the runoff of basins.

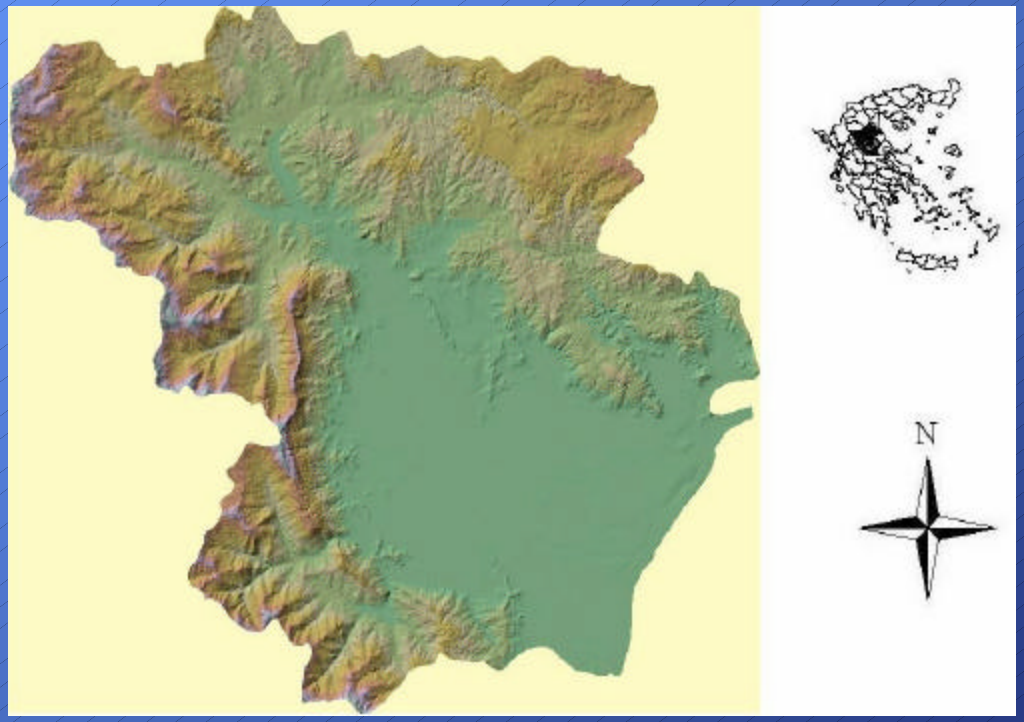
– Case study: The Pinios Catchment in Thessaly, Greece

– SWAT: Simulating the water cycle

– LADEMO: Building the land use change scenarios

The study area

– The SWAT model was implemented in the catchment of the Pinios River, at the outlet of Ali Efenti



Area 2796 km^2

Mean elevation 540 m

Mean annual rainfall 933 mm

Mean annual storm runoff coef. 0.428

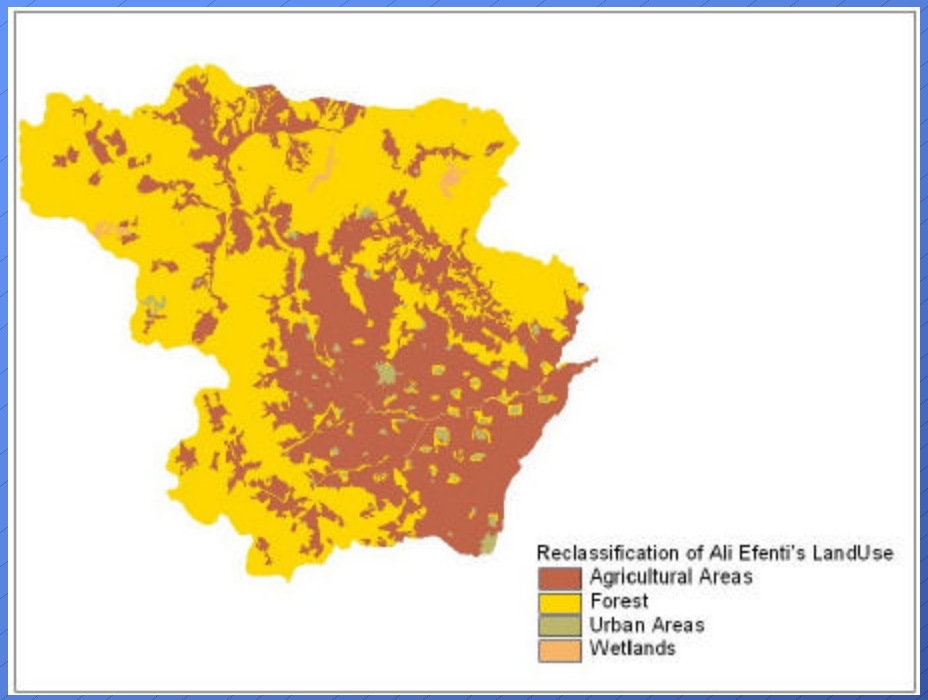
Mean annual flow 39 m^3/s

Topography

Land Use data

- Land use patterns were derived from the European project CORINE
- 4 types of land uses (Agricultural, Forest, Urban and Water)
- Previous studies of SWAT application on same basin with 10 types of land uses (i.e more detailed representation of agricultural land, different forest types etc) pointed out a small sensitivity of the model in the detail of land use data.
- Important: Quantitative simulation

Land Use data



Forest 57 %

Agricultural 41%

Urban 1.7%

Wetlands 0.7%

The method and the scenarios

- LADEMO is a technique that makes use of spatially distributed information of the landscape and generates a dynamic evolution of land use patterns based on a *given* scenario target

- Basic input: Gridded info on actual land use

- Optional: Spatial info on natural conditions (i.e topography, soils)

- Output: a digital map of future land use according to the predefined scenario conditions

The method and the scenarios

- User based method: Interactive dialogue to integrate expert knowledge into the procedure

1. The user defines the *source class*, the land use class which is assumed to increase or decrease in its spatial extent.

2. The user defines the *target classes*, the land use classes that are considered to be affected by an area change of the source class.

3. If more than one target class is selected, each of these is assigned a priority, and the target class with the highest priority will be considered first.

The method and the scenarios

4. Additional available info on natural conditions (topography, soil) is reclassified to represent *good*, *medium* and *poor* conditions for the realisation of the target scenario.

5. The user may assign different weights to the selected themes in order to give a certain theme a higher preference.

• Focal analysis (considering neighborhood relationships) and pixelwise modification

[Limitations]

- Only 4 types of land uses considered at a time
- Only full deforestation (100%)
- Land use change percentages may seem too precise

The method and the scenarios

- Expansion of *agricultural land*

Source class: 21%,

Target class: Forest 15%, Urban and Water no changes

- *Deforestation* of subbasin

Source class: 100%

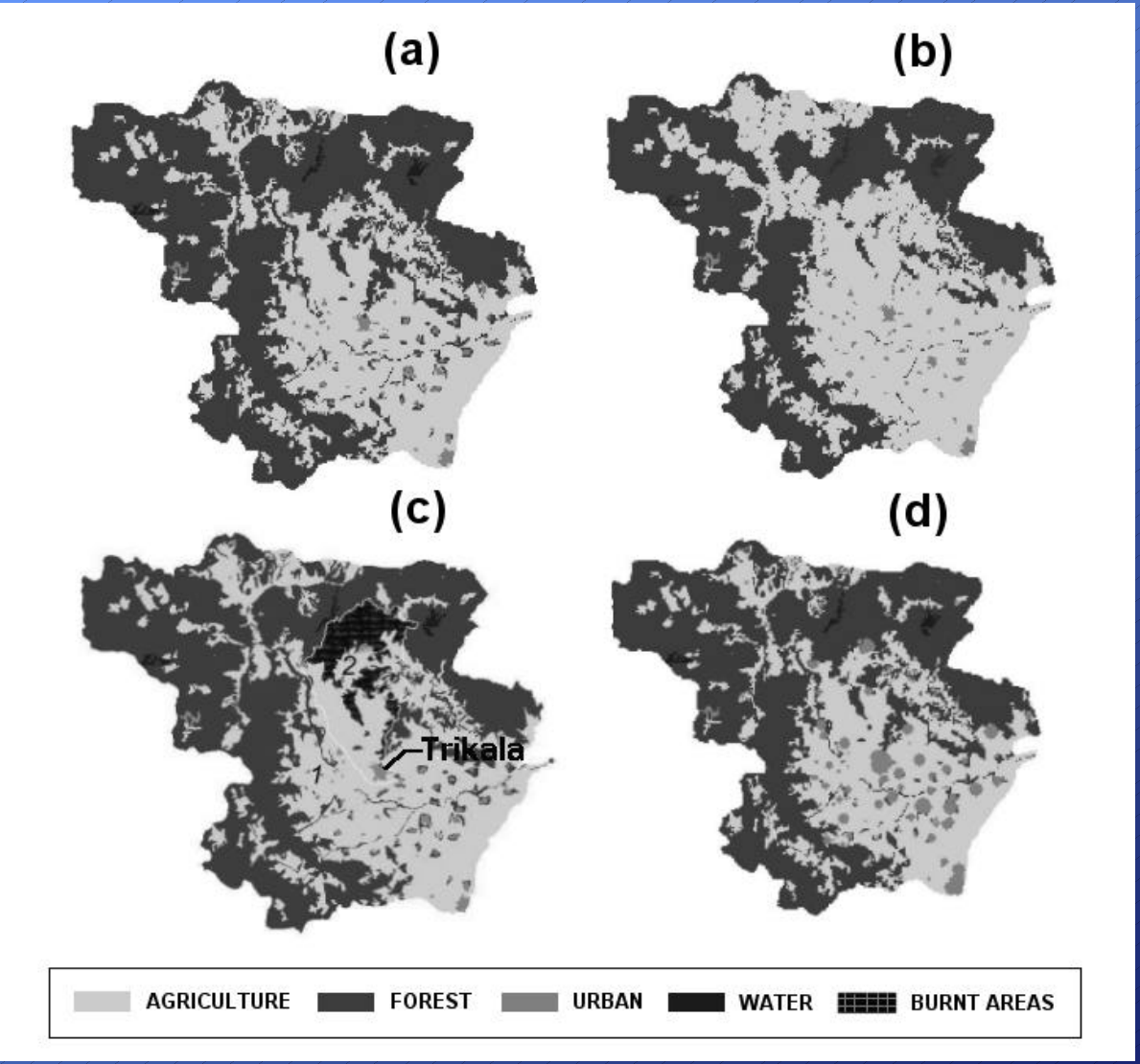
Target class: Burned area

- Expansion of *urban areas* in subbasin

Source class: 132%

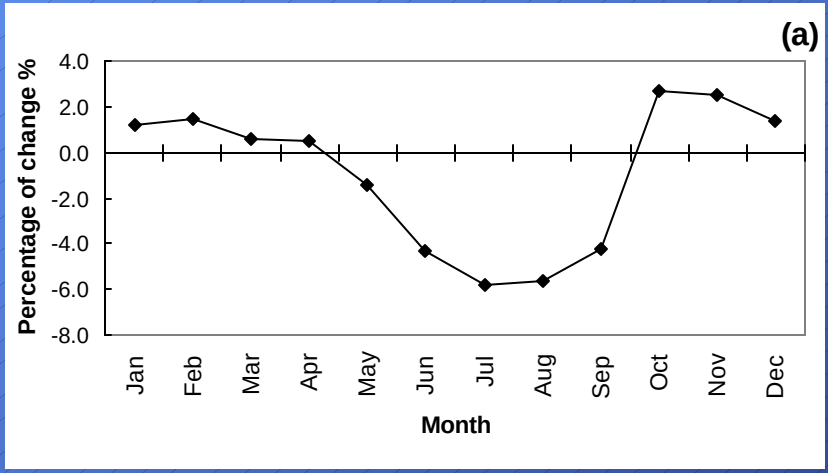
Target classes: Agricultural 5.6%, Forest 2.4%

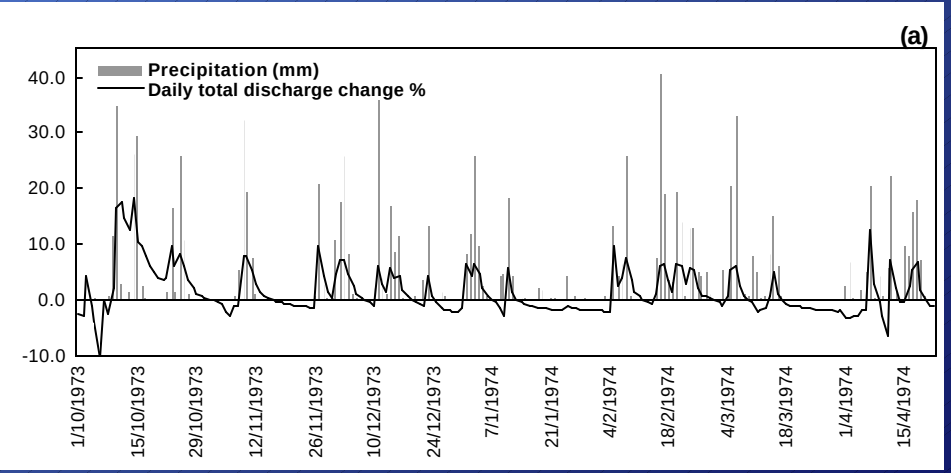
The method and the scenarios



Results

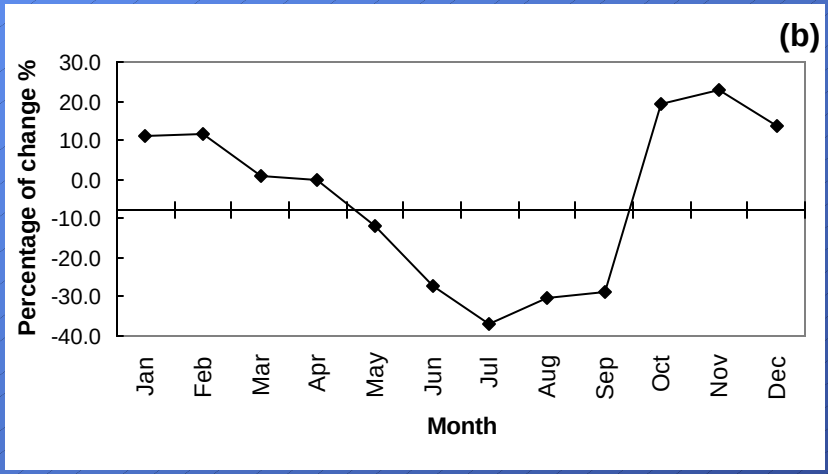
- By expanding the *agricultural land* over forest by 20%,
  - a mean monthly increase in the river discharge of up to 3%, was observed from Oct to Apr, and a reduction from May to Sep, which reached 6% in July.
  - In a daily time step, discharge increases of aprox. 20% after precipitation incidents, followed by reductions in base flow.

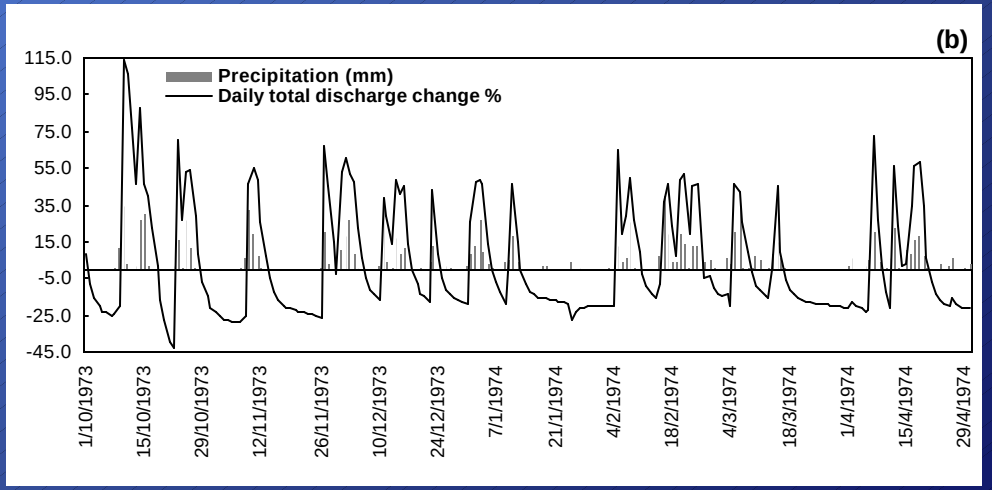




Results

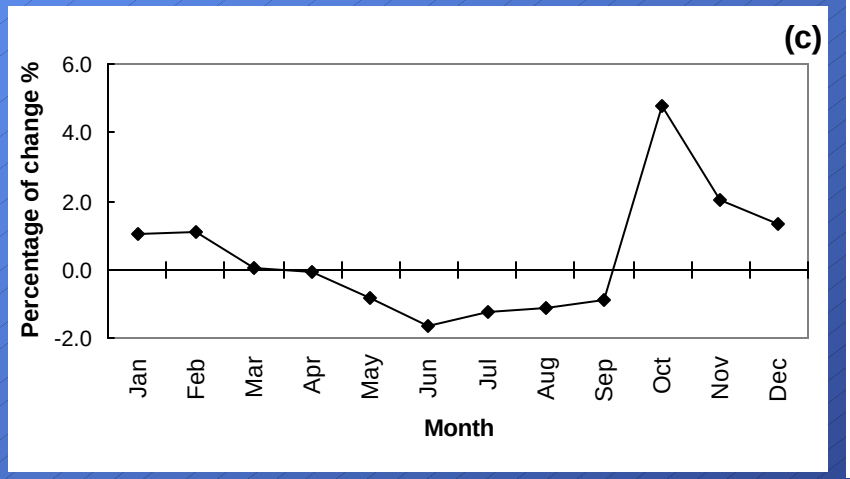
- The *deforestation* of the subbasin scenario
  - Increases in mean monthly discharge of around 23% for wet months, decrease up to 38% during summer.
  - In a daily time step, increases of the order of 130%.

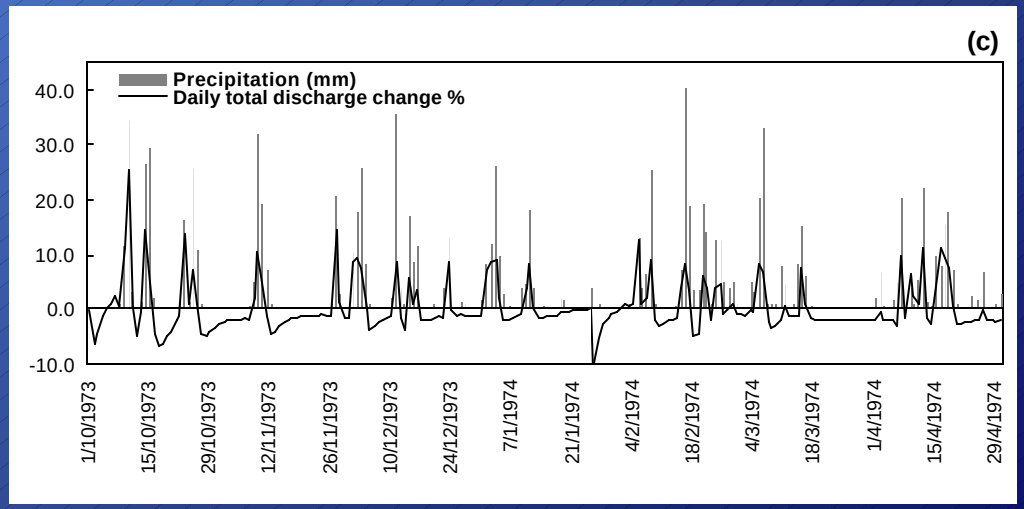




Results

- The final scenario of expansion of *urban land* by 130 %
  - Similar results for the monthly step to the agricultural expansion scenario, but smaller reductions in discharge during the summer months.
  - In the daily step, increases were as high as 35%.



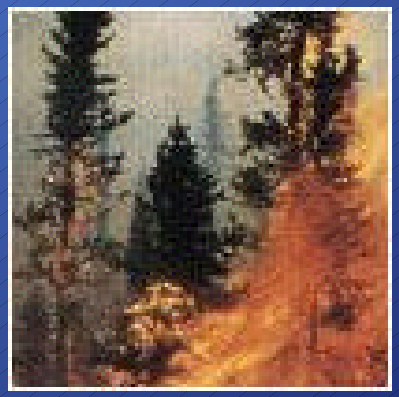


Results

Scenario	Maximum mean monthly increase %	Maximum mean monthly decrease %	Maximum daily increase %
A. Expansion of Agricultural Land	3.0	-6.0	20.0
B. Deforestation	23.0	-38.0	130.0
C. Expansion of Urban Land	5.0	-2.0	35.0

Conclusions

- Empirical knowledge of the consequences of land use change is generally common, however it is often difficult to make an explicit quantification of these consequences.
- This study, although based on a prototype with several limitations, underlined the potential flood risk in a case of a forest fire, which is not unusual, considering the prolonged warm and dry summers and Greece.



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Thank you for your attention!