MODELING IMPACTS OF BIOENERGY CROPS ON STREAMFLOW, SEDIMENTS AND NUTRIENT FLOWS USING THE SWAT MODEL

[1]Giuseppe Pulighe, [1]Guido Bonati, [1]Filiberto Altobelli, [1]Flavio Lupia, [2]Marco Colangeli, [2]Lorenzo Traverso, [3]Marco Napoli, [3]Anna Dalla Marta

[1] CREA - Research Centre for Agricultural Policies and Bioeconomy, Rome
[2] FAO - Food and Agriculture Organization of the United Nations, Rome
[3] UNIFI - Dipartimento di Scienze delle Produzioni Agroalimentari e dell'Ambiente, Florence

1. Introduction and objectives

In the next years European Union (EU) bioenergy production is expected to grow significantly to meet the new Renewable Energy Directive (RED II). In this sense, **marginal, contaminated and underutilized lands** in the Mediterranean regions have great potential to meet EU goals with a sustainable feedstock production (Pulighe et al., 2016). In this context, is fundamental set-up sustainable landscape design with regard future bioenergy expansion scenarios on marginal areas. However, far too little attention has been paid to investigate the environmental effects of growing dedicated energy crops in these environments. The **SWAT** model (Soil and Water Assessment Tool) was used to simulate the impacts of bioenergy-induced changes on streamflow, soil erosion and nutrient losses at the watershed level in the **Sulcis area** (Sardinia, Italy) (Fig. 1).

The specific objectives are to:

- implementing the SWAT model for a **baseline scenario** that represents the actual land use and identifying a set of best setting parameters;
- simulating the growing of **energy crops** in the irrigated and rainfed area in order to evaluate the effects land use change on discharge, sediments and nutrient flows by monitoring the water balance (Fig. 2).

2. Materials and methods

Material

- Digital Elevation Model (10x10 m resolution);
- Hydrologic network;
- Land use map (21 classes):
  - durum wheat 60 km^2, irrigated area 78 km^2;
- Soils map showing soil types (31 map units);
- Meteorological data (4 stations);
- Stream flow data (1 gauging station – 12 years);
- Water quality data (2 stations – 8 years).

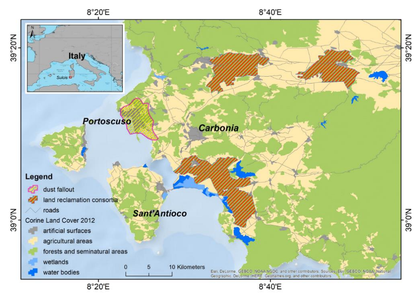

Fig. 1: Map of the study area

Methods

- Setup of the ArcSWAT model on the watershed;
- Hydrologic response unit delineation (HRU);
- SWAT simulation:
  - period of simulation: 1980 – 2013;
  - warm-up period (3 years): 1980-1982;
  - monthly time-step simulation.

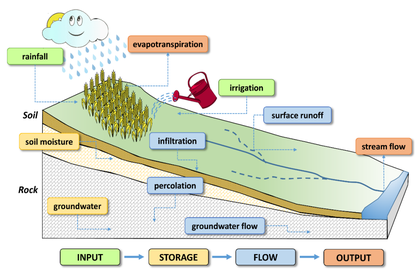

Fig. 2: Water cycle dynamics

Fig. 3: Map of DEM, soil types and land use units in the study area

3. Preliminary results

Climatic data show a typical bimodal pattern of Mediterranean environments for rainfall distribution and temperature (mean rainfall 668 mm; mean temperature 17.3 °C) (Fig. 4);

The model results in a watershed area of 254,8 km^2, 736 HRUs, 101 subbasins, potential evapotranspiration of 1584 mm;

The simulated **stream discharge** resembled with the observed discharge reasonably well for the observed period (years 1990-1992) (Fig. 5).

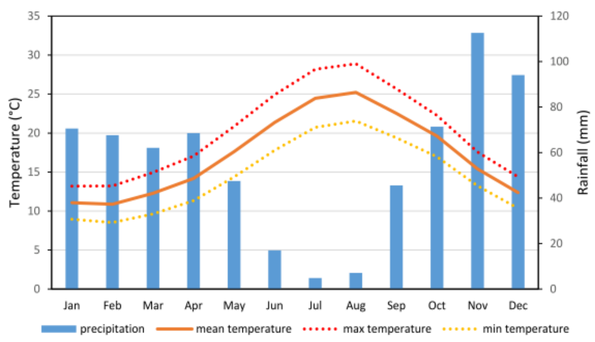

Fig. 4: Climatic data of the study area

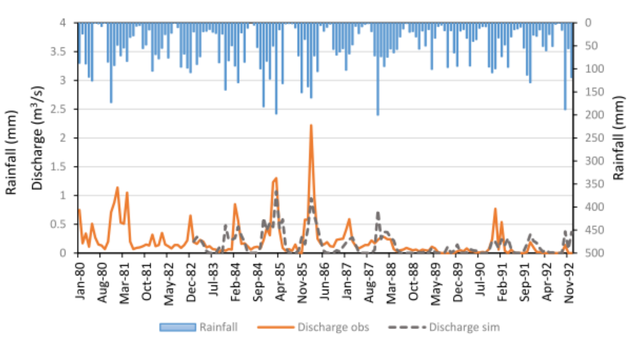

Fig. 5: Stream discharge of the study area

- The results of the simulation for a future planting of perennial energy crops in the arable land show a significant decrease of **sediment deposition** and **nitrogen losses** in the basin (Tab. 1);
- Less marked surface runoff for energy crops scenario could be attributed to the presence of perennial crops (e.g. vineyards) and partly to the model that requires further calibrations.

Tab. 1: Scenarios of feedstock production

Scenario	Sediment loading	N losses	Surface runoff
Baseline scen.	2.4 Mg/ha	33.1 kg/ha	63.6 mm/yr
Energy crops scen.	1.4 Mg/ha	16.3 kg/ha	62.4 mm/yr

4. Conclusions and way forward

- The work shows that the semi-distributed SWAT model is realistic predictor of hydrological flow, sediment and nutrient cycle in the study area;
- Preliminary results suggest positive impacts for future scenarios of bioenergy feedstock production with perennial crops on water quality and environmental sustainability;
- Future work will be carried out to validate and calibrate the model using SWAT-CUP (Calibration Uncertainty Program), especially for setting streamflow and surface runoff;
- Data gathered from field trials and literature will help to identify the best setting parameters for the implementation on new energy crops in the model (e.g. giant reed, cardoon, swichgrass, etc.);
- Future scenarios of bioenergy feedstock production will be modeled and simulated for in depth analysis of the impacts of different landscape scenarios comprising detailed management operations such as tillage, fertilizer, pesticide application, irrigation and harvesting.

References: Pulighe G, Bonati G, Fabiani S, Barsali T, Lupia F, Vanino S, et al. *Assessment of the Agronomic Feasibility of Bioenergy Crop Cultivation on Marginal and Polluted Land: A GIS-Based Suitability Study from the Sulcis Area, Italy*. Energies 2016;9:895

Contacts: Giuseppe Pulighe
CREA – Research Centre for Agricultural Policies and Bioeconomy
via Po 14, 00198 Rome, Italy giuseppe.pulighe@crea.gov.it

Acknowledgements: *The FORBIO project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691846. This poster reflects only the author's view and the INEA is not responsible for any use that may be made of the information it contains.*