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Assessment of switchgrass implementation in Pinios River Basin in Thessaly, Greece

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SWAT Conference
10-12 July 2024

Key issues in Greece

- Climate change and energy crisis
- Degradation of water resources
- Intensification of agricultural activities
- High Nitrogen and Nitrates diffuse losses to surface waters and/or groundwater in the main agricultural areas of the country
- Need to increase bioenergy production
- Challenging to adopt bioenergy production plans

The Biograss project

BIOGRASS
sustainable energy future

A few words for the project :

- ✓ Period of implementation : Oct. 2023 – Oct. 2025
- ✓ Coordinator: Aristotle University of Thessaloniki
- ✓ Funded by the European Union (Next Generation EU)
- ✓ A pilot example towards energy security in Greece based on the perennial crop Switchgrass
- ✓ Implemented in Pinios river basin, Thessaly

H.F.R.I. Hellenic Foundation for Research & Innovation
Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

Switchgrass

- **Perennial crop**
- **High efficiency in biomass production**
- **Resource-efficient**
- **Low-input**
- **Conventional tillage equipment**
- **Erosion protection**
- **Nitrate reduction**

Pinios river basin

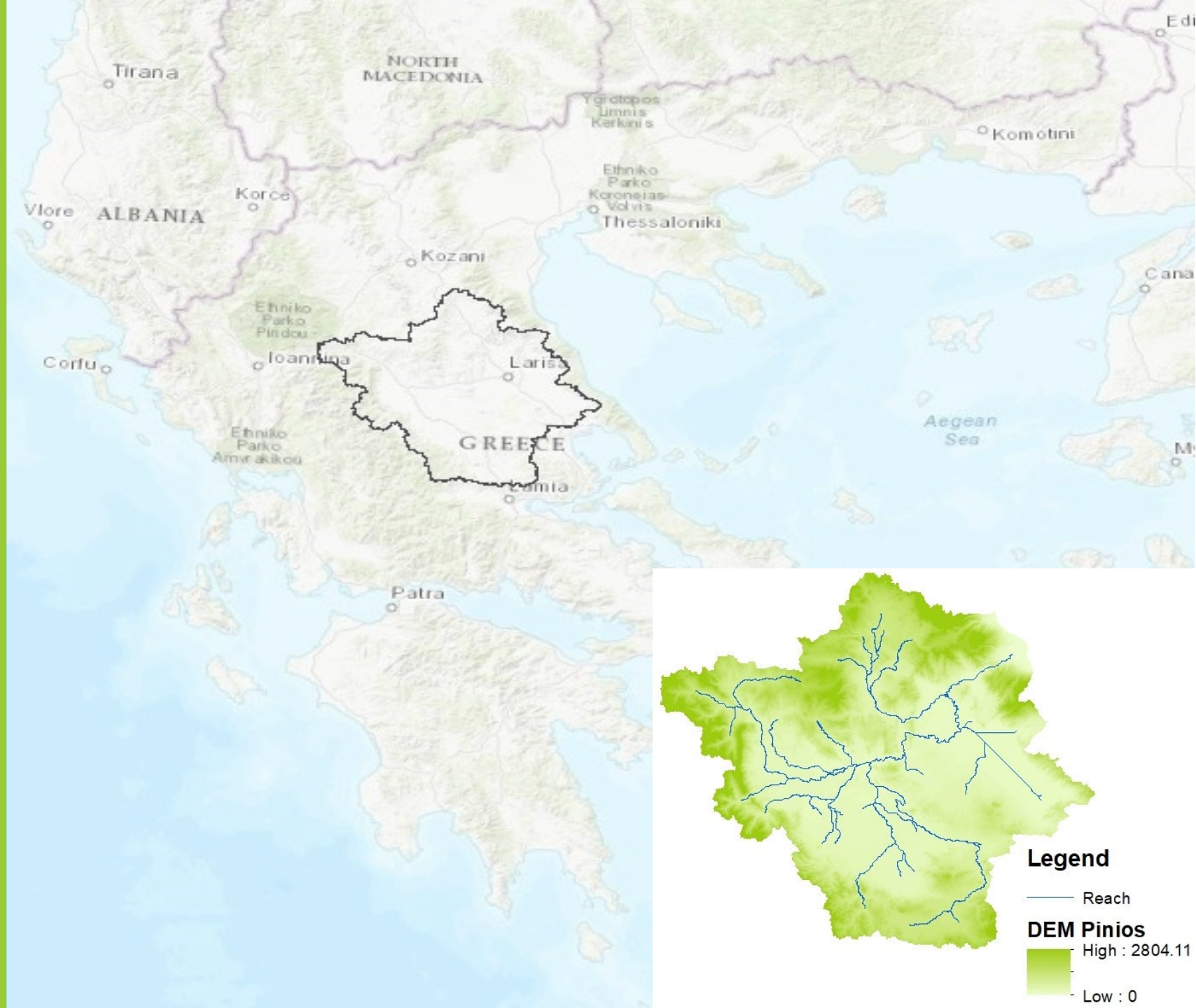
The most important agricultural producer in Greece

Area: 10600 km2
Agricultural area: 4000 km2

Main cultivated crops: cotton, wheat, corn, alfalfa

Overexploitation of surface and groundwater

A nitrate vulnerable zone



Objectives of the study

Implementation of the SWAT model in the Pinios river basin in order to:

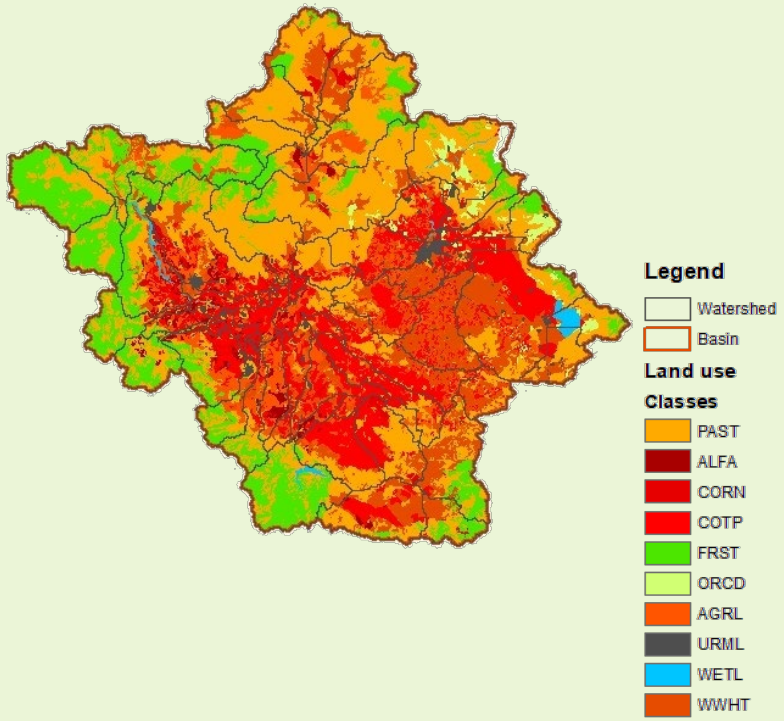
- Explore 4 initial switchgrass implementation scenarios
- Identify the ideal one out of them for the study area
- Improve water quality with respect to N pollution
- Produce sufficient amount of biomass

SWAT model – Soil Water Assessment Tool

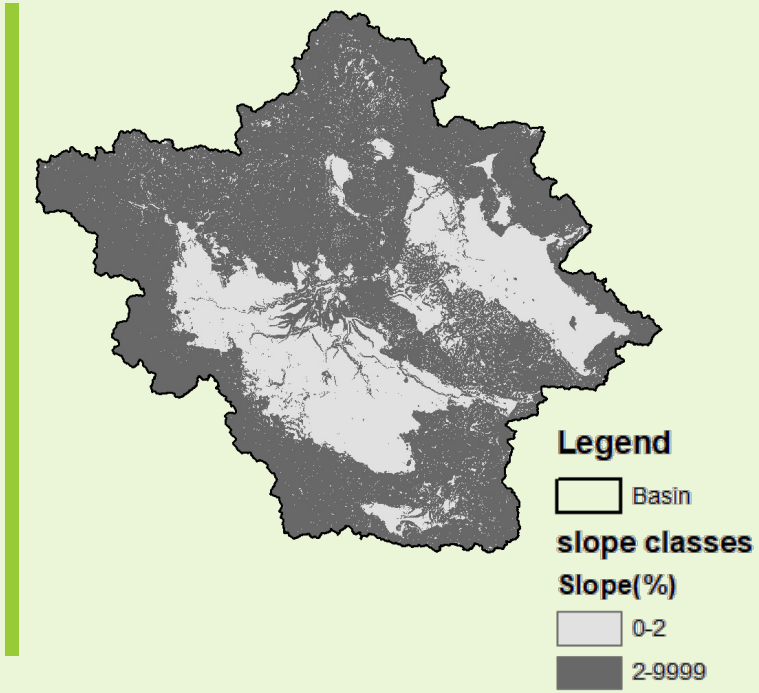
WHY SWAT?

- Process-based (management practices – crop growth simulation)
- Distributed (Hydrologic Response Units - HRUs: The combinations of unique land use and soil types)
- Long-term impacts of pollutants
- Developed for use in agricultural catchments

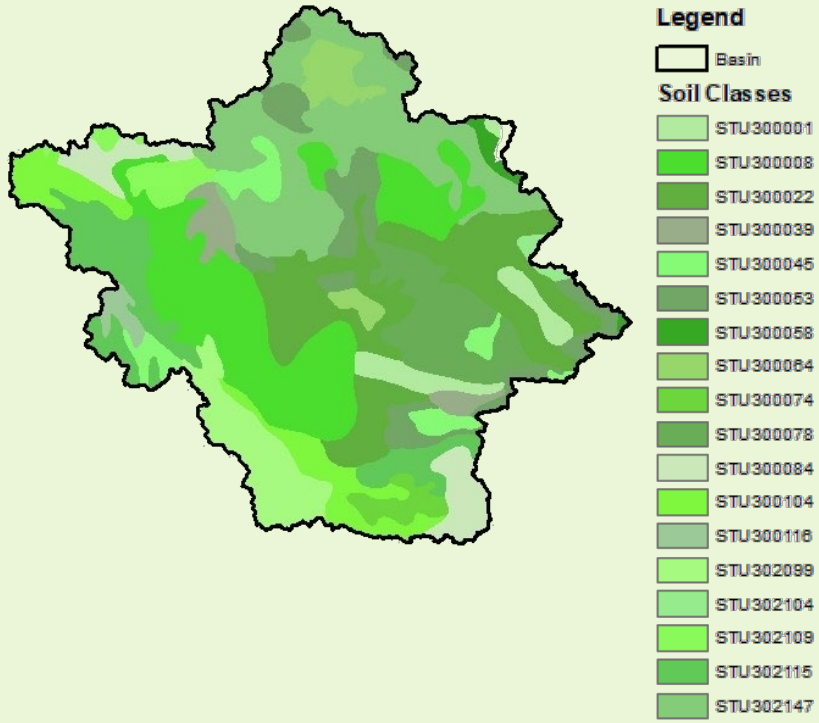
Land use map



Slope map



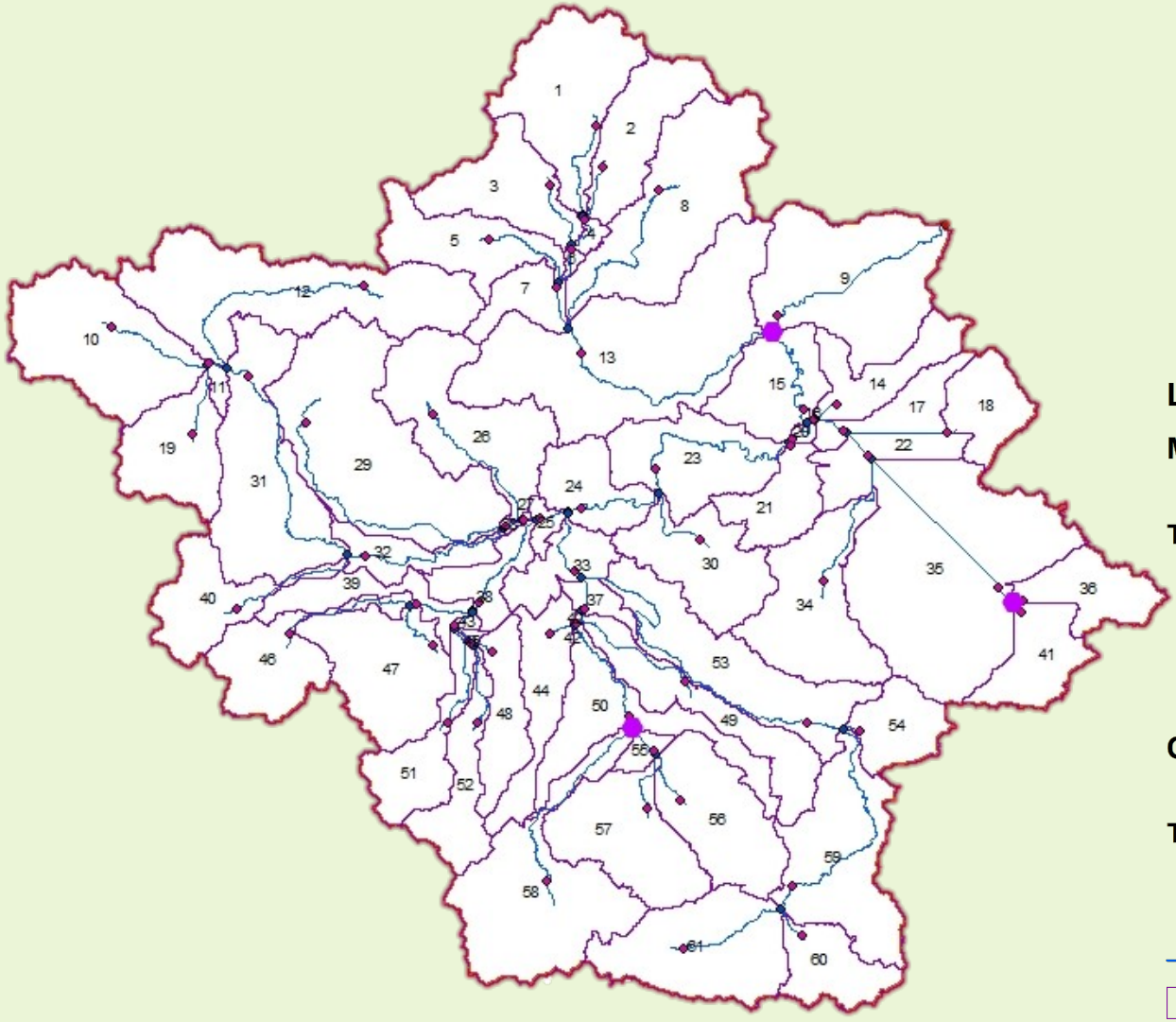
Soil map



Model inputs

Pinios basin modelling with SWAT

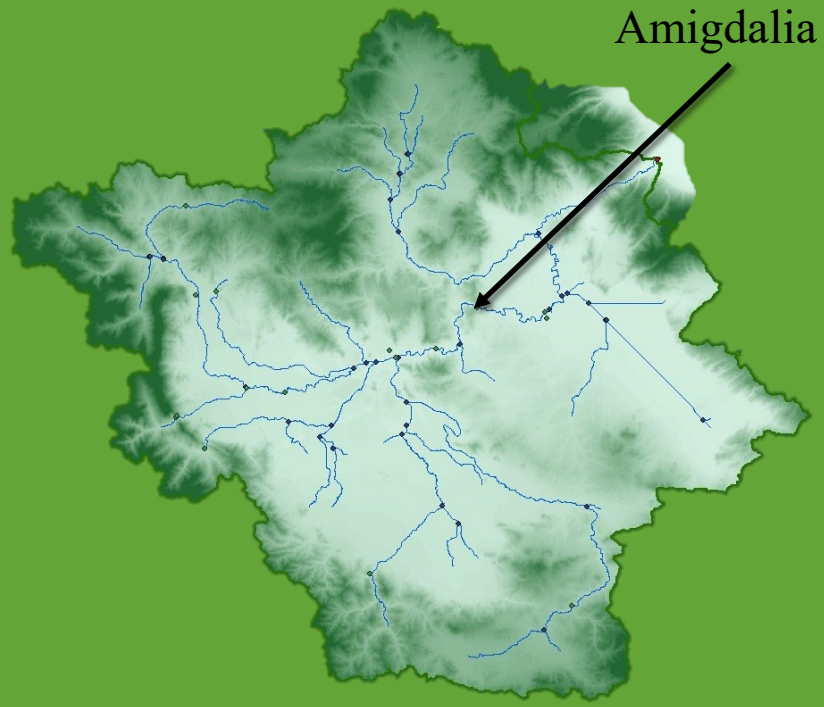
- 61 subasins
- 1837 HRUs
- The area of the basin : 10622 Km^2
- The Cropland area : 452471 Ha
- Weather data for 16 years (1977-1993) and for 8 years (2016-2023)
- Mean annual precipitation : 700mm
- 3 reservoirs in the catchment
- Outside source: Plastira
- Operation schedules for the main crops

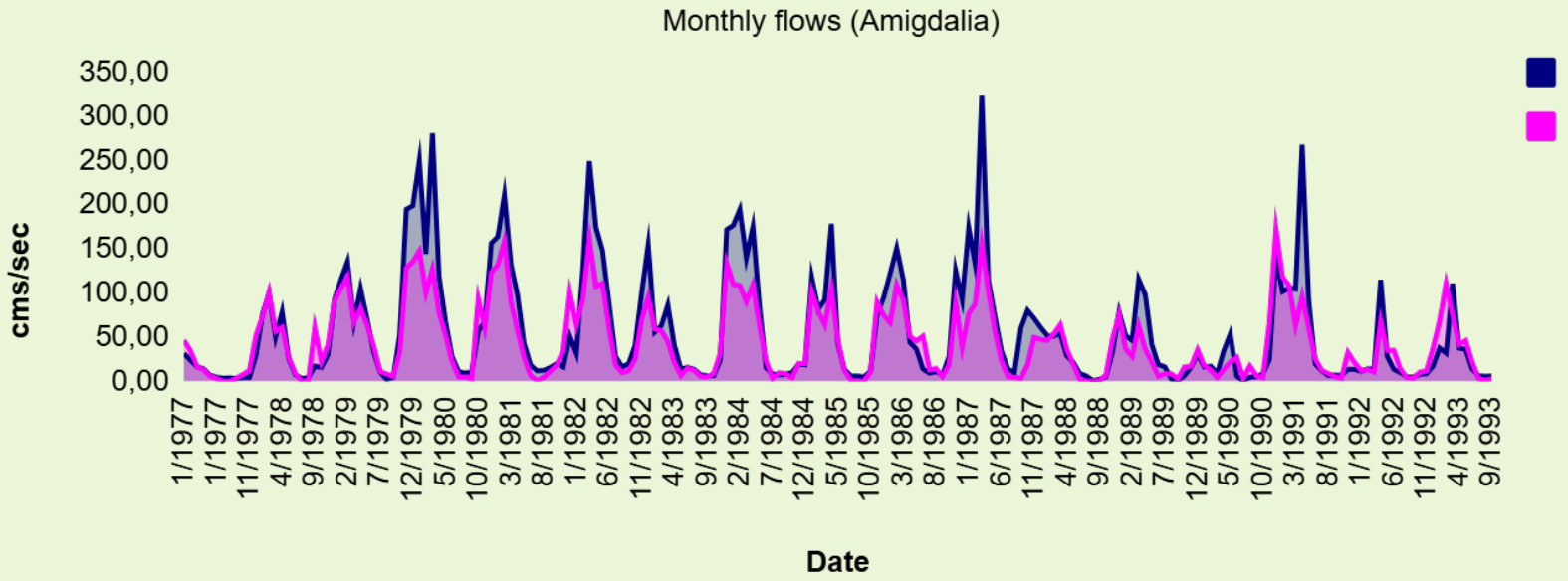


Flows calibration

Calibration for flows was carried out :

- At 2 sites (Amigdalia and Ali-Efenti)
- In monthly basis
- With the use of 16 years (1977-1993) of available flow data
- Evaluation of the results using Nash-Sutcliffe-statistical indexes



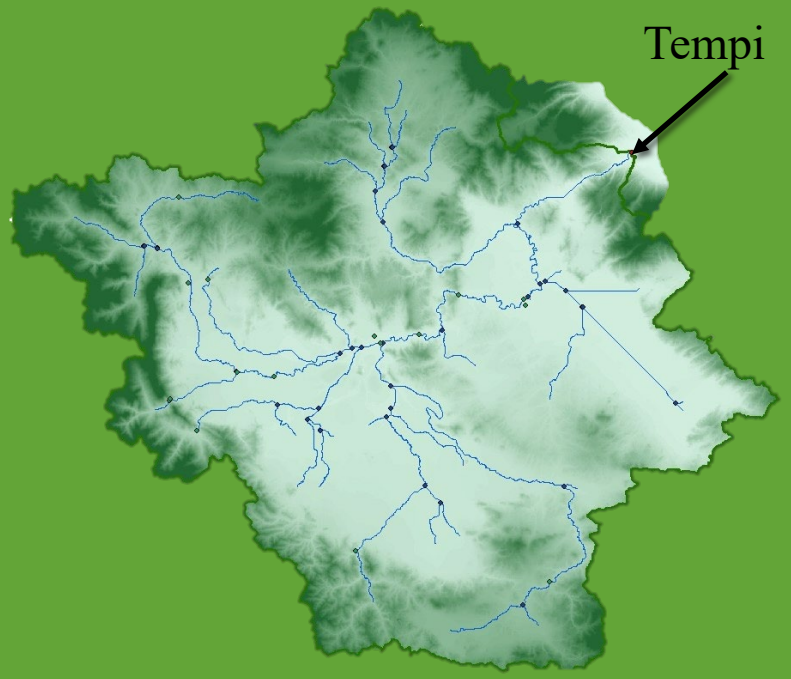


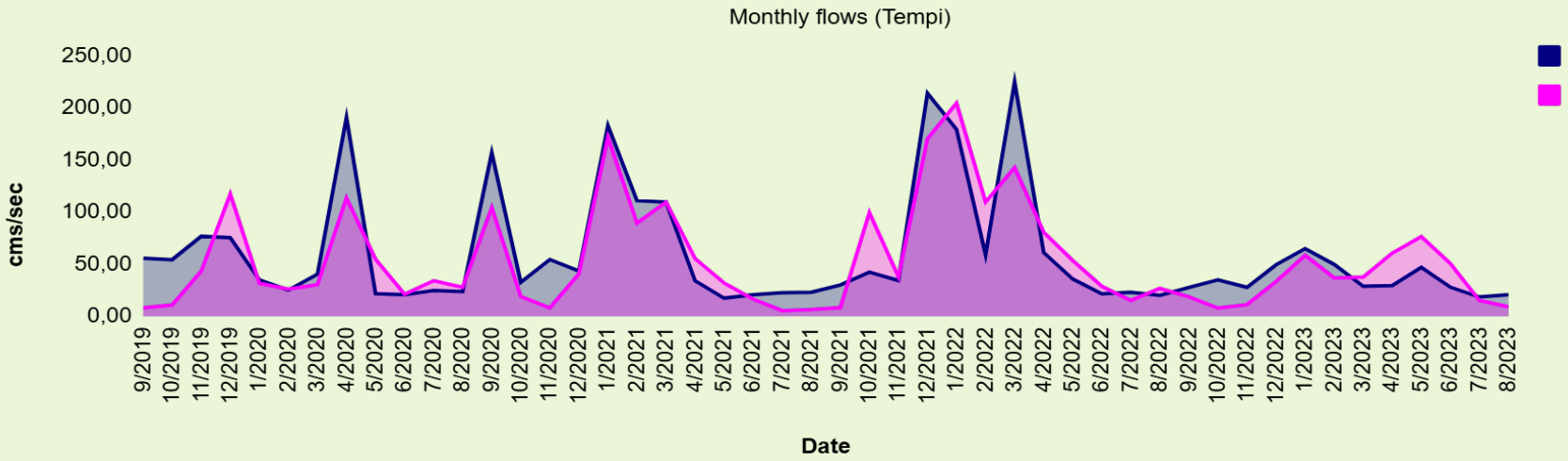
Nash-Sutcliffe	R^2
0,8	0,9

Flows validation

Validation for flows was carried out :

- At 2 sites (Tempi and Nomi)
- In monthly basis
- With the use of 5 years (2019-2023) of available flow data
- Evaluation of the results using Nash-Sutcliffe-statistical indexes





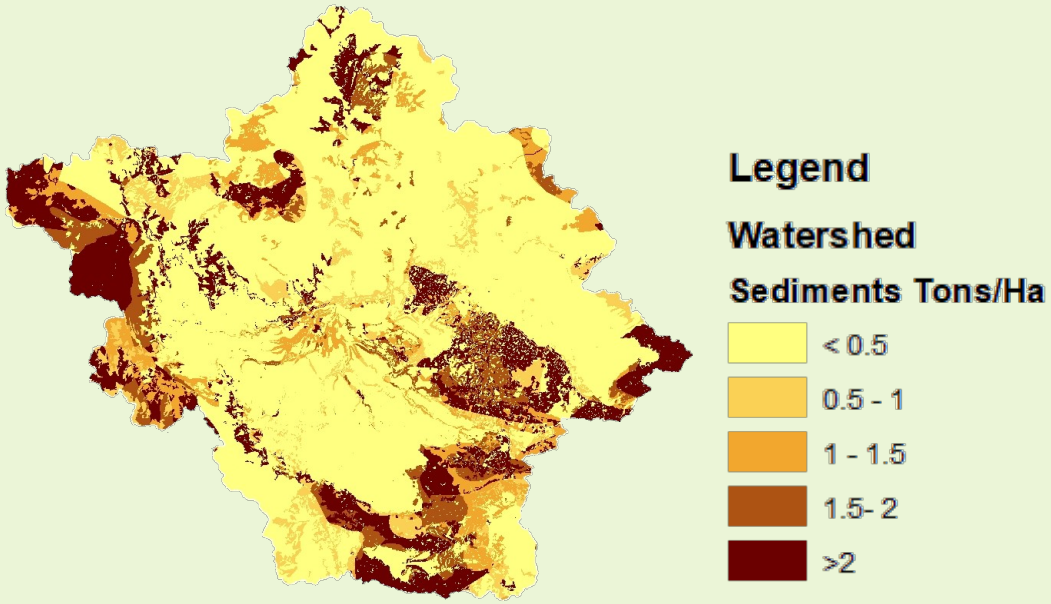
Nash-Sutcliffe	R^2
0,7	0,8

N Calibration

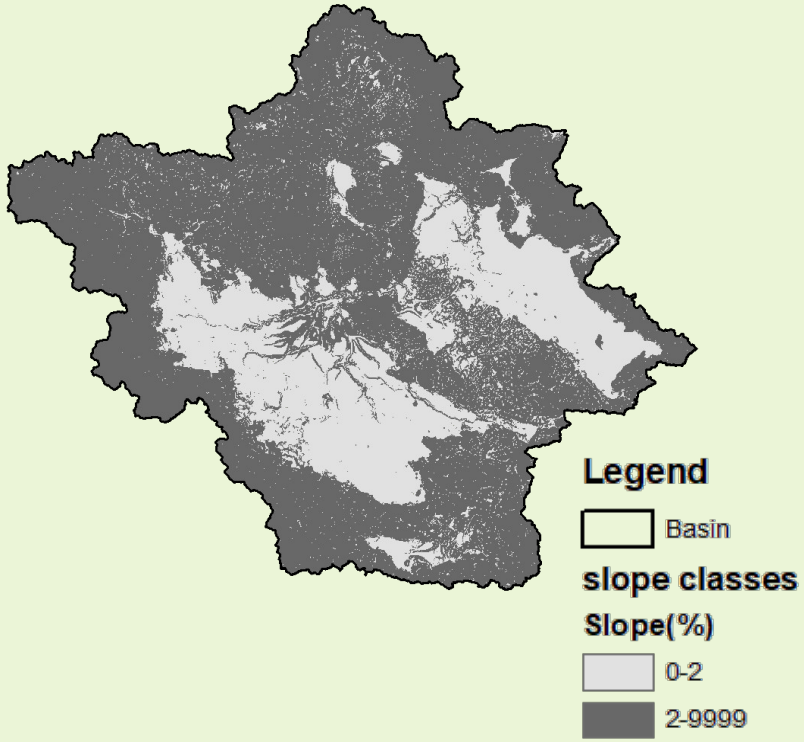
Calibration for N was carried out :

- At 2 sites (Tempi and Amigdalia)
- Evaluation of the results using statistical indexes

Sediment distribution



Slope map

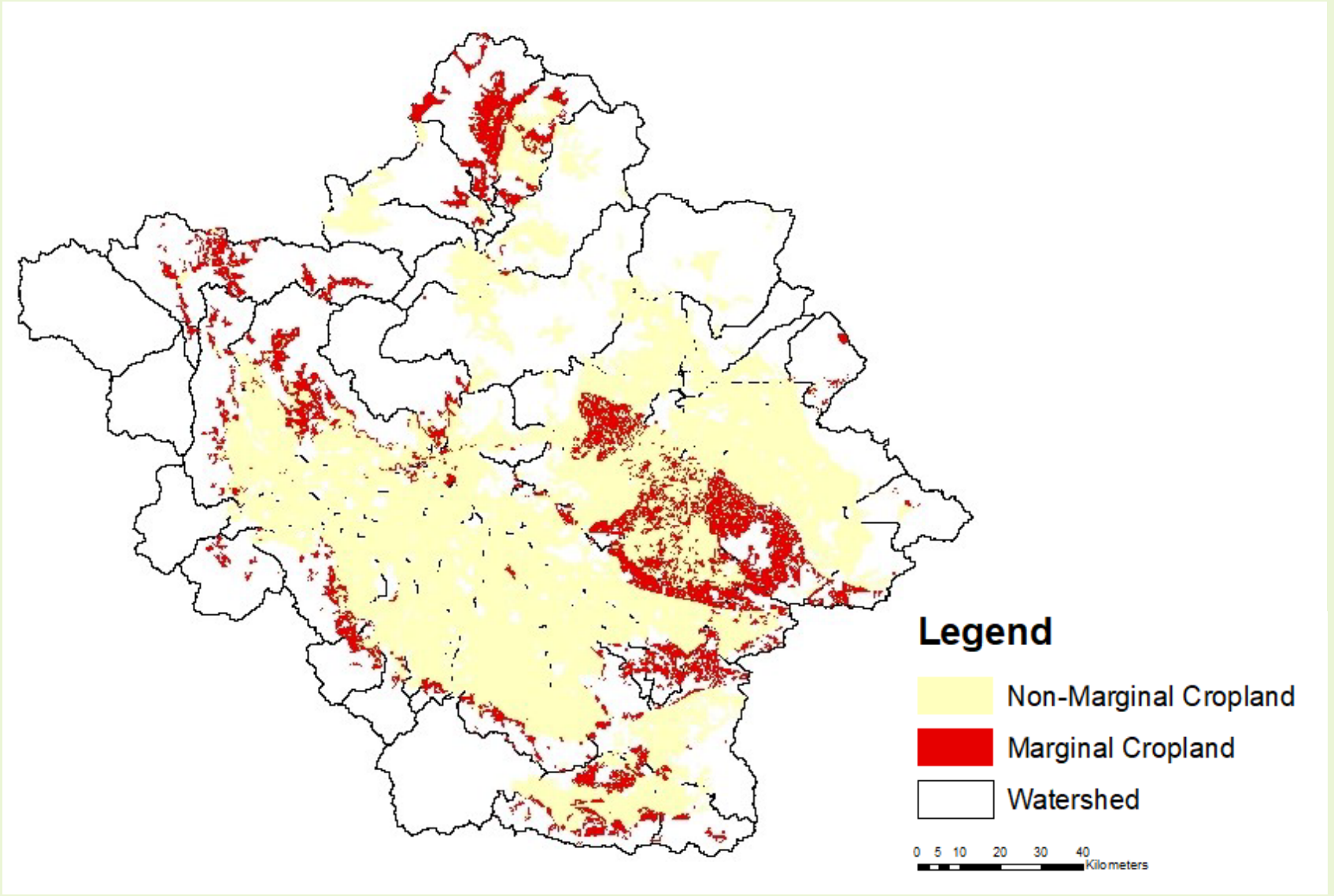


Marginal cropland

Marginal selection criteria
- Slope class >2%
- Sediments > 2 tons/Ha (baseline)
- Agricultural use (Panagopoulos et al, 2017)

Marginal cropland

8% of the whole watershed
19% of the cropland



Marginal cropland

Marginal Cropland				
corn	cotton	wheat	alfalfa	fallow areas
20%	23%	30%	1%	26%

Switchgrass implementation scenarios in Pinios river basin

Scenarios:

- 20% implementation of switchgrass in marginal cropland
- 50% implementation of switchgrass in marginal cropland
- 80% implementation of switchgrass in marginal cropland
- 100% implementation of switchgrass in marginal cropland

Switchgrass modeling with SWAT

Switchgrass operations	
Irrigation	250mm (5 applications)
Fertilization	4 N units (2 applications 60 kg/Ha each)

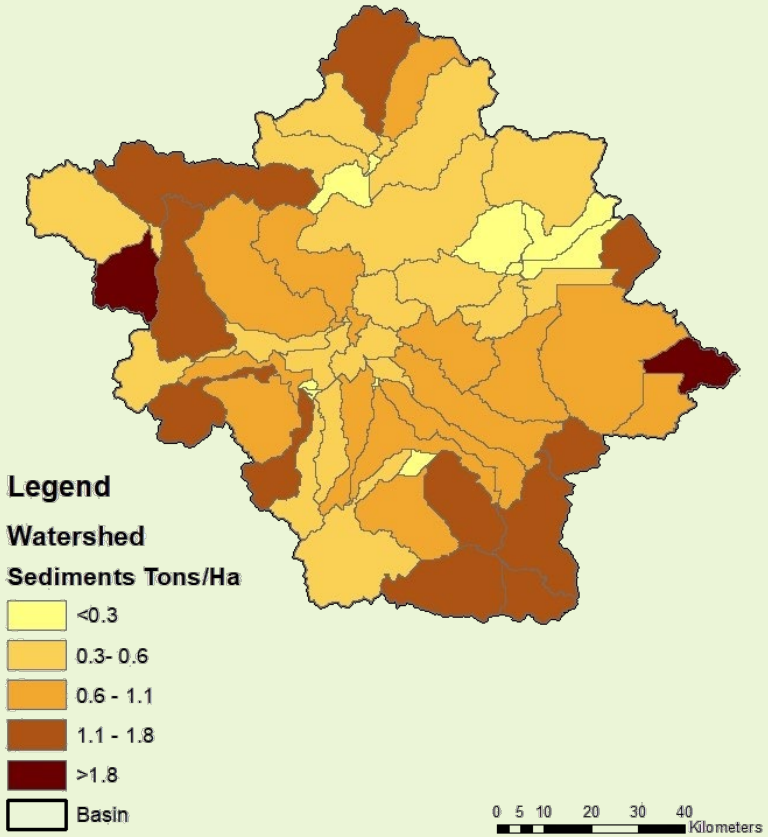
Baseline

Baseline Cropland				
corn	cotton	wheat	alfaalfa	fallow areas
5%	36%	37%	3%	19%

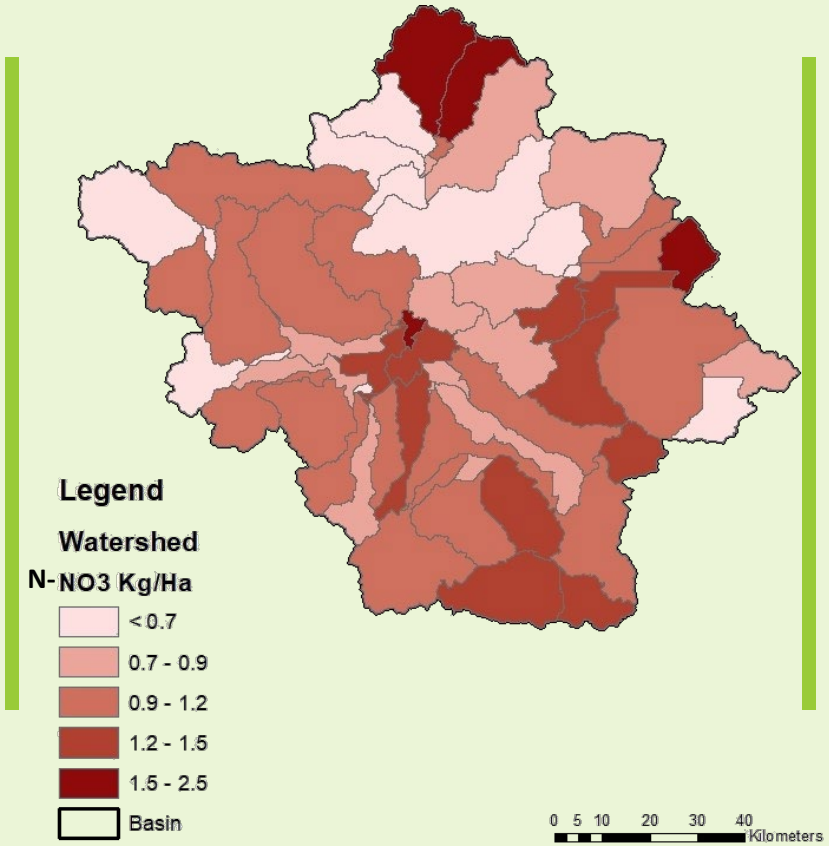
Sediments (tons/Ha)	Total Nitrogen (kg/Ha)	Average N-NO3 (kg/Ha)	Average water from Shallow Aquifer for irrigation($10^6\ m^3$)
1.2	3.9	1.3	528

Baseline

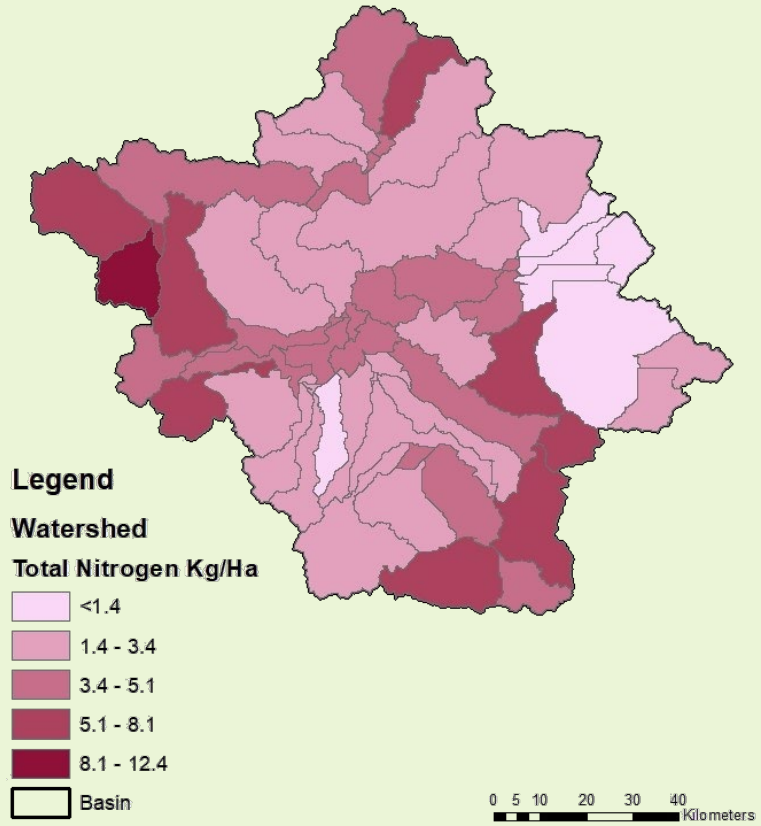
Sediment loss map



N-NO3 loss map



Total Nitrogen loss map

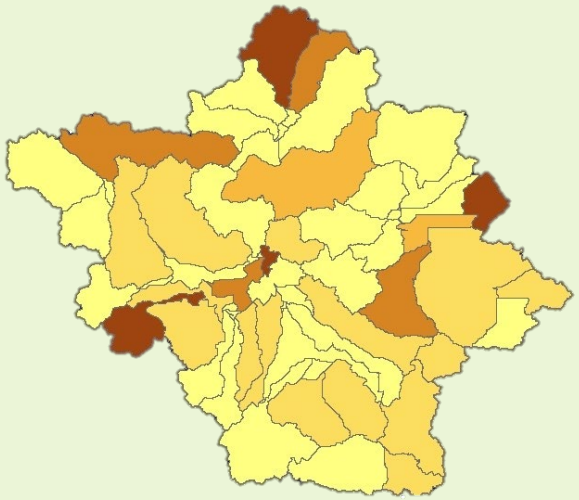


Baseline

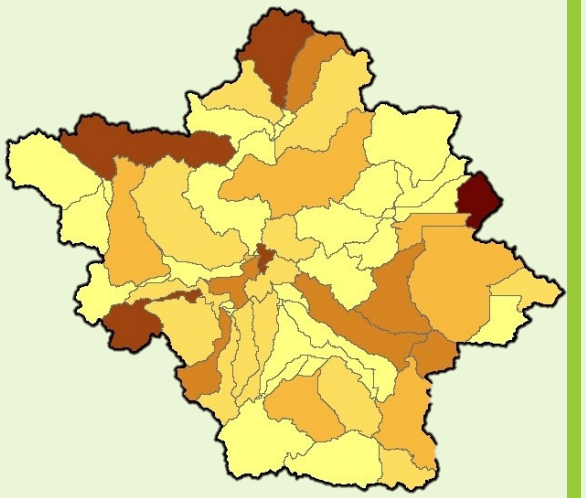
Preliminary results presentation

- For the entire Pinios river basin at watershed level
- Mean annual basis
- Sediments and nutrients (as % change from baseline)
- Sediments and nutrients (column bars)
- Average water for irrigation ($10^6 m^3$)
- Crop grain yields and bio-yields (tons)

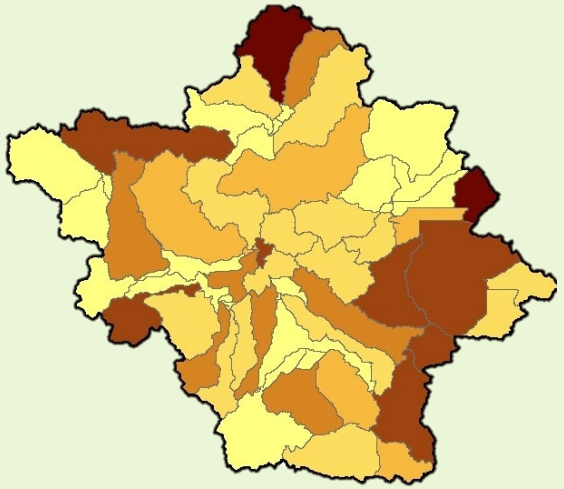
20% switchgrass implementation



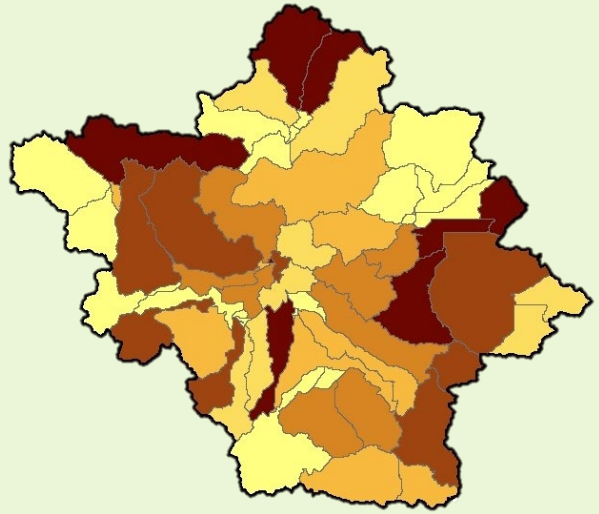
50% switchgrass implementation



80% switchgrass implementation

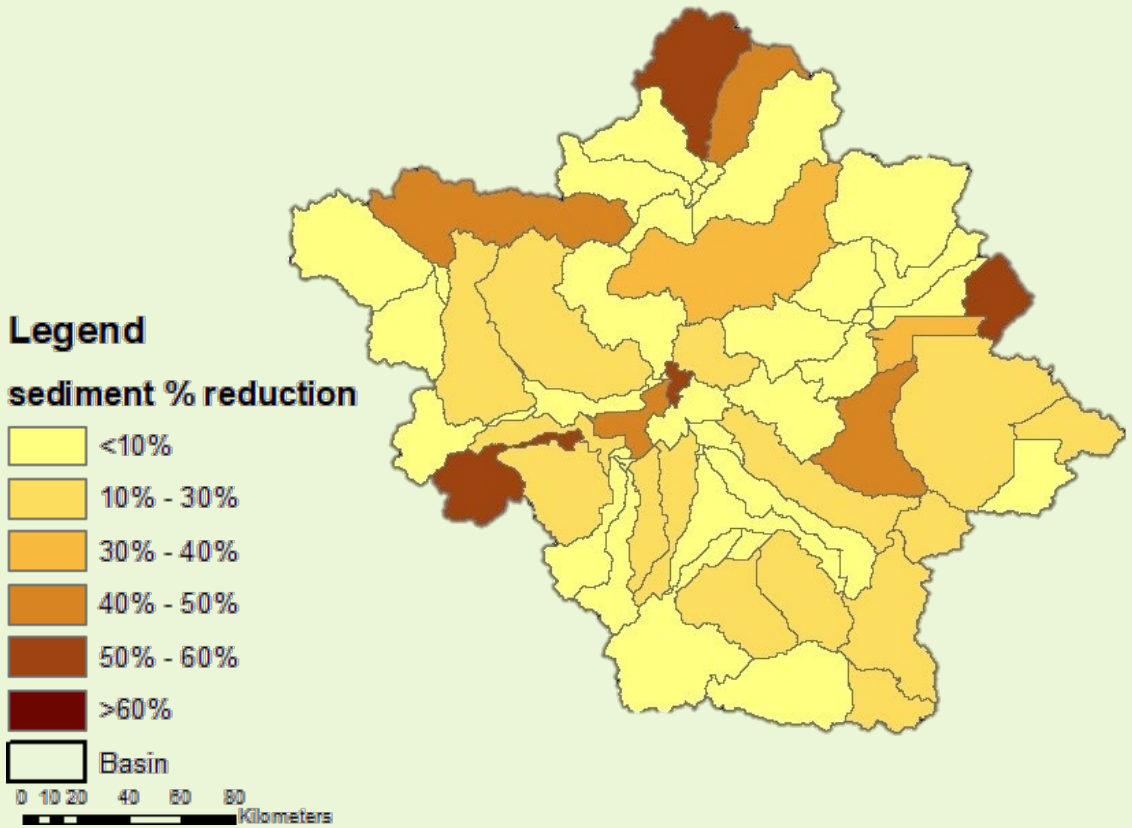


100% switchgrass implementation



Preliminary results(1): Sediment reduction

20% Switchgrass implementation



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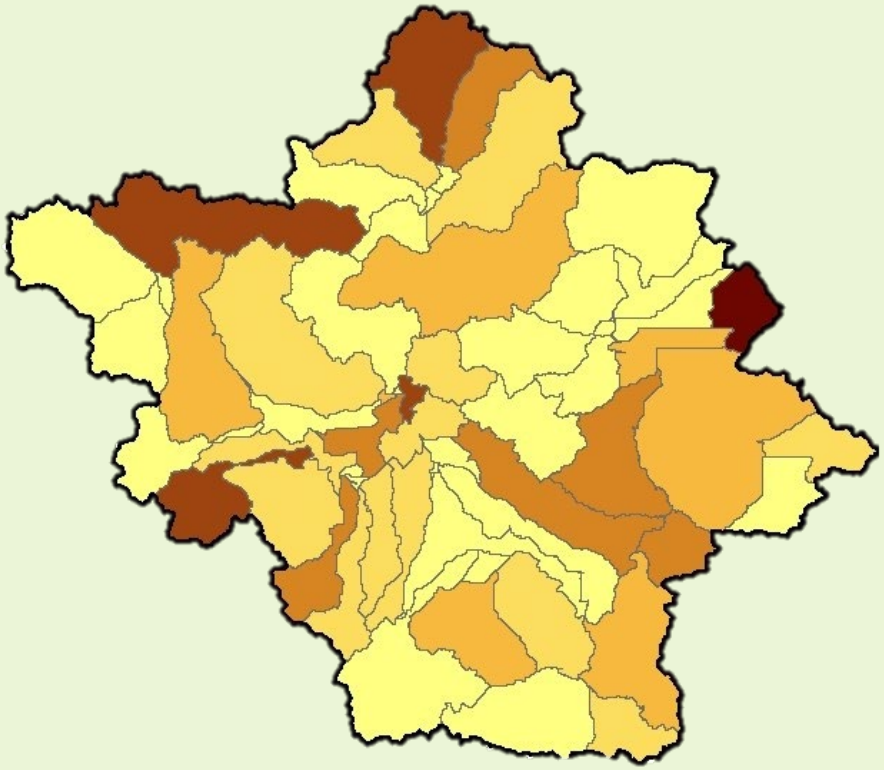

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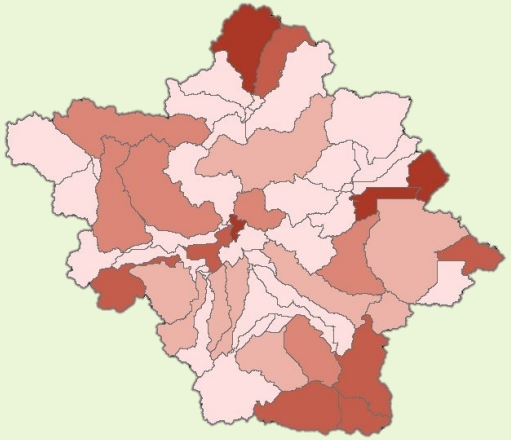
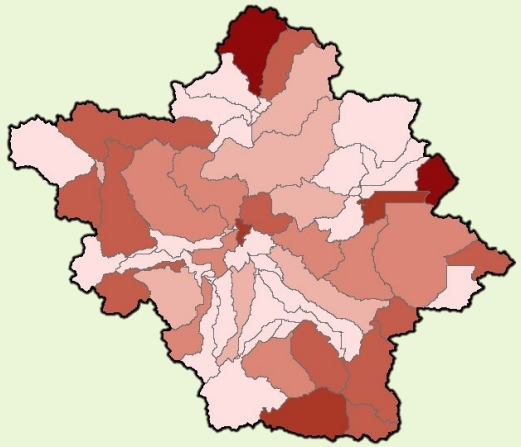


50% switchgrass implementation



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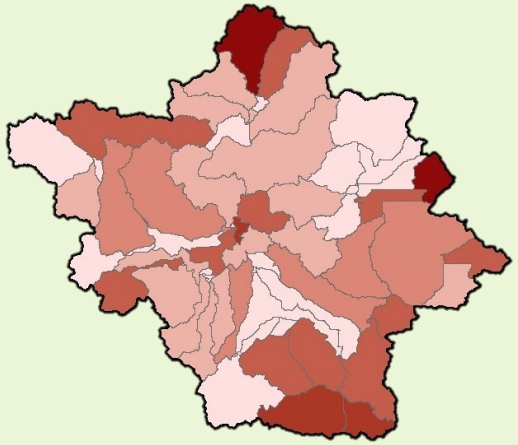

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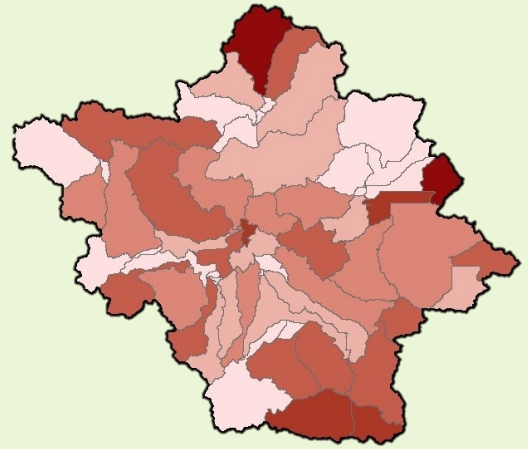
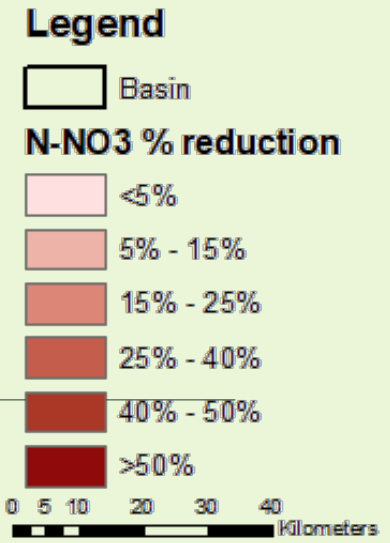
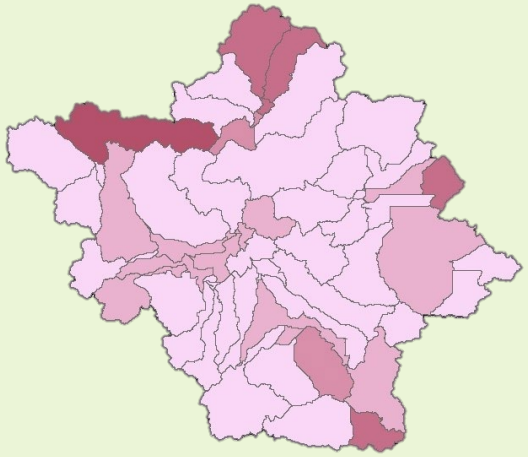


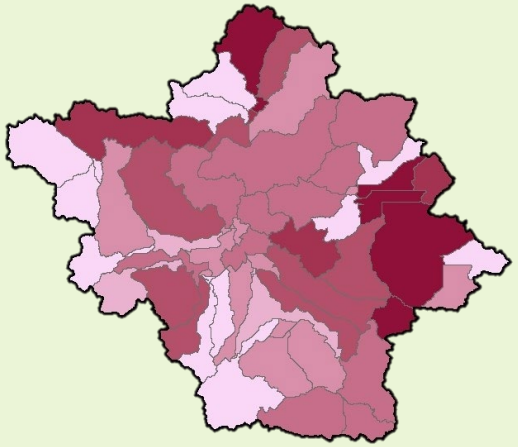


Preliminary results(2): N-NO3 reduction

20% switchgrass implementation



50% switchgrass implementation



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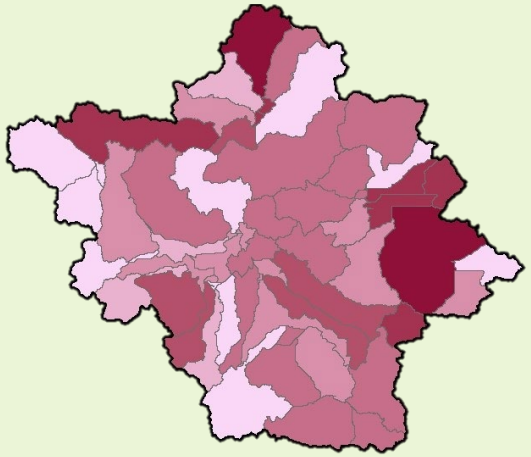

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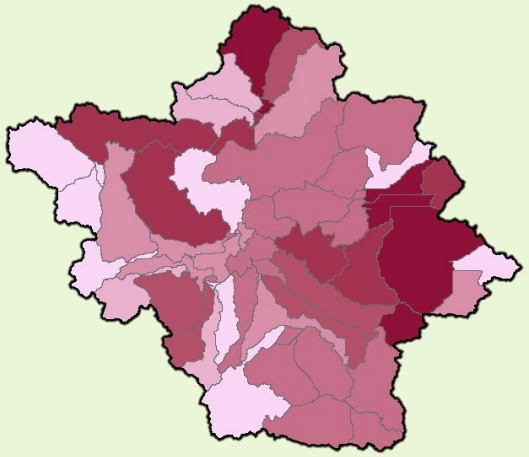
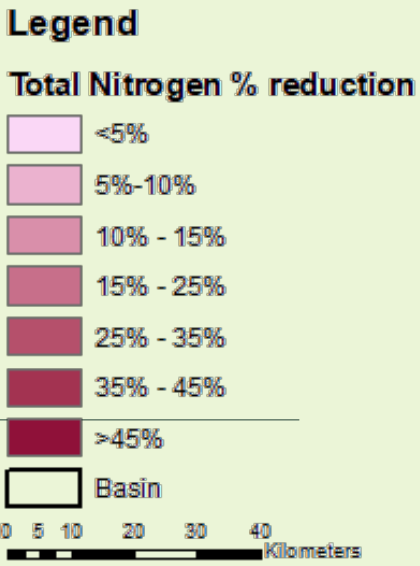
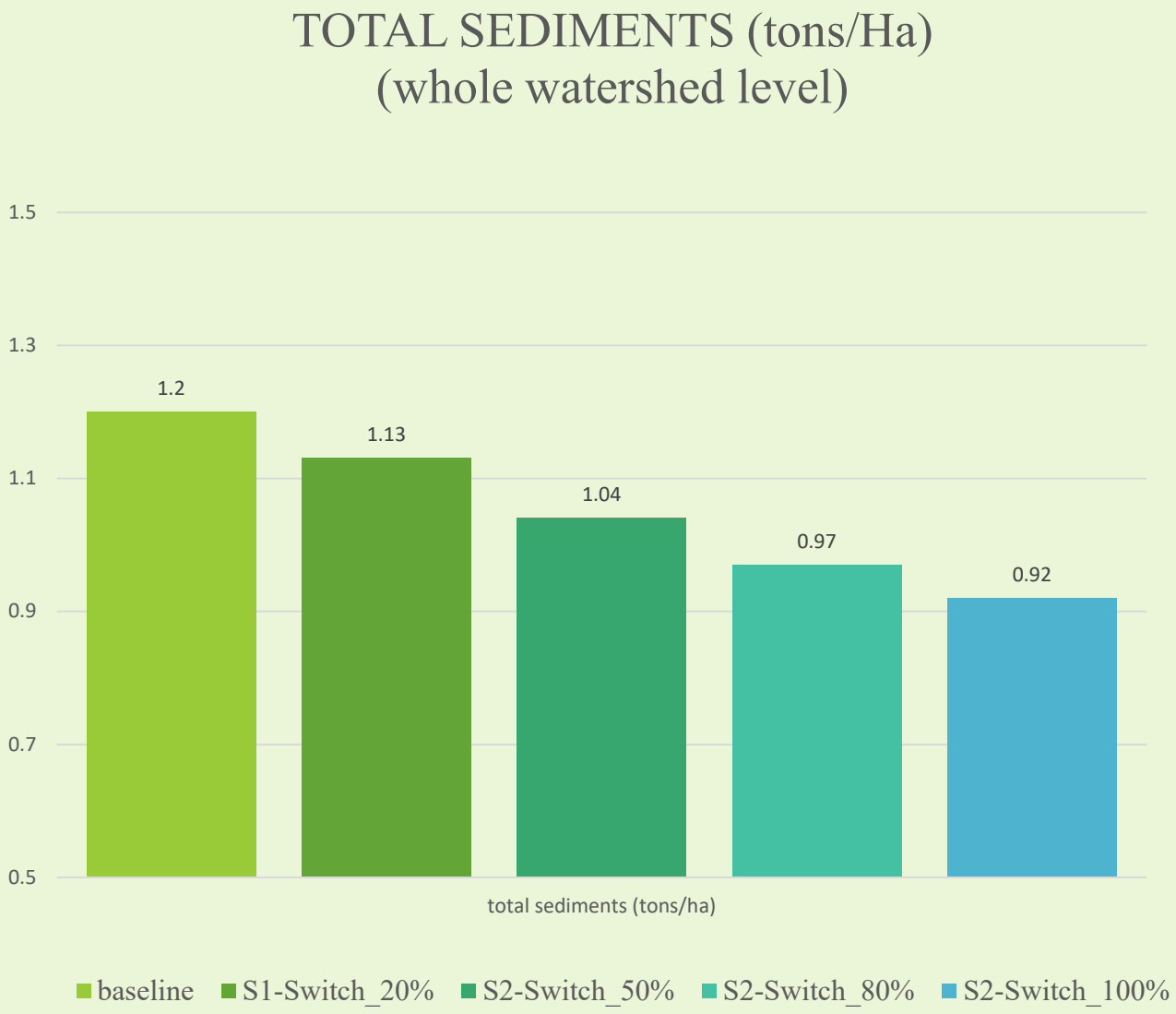
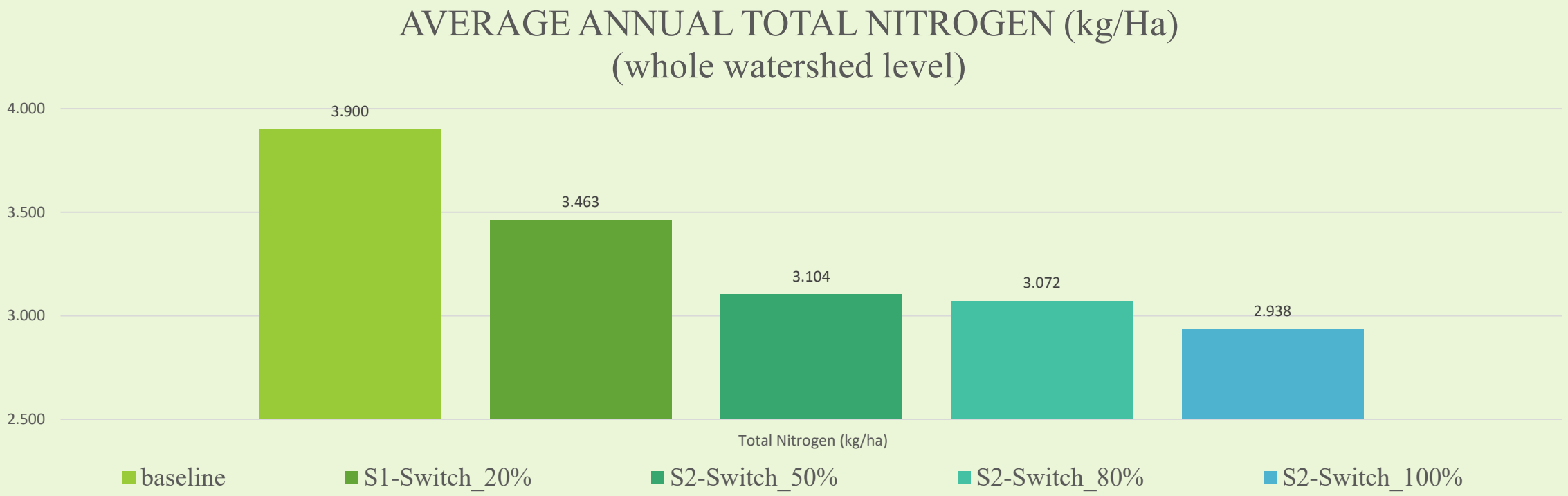




Preliminary results(3): Total Nitrogen reduction



Preliminary results(4)



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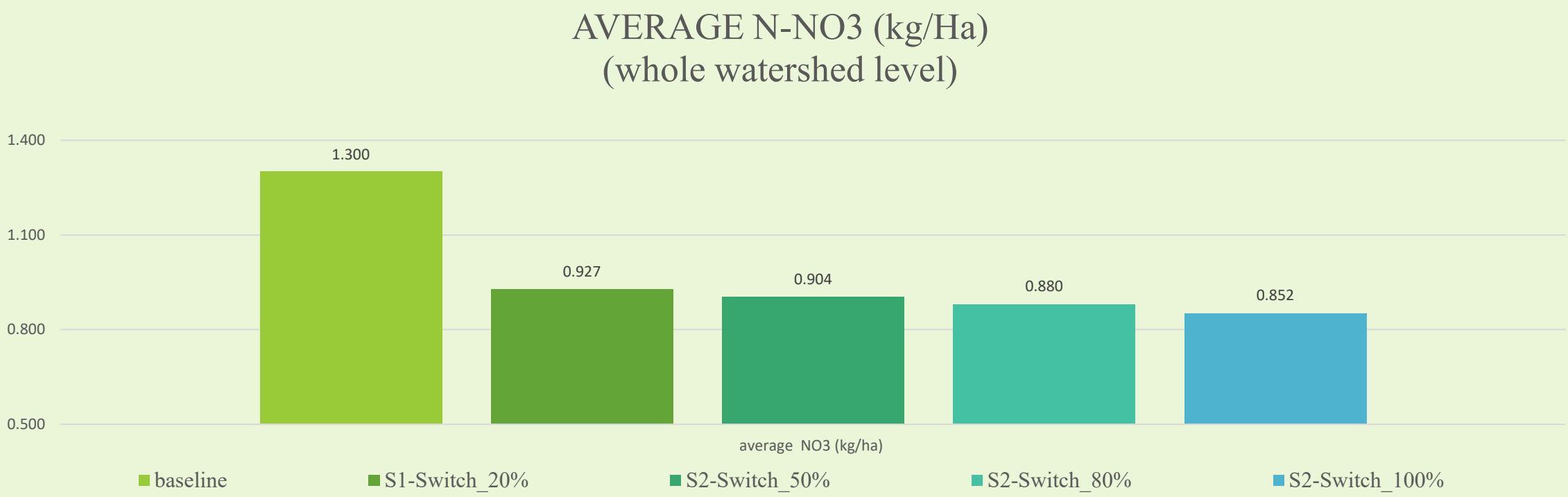
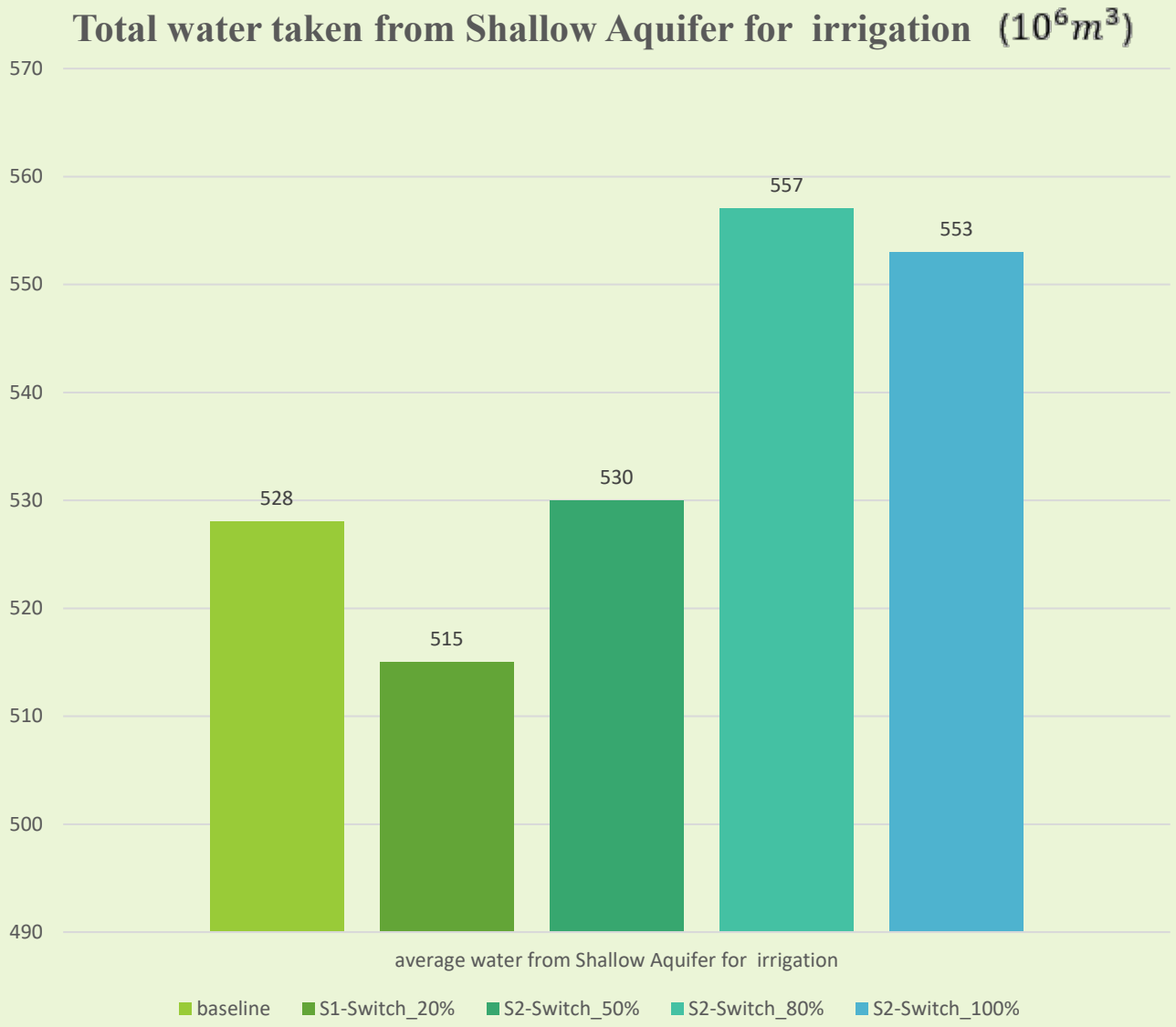
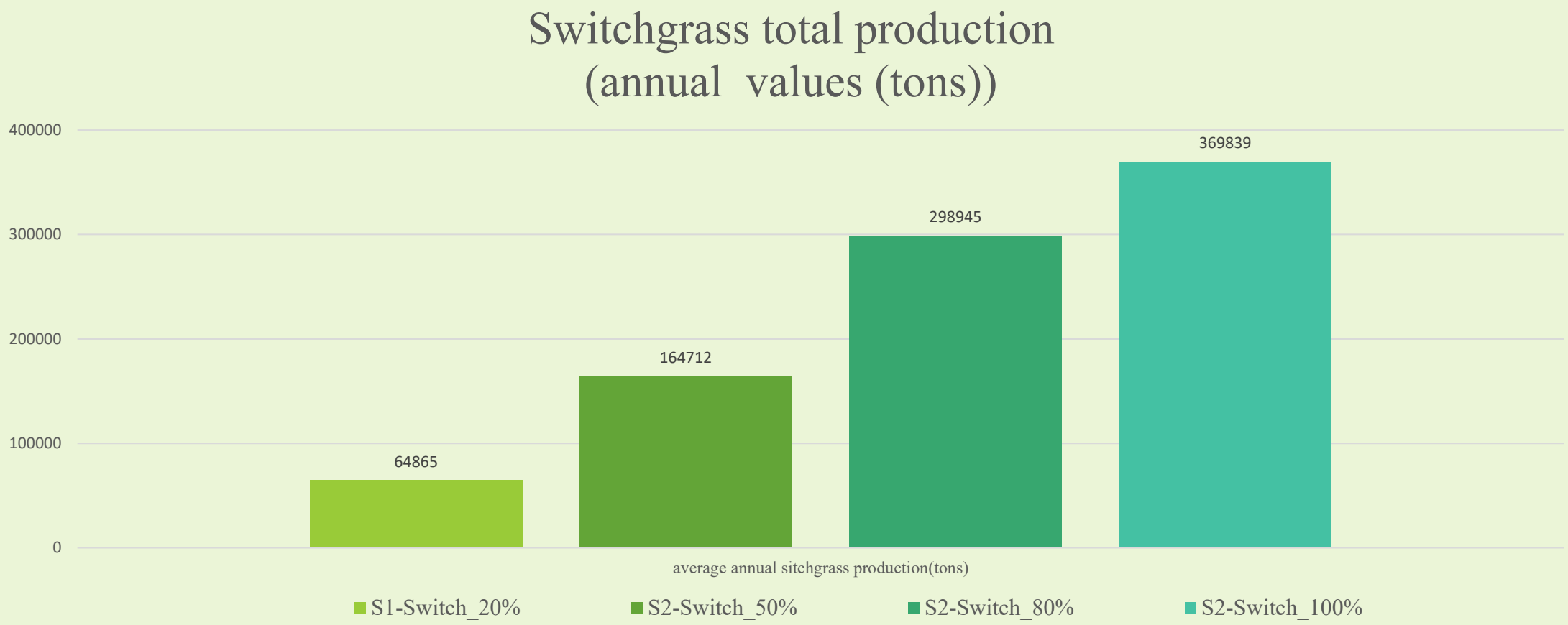


Preliminary results(6)



Preliminary results(8)

Preliminary results(9)



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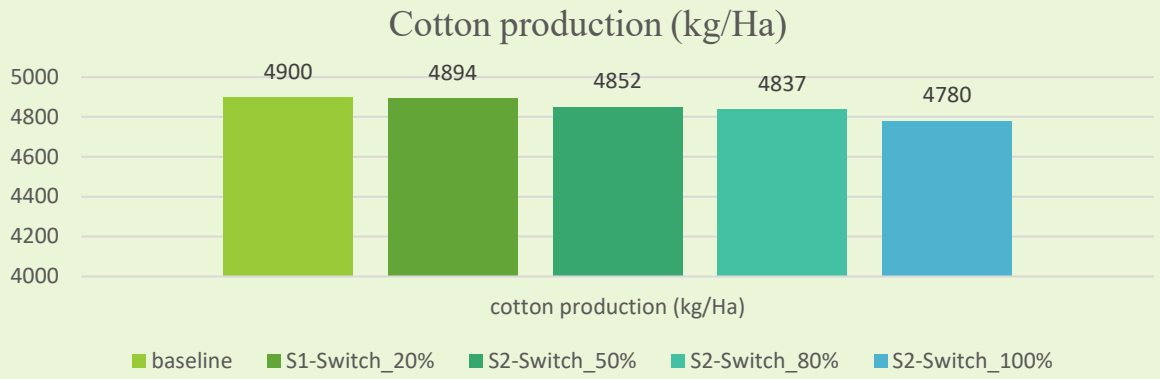

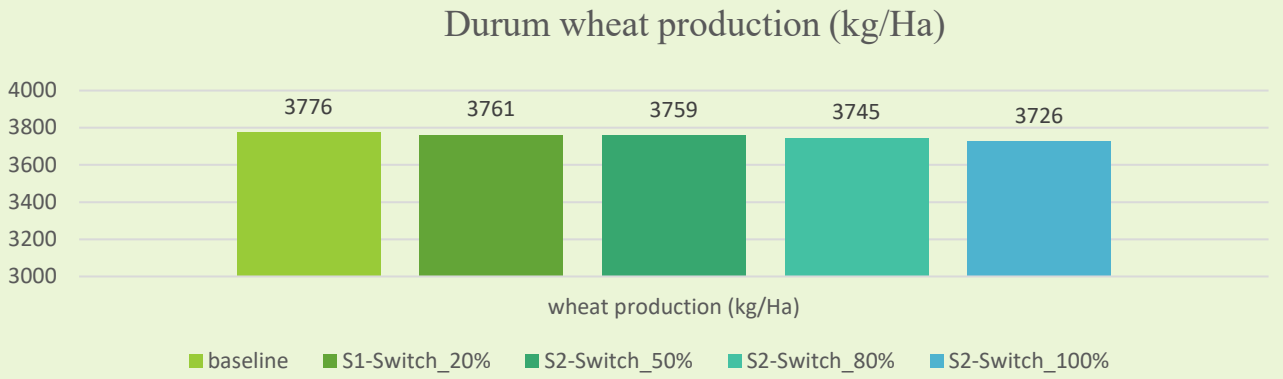

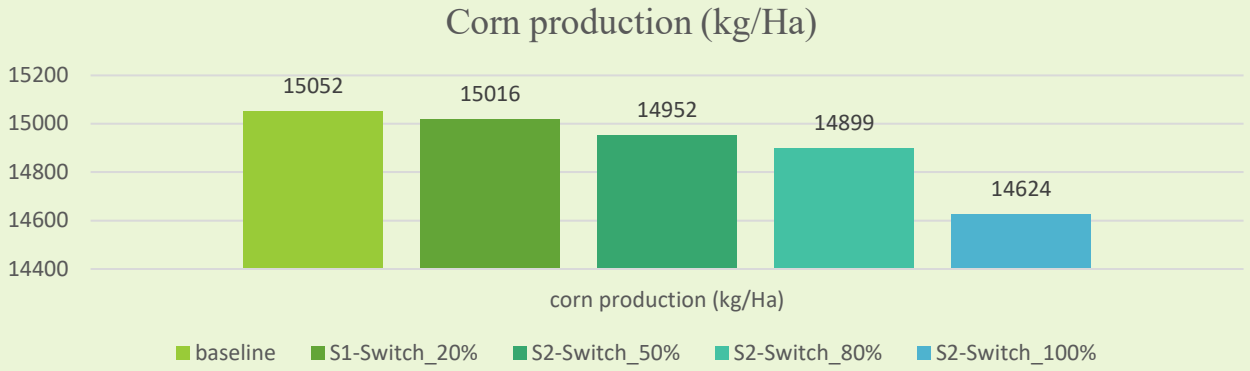

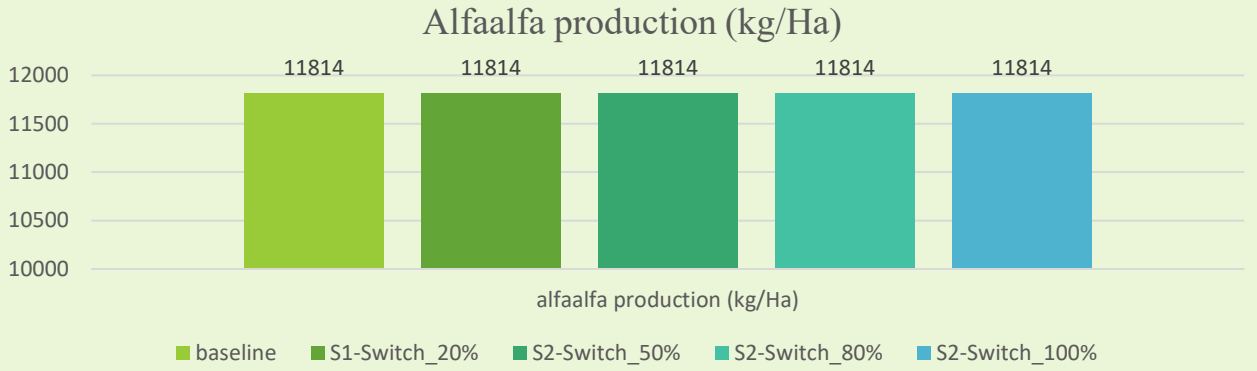

Conclusions

- Switchgrass is very effective in reducing N water pollution and sediments
- The 80% and 100% implementation scenarios are not realistic
- The 20% Switchgrass implementation scenario is the ideal one for the study area
- SWAT switchgrass yields underestimated

Further research

- Improve SWAT modeling for bioenergy crops
- Crop yields and biomass need calibration
- Progressively add more areas for switchgrass implementation based on economic factors
- Optimization to determine the optimal scenario for the study area

Thank you for your attention

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Hydrological Modelling for the Sustainable Management of Water Resources in River Basins

Guest Editors

Dr. Ioannis Panagopoulos, Dr. Pantelis Sidiropoulos

Deadline

31 October 2024

Special Issue