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School of Agriculture
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Evaluation of agricultural Best Management Practices' impact on water quality: case of Pinios catchment, Thessaly Greece

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2024 International SWAT Conference
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Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

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Introduction

Agriculture:

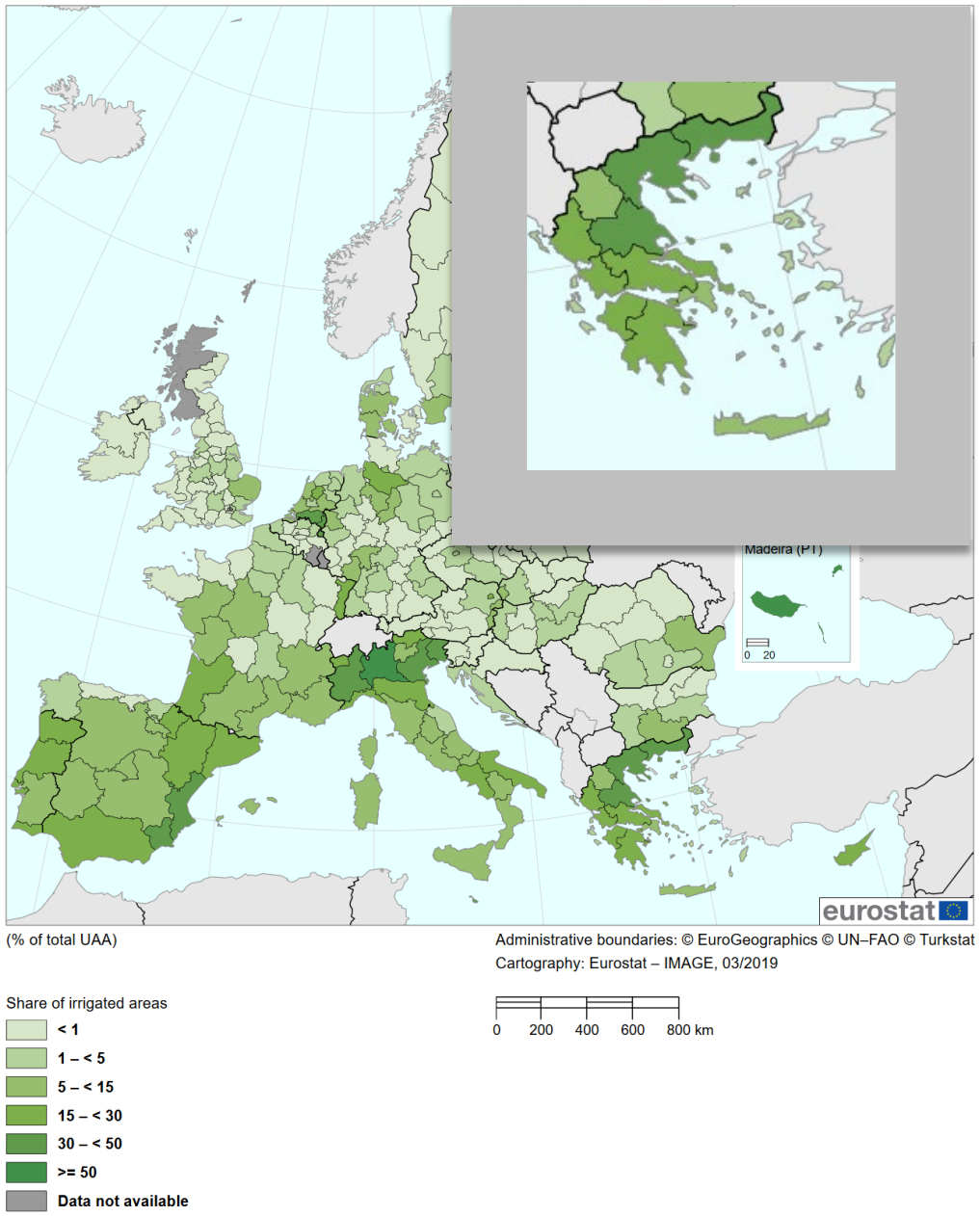
- 50% of European water abstractions (Zhang, S. et al. 2022)
- 86% of water abstractions in Greece (European Commission: Rural Development Programme for Greece 214-2022)

➢Water scarcity

➢Nutrient pollution

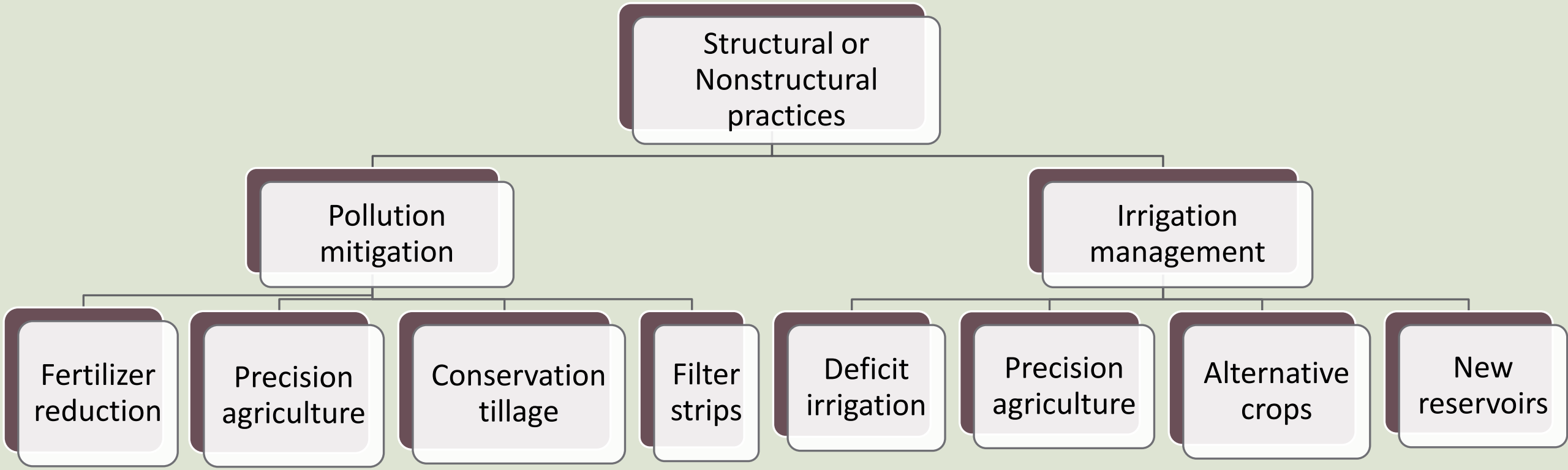
Water Framework Directive (WFD)

- Monitoring nitrate concentrations of water bodies
- Designating nitrate-vulnerable zones
- River Basin Management Plan



Source: Eurostat (online data code: ef_poirrig)

BMPs for degradation of water quality and water resources



The project "BIOGRASS"

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The project “BIOGRASS”

A few words for the project…

- **Project duration:** Oct. 2023 - Oct. 2025
- **Coordinator:** Aristotle University of Thessaloniki
- Carried out within the framework of the **National Recovery and Resilience Plan Greece 2.0, funded by the European Union – NextGenerationEU** (Implementation body: **HFRI**)
- Implemented in **Pinios river basin**, Thessaly, Central Greece
- The Greek pilot towards energy security based on the perennial crop switchgrass and the implementation’s results in quality and quantity of water bodies

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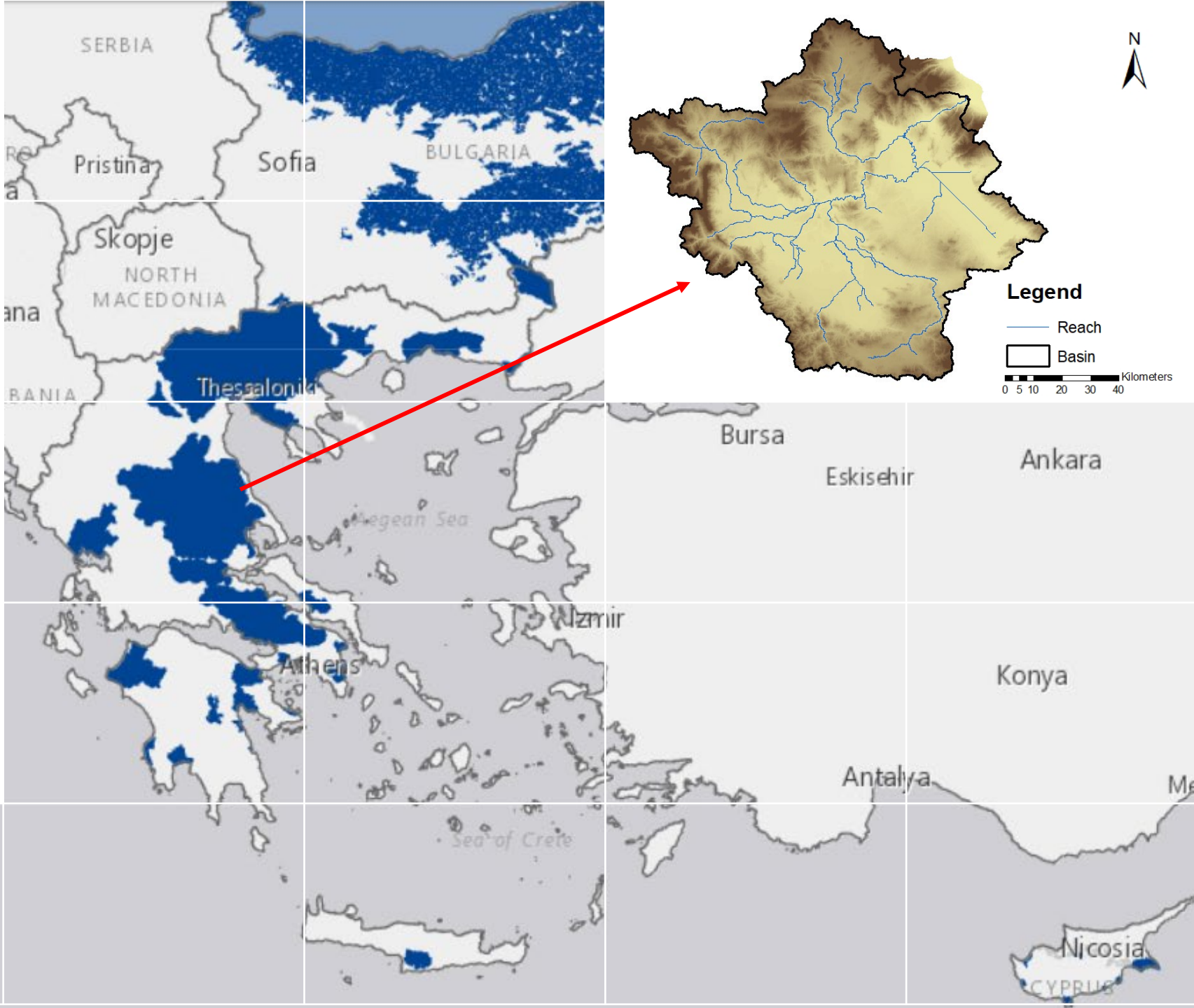
Pinios River Basin

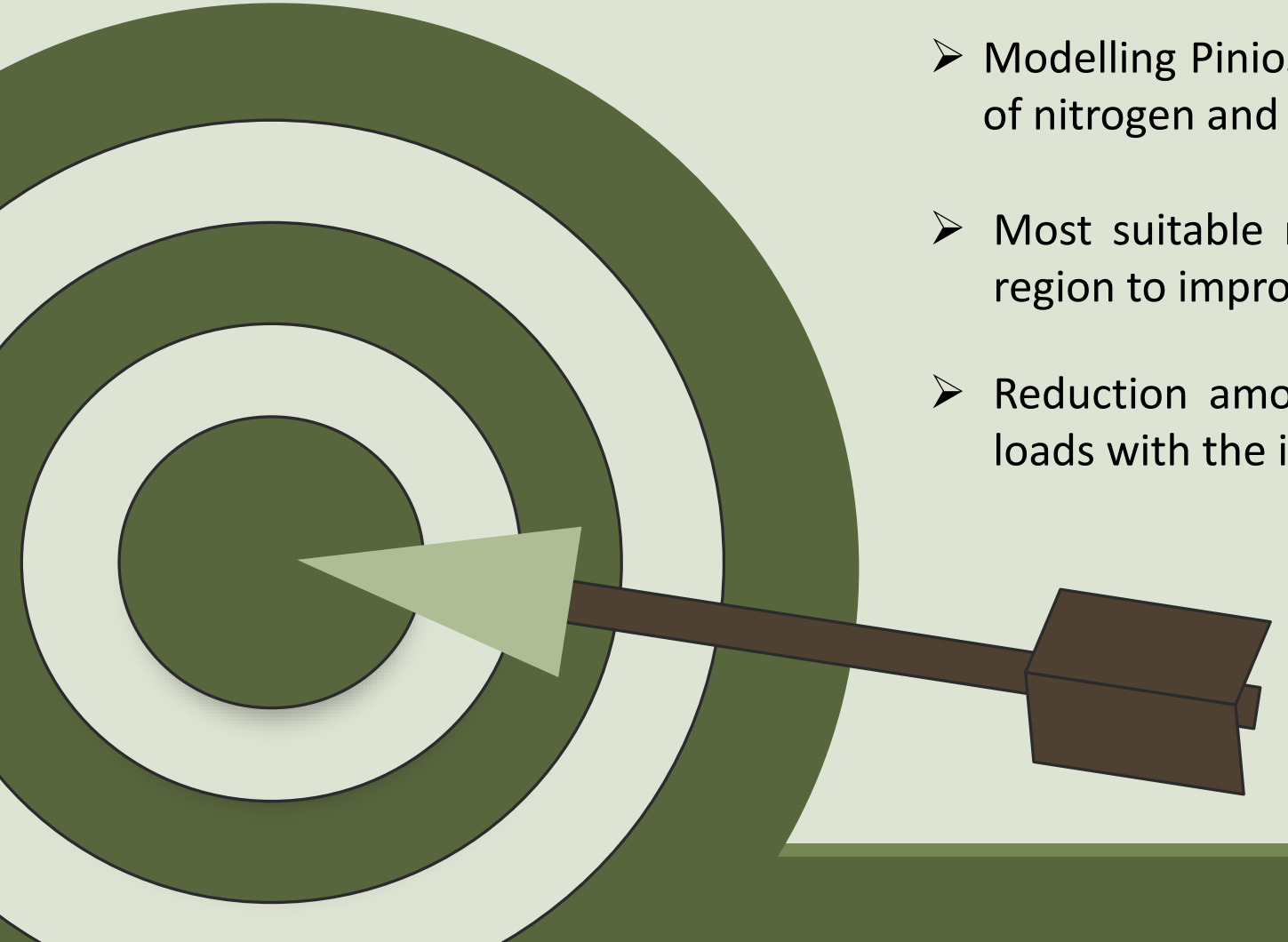
- The most important agricultural producer in Greece
- 94% of total water consumption is allocated to irrigation
- Abstractions mainly from groundwater
- Water scarcity
- Nitrate vulnerable zone



Source:
https://water.jrc.ec.europa.eu/portal/apps/webappviewer/index.html?id=b33a220c1b284583851e93a245da02ef

Objectives

Objectives



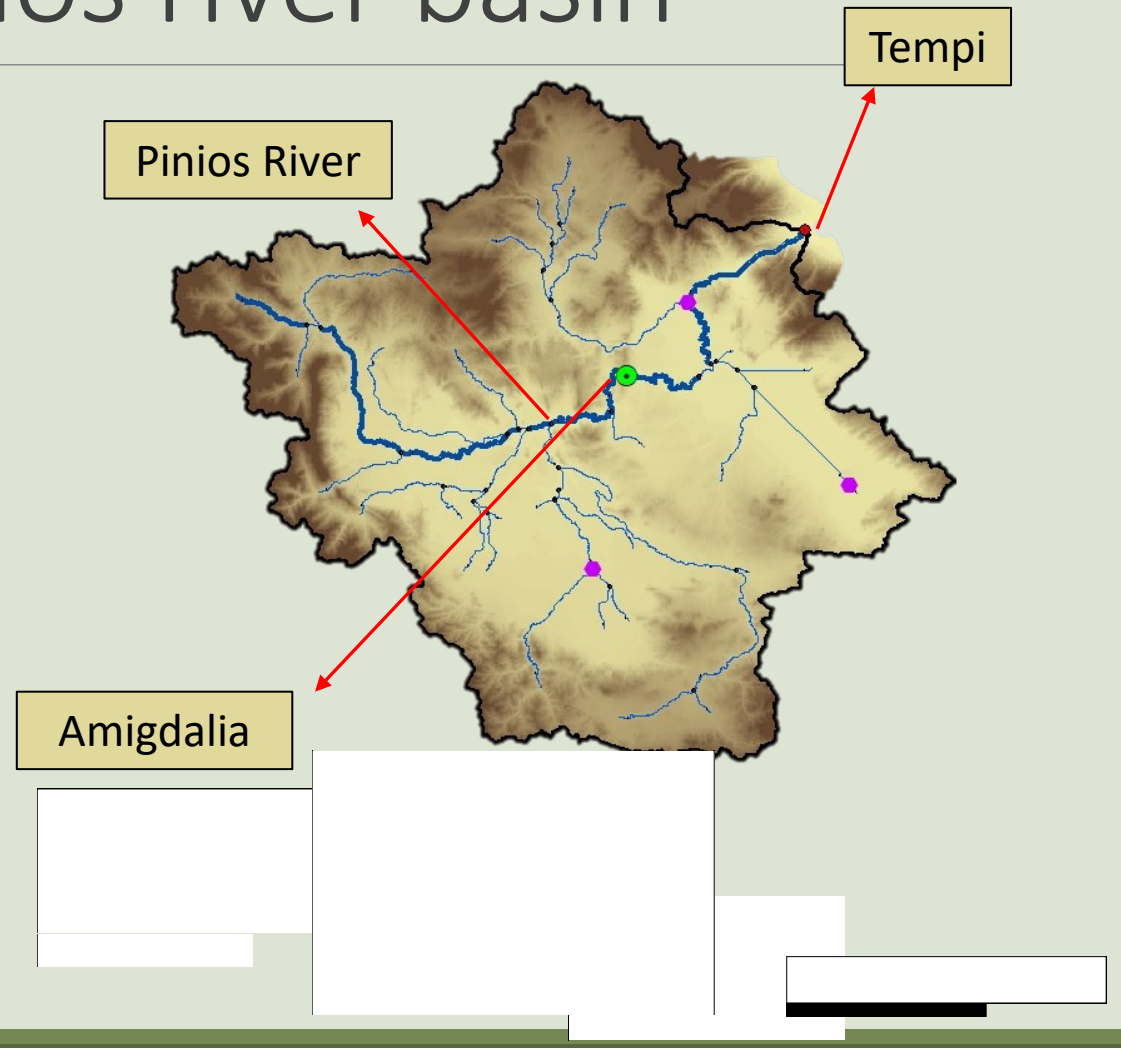
- Modelling Pinios River Basin for the simulation of nitrogen and sediment load
- Most suitable management practices for the region to improve water quality and quantity
- Reduction amount in nitrogen and sediment loads with the implementation of BMPs

WHY SWAT?

- Physically based model with computational efficiency
- Predicts the impact of a variety of management practices on water, sediment and nutrient load in large and complex watersheds
- Distributed model (combinations of unique land use, soil types and slopes)
- Tested on various agricultural catchments
- Used for Policy Making in the USA (EPA, USDA)

Implementation in Pinios river basin

- Area: 10,622 km^2
- Precipitation: 700 mm/year
- Cropland: 452,471 ha
- Irrigated land: 202,652 ha
- Main crops:
  - Winter wheat: 37%
  - Cotton: 36%
  - Other (Alfalfa, Corn, Fallow areas): 27%



Model Inputs

4

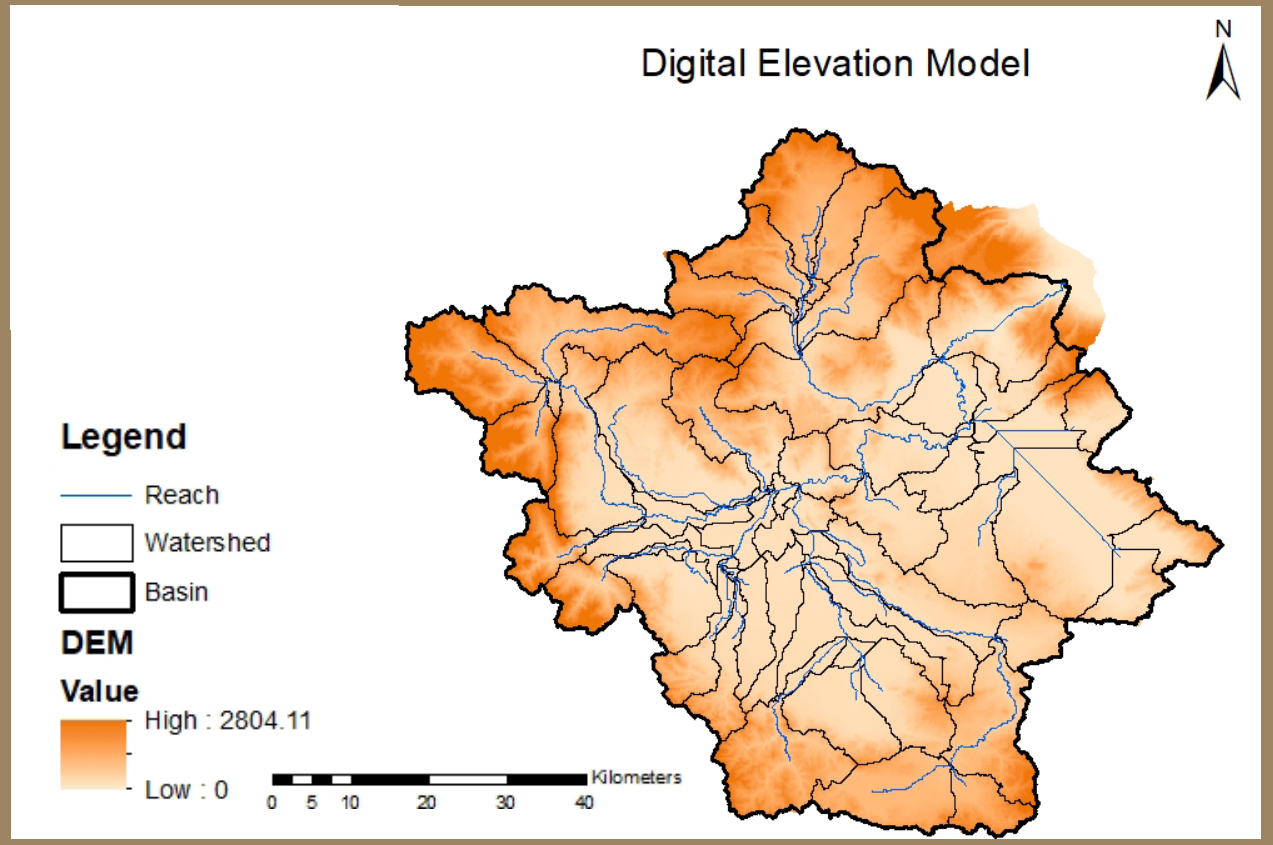
3

2

1

Model Inputs

Digital Elevation Model



25x25 DEM
Elevation range: 0-2804 m

4

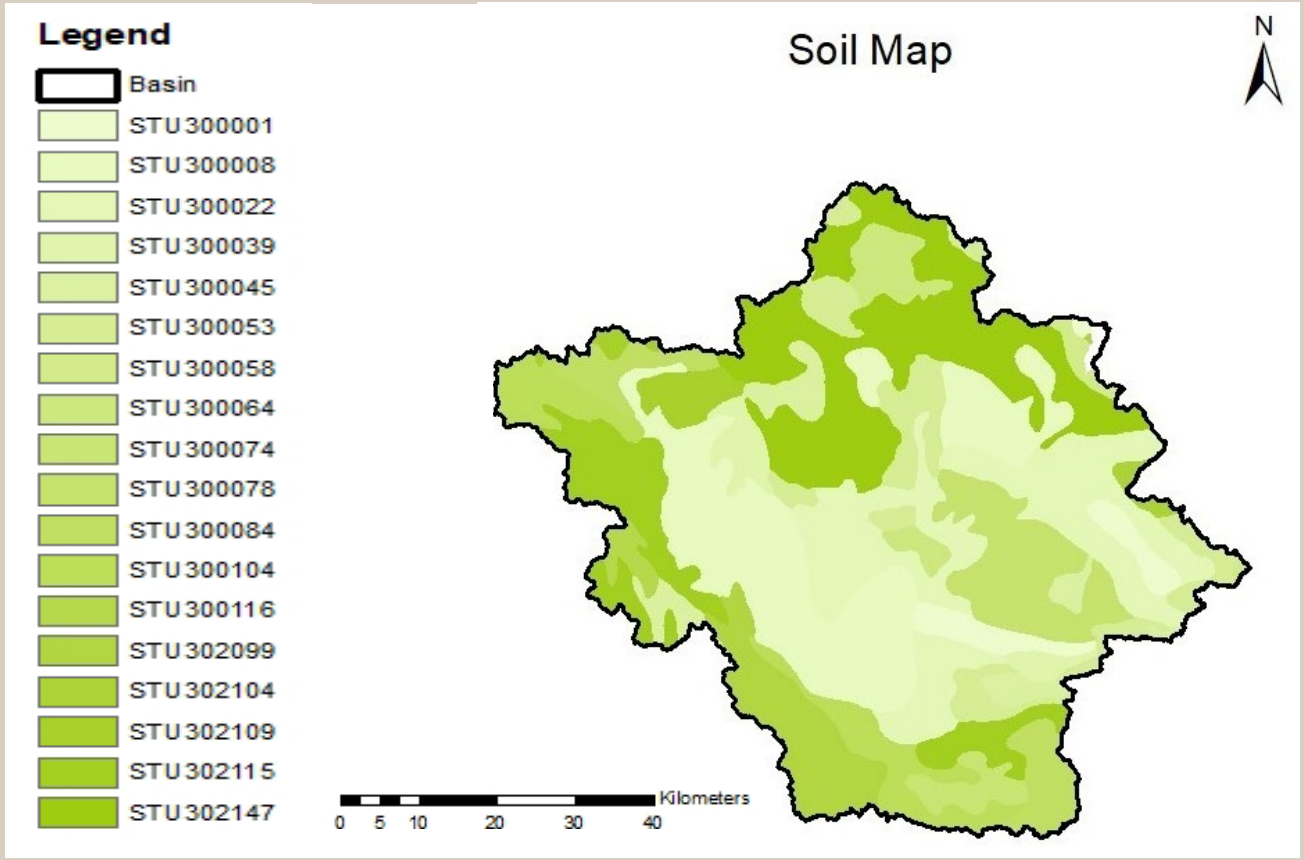
3

2

1

Model Inputs

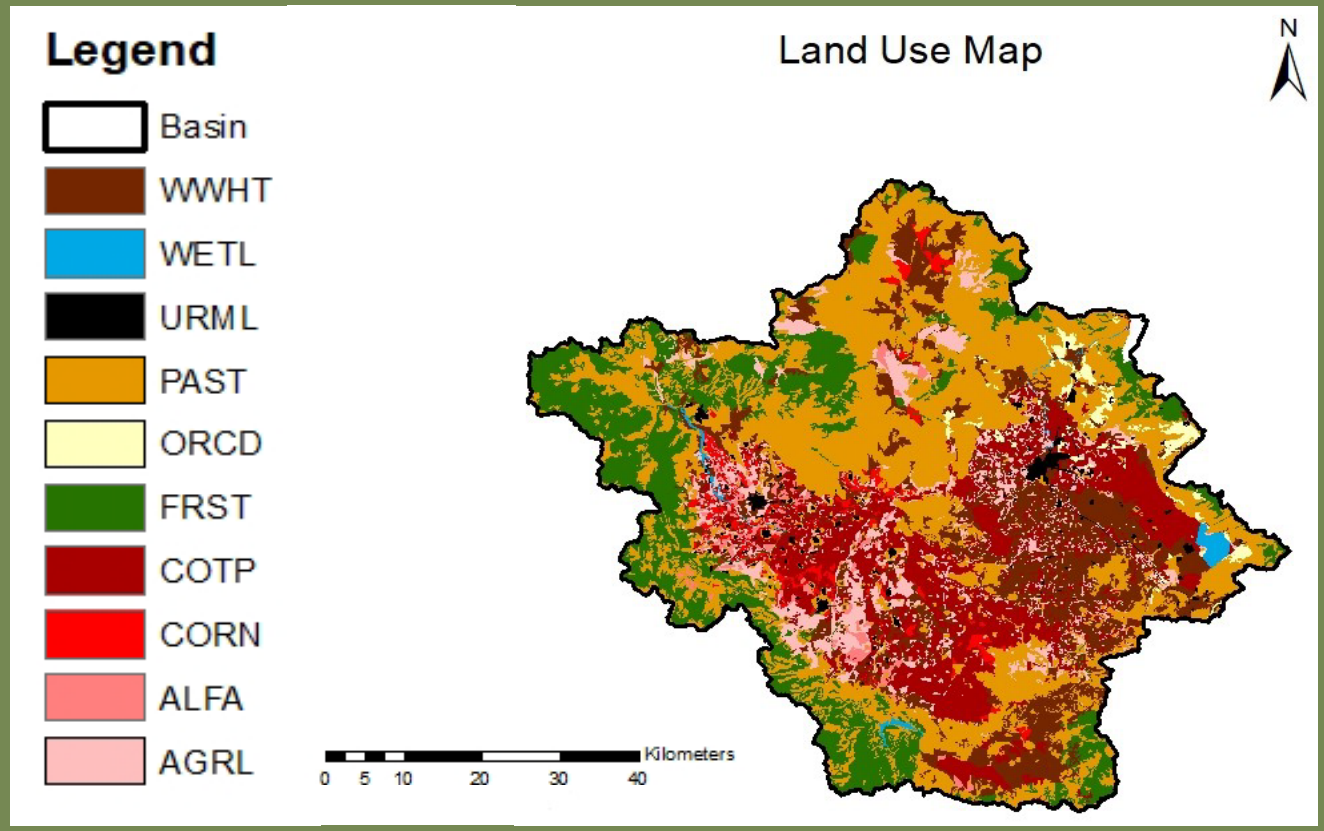
Soil map



European Soil Data Centre (ESDAC)

Model Inputs

Land Use map



Corine 2012 +Hellenic Statistical Authority

- 37% Pastureland
- 17% Forest
- 16% Winter wheat
- 15% Cotton

4

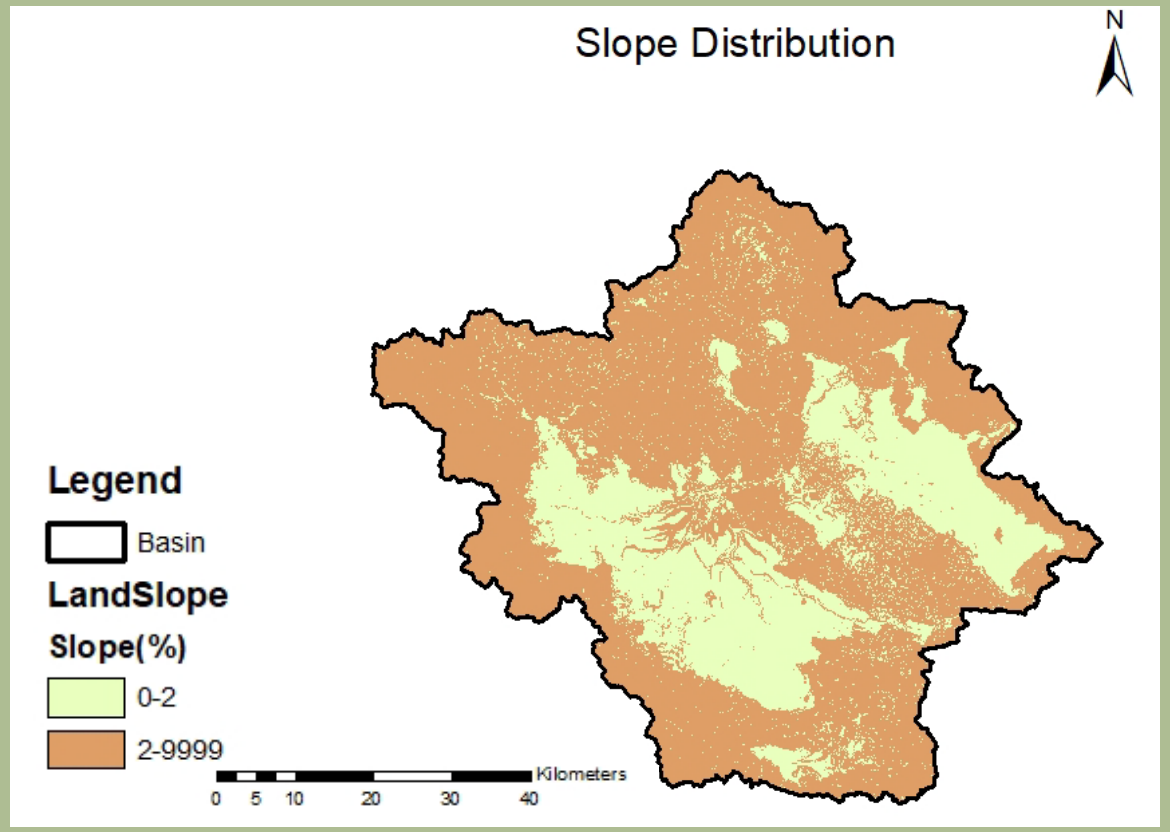
3

2

1

Model Inputs

Slope map



Slope classes:

- 0-2%
- 2-99%

4

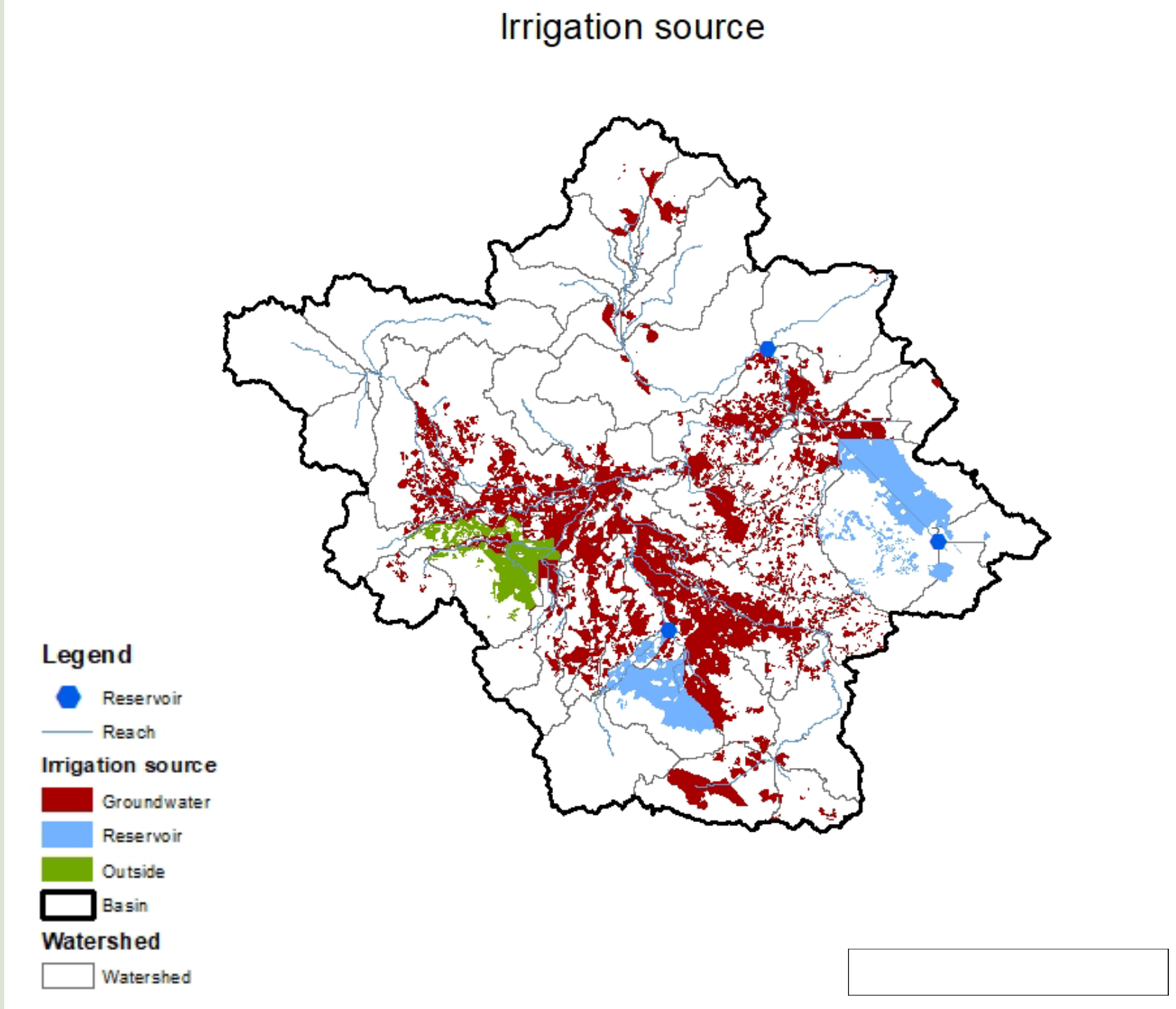
3

2

1

Model Inputs

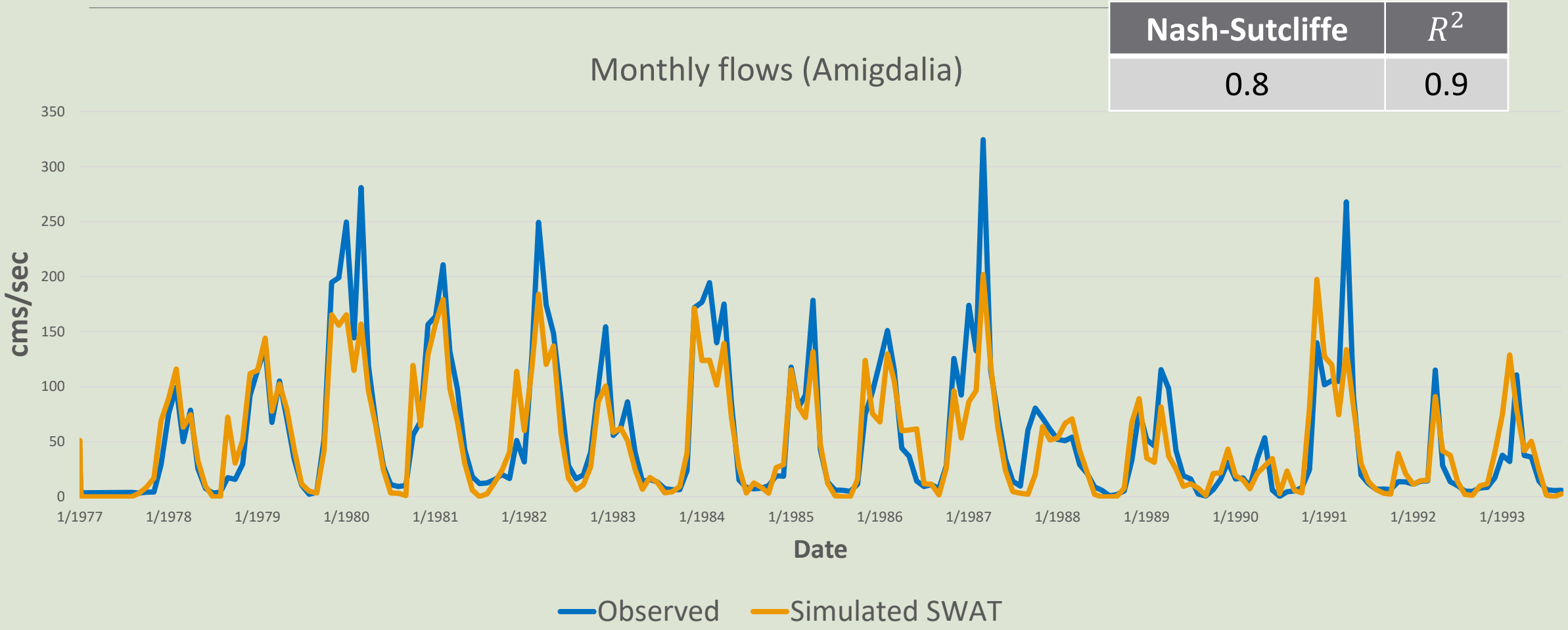
- 61 Subbasin – 1837 HRUs
- 3 Reservoirs (18% of total irrigated area)
- Plastiras lake – Outside source (7% of total irrigated area)
- Groundwater (75% of total irrigated area)



Calibration

- Calibration was carried out at 2 sites (Ali Efenti and Amigdalia)
- Monthly time step
- Available data for 16 years (1977-1993)
- Evaluation of the results with the use of the statistical indicators

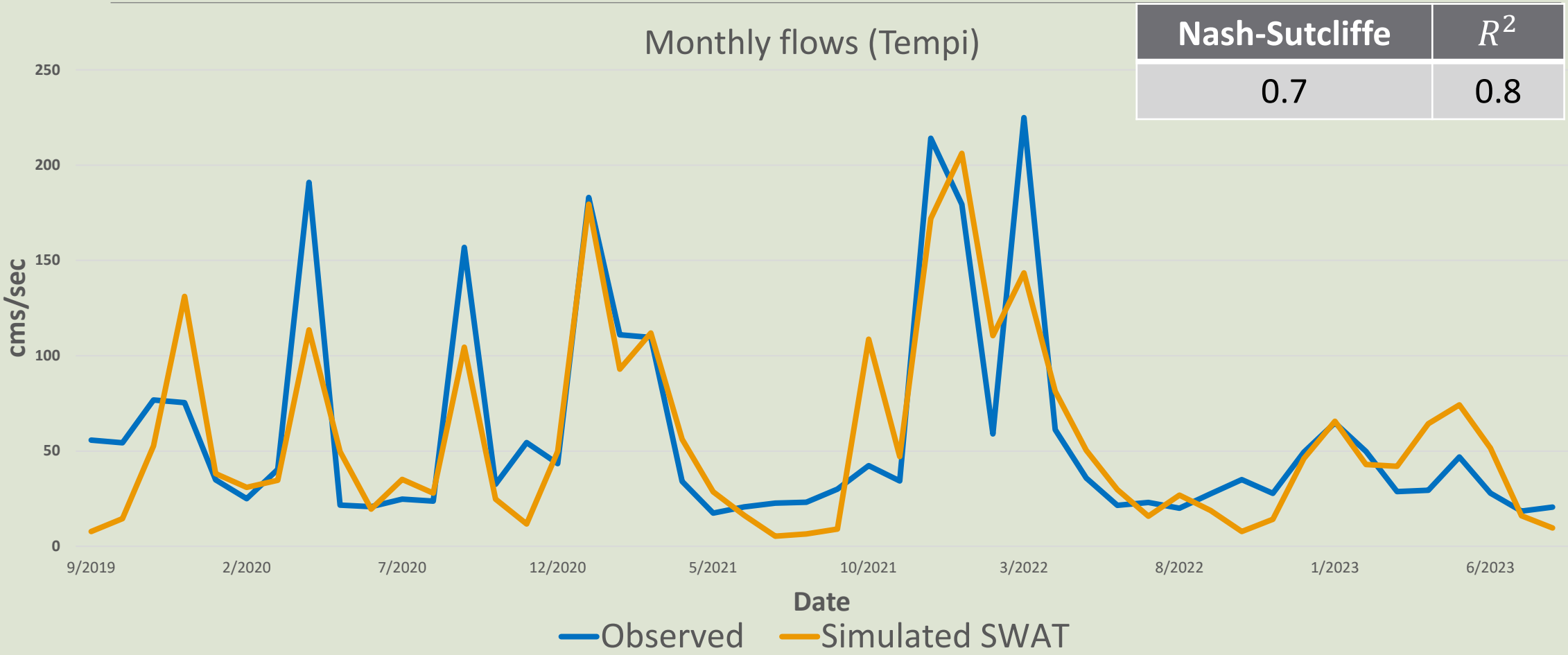
Nash-Sutcliffe	R^2
0.8	0.9



Validation

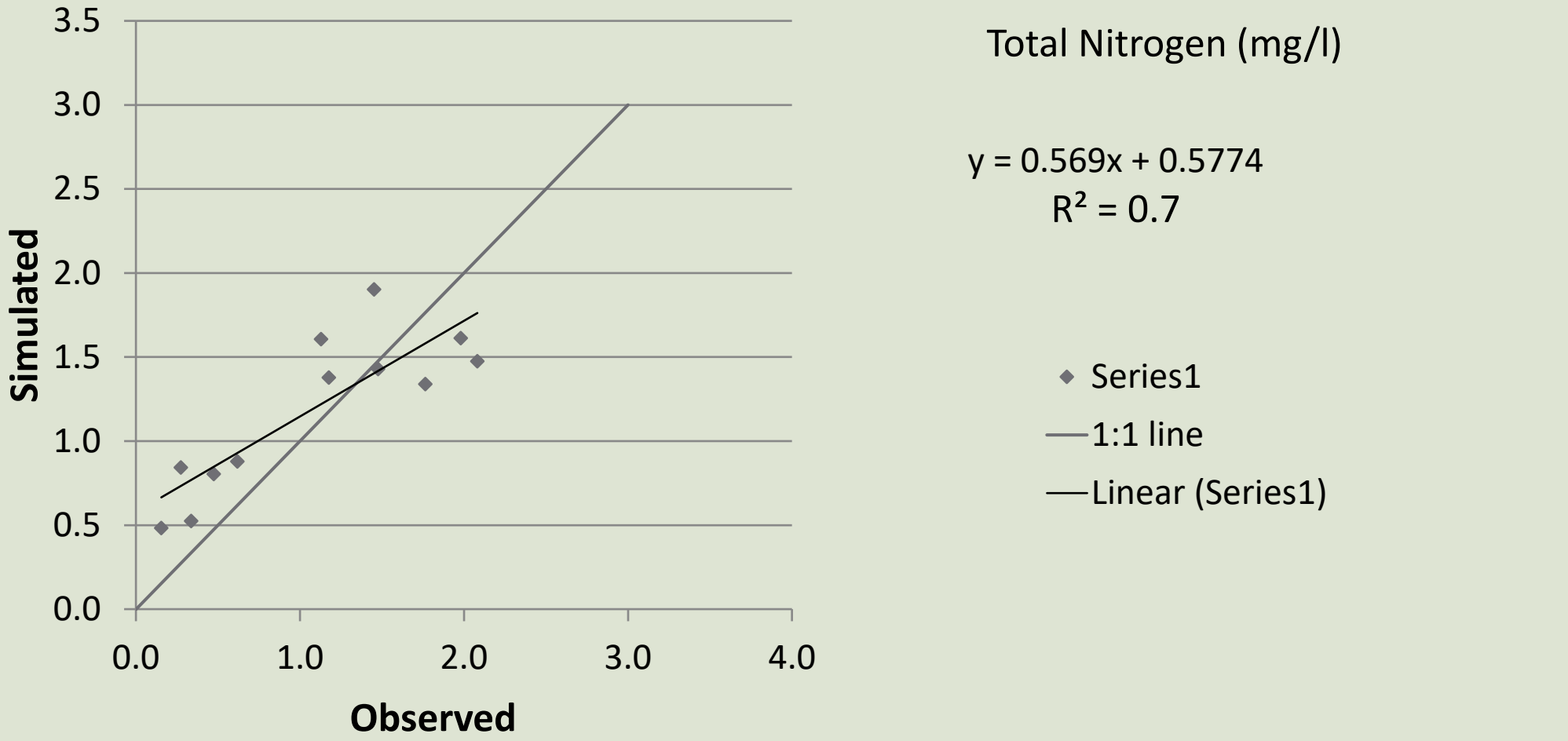
- Validation was carried out at the watershed's outlet (Tempi)
- Monthly time step
- Available data for 5 years (2019-2023)
- Evaluation of the results with the use of the statistical indicators

Nash-Sutcliffe	R^2
0.7	0.8

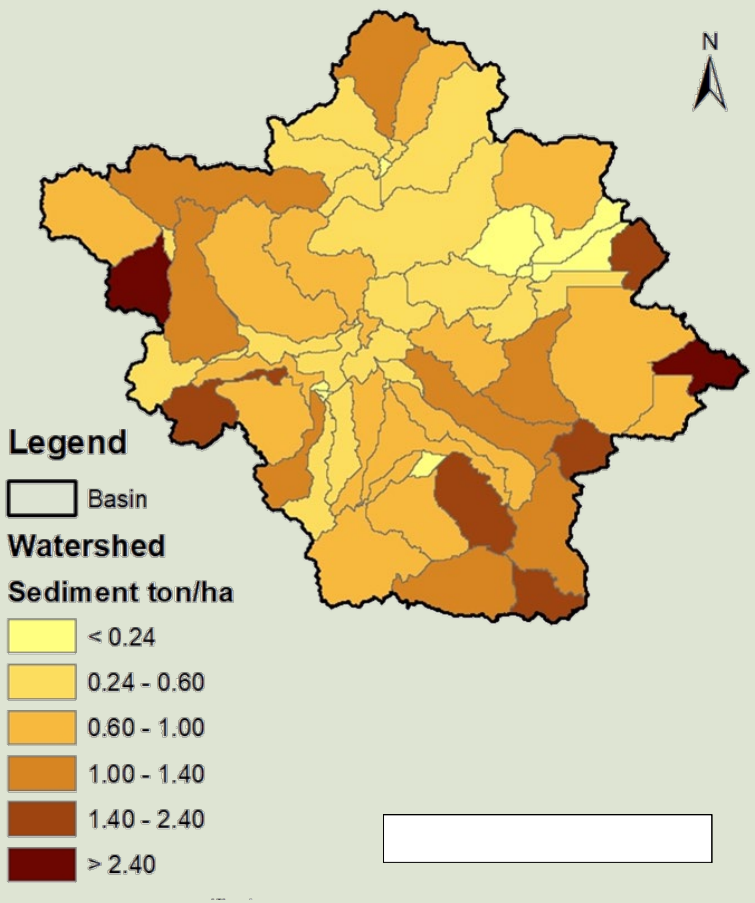


Total Nitrogen calibration at Tempi

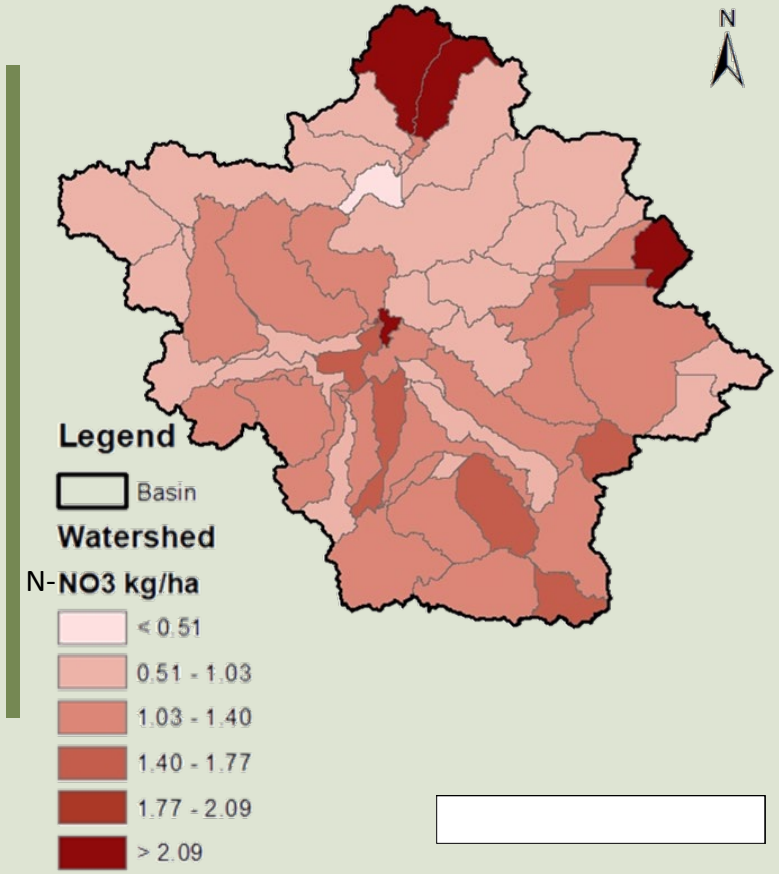
- Calibration was carried out at the watershed's outlet (Tempi)
- The results were evaluated with statistical indicators



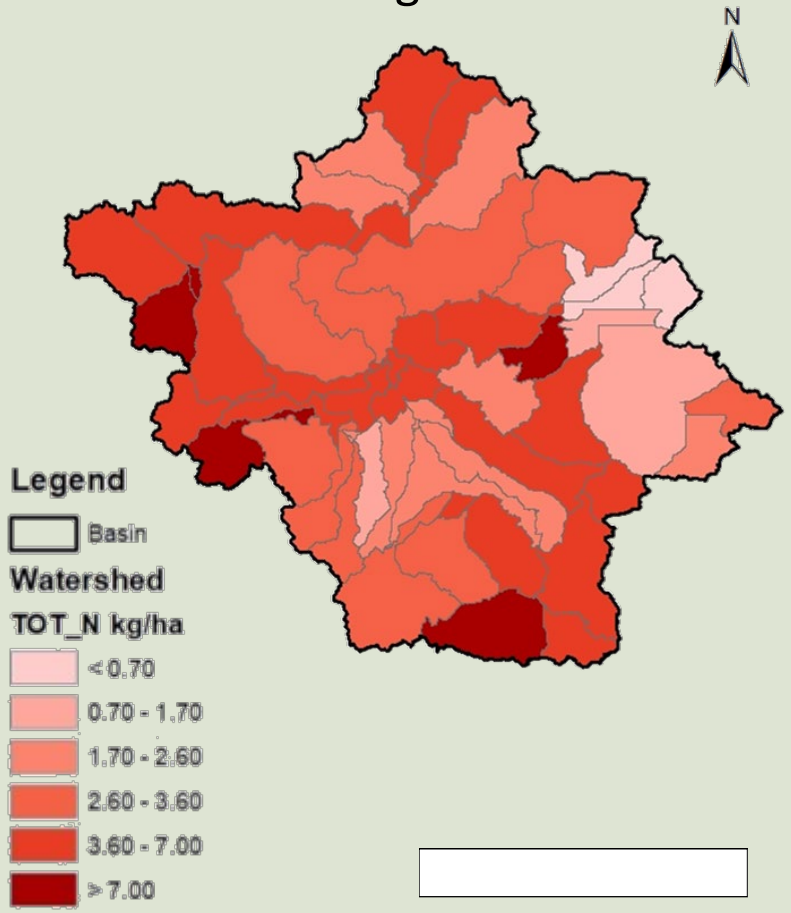
Sediment load



$N - NO_3$ load



Total Nitrogen load

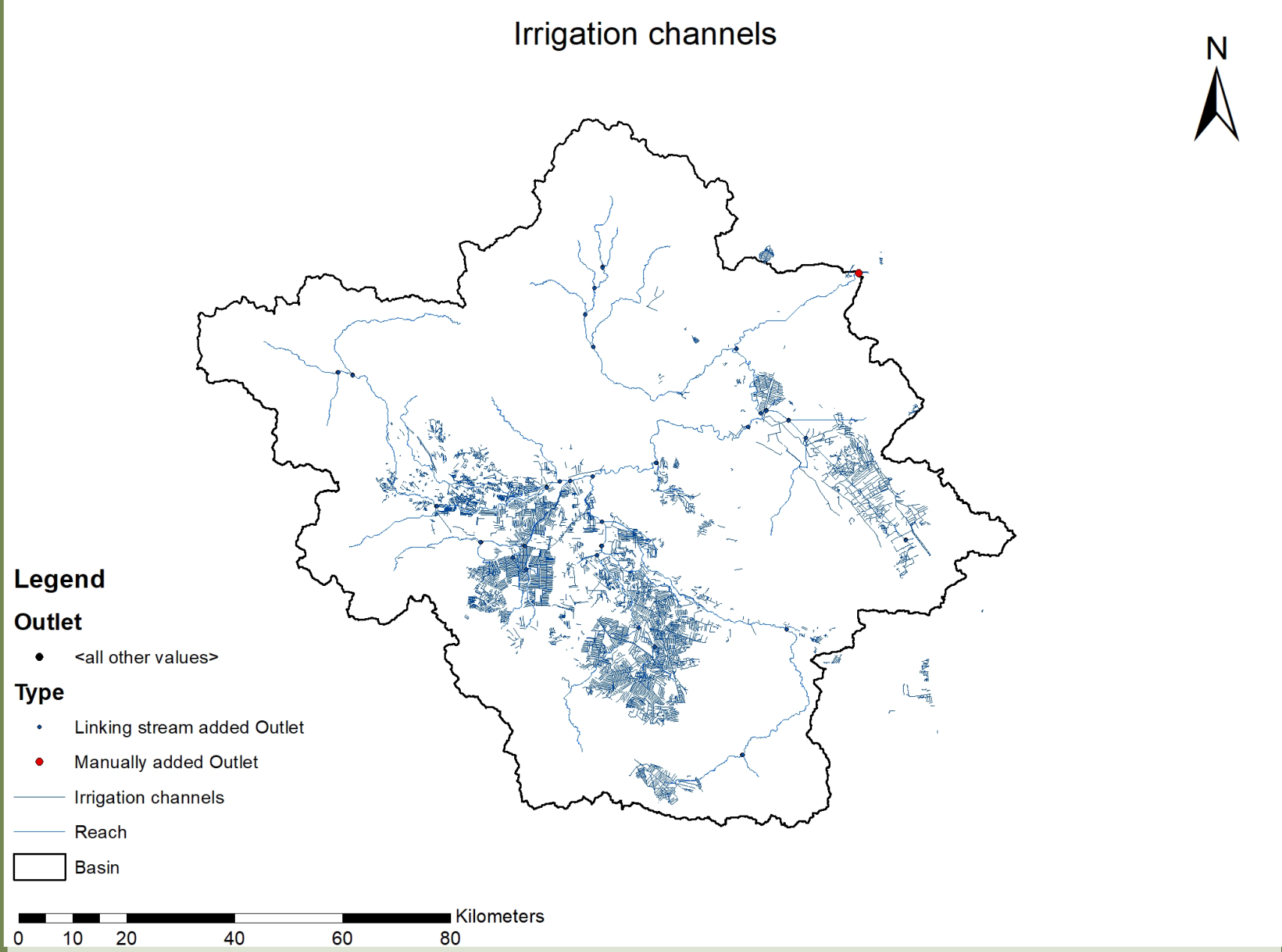


Baseline

Whole watershed		
Total Nitrogen load (kg/ha)	N-NO_3 load (kg/ha)	Sediment yield (ton/ha)
3.9	1.3	1.2

Scenarios

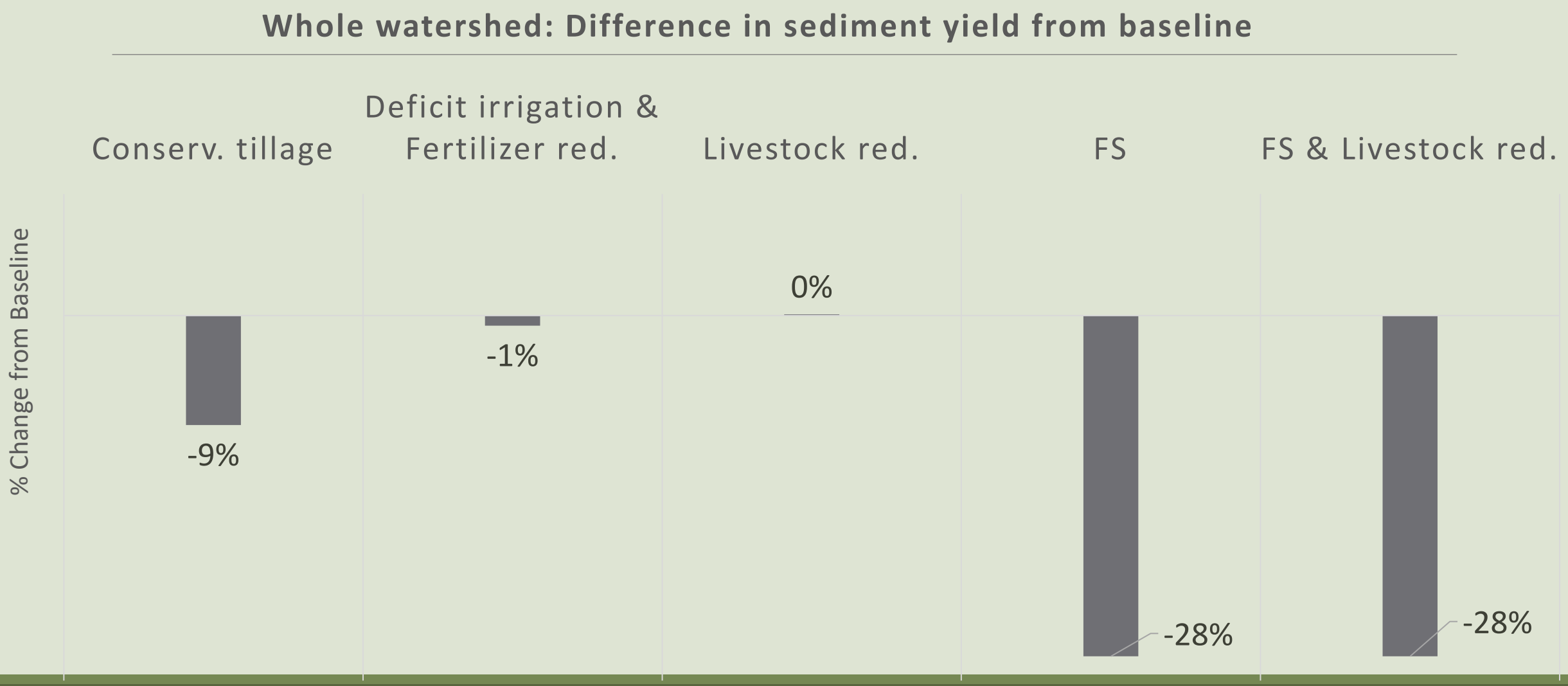
1. 20% Deficit irrigation & 30% Fertilizer reduction on Corn, Cotton, Alfalfa, Winter wheat
2. Conservation tillage on Corn, Cotton, Winter wheat
3. 30% Livestock reduction
4. 4m Filter strips in areas next to drainage canals with Pastureland and Cropland including fallow land
5. Combination of scenarios 3 and 4

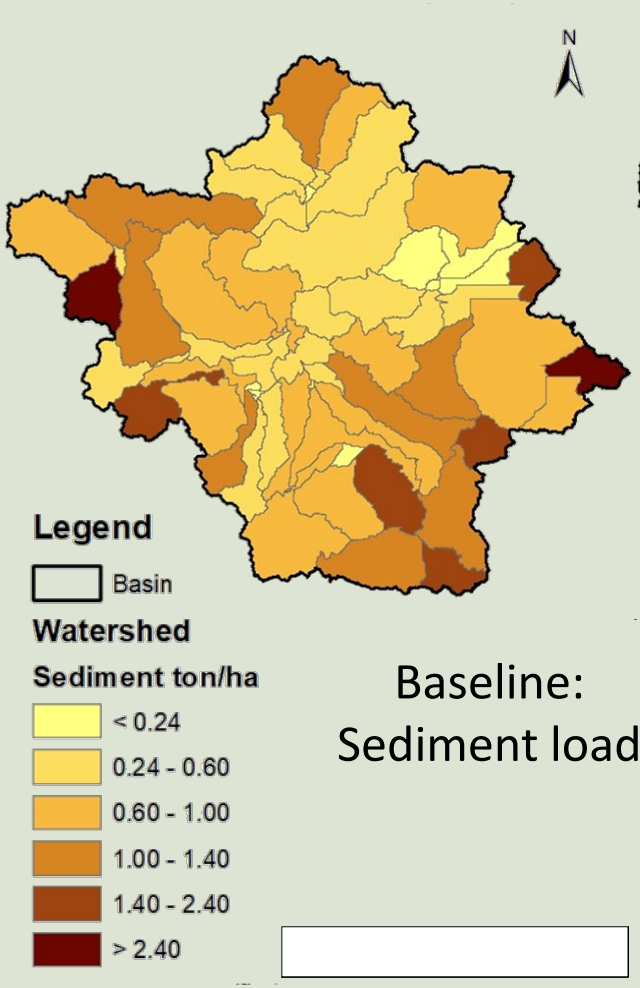


Preliminary results presentation

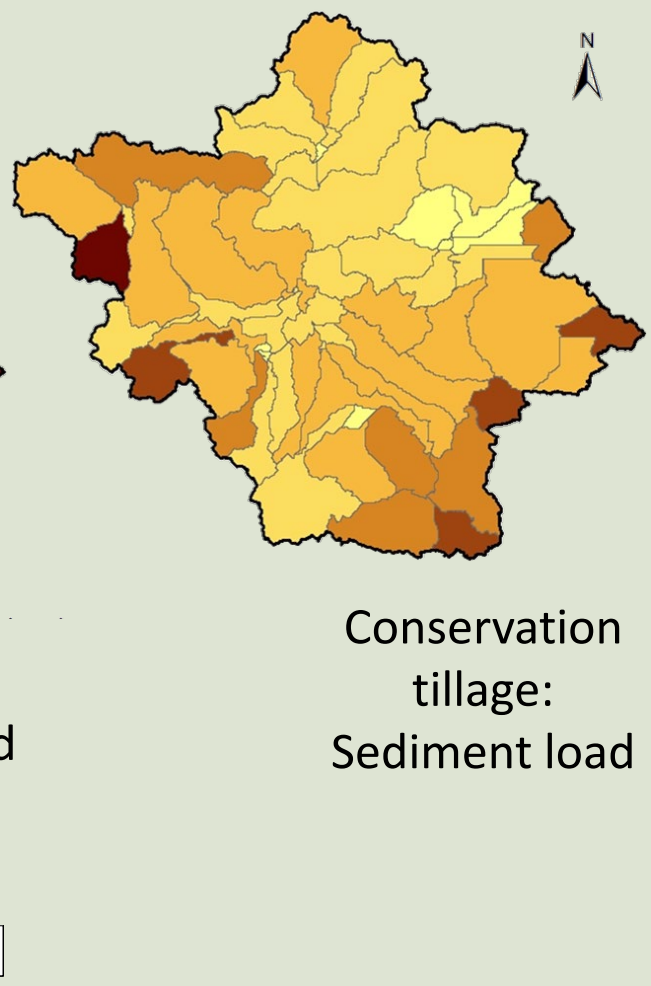
- **Sediment** (ton/ha), $\boldsymbol{N - NO_3}$ (kg/ha) and **Total Nitrogen** (kg/ha) loads at subbasin level
- **Difference** in sediment yield, N-NO3 and Total Nitrogen **from baseline**
- Amount of **water removed from shallow aquifers** for irrigation purposes
- **Crop yield** (kg/ha)

Results

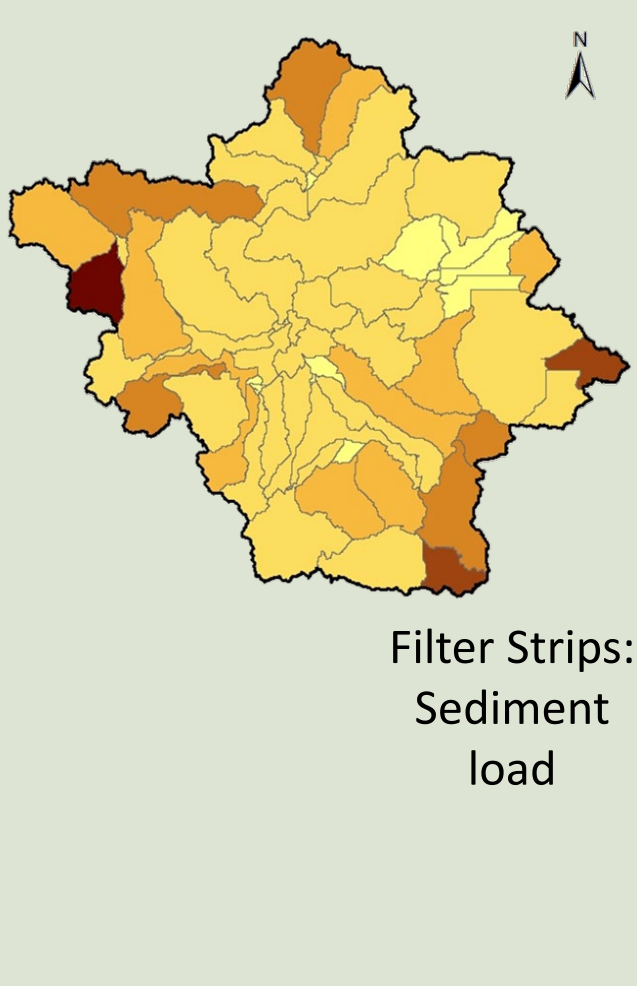

Whole watershed: Difference in sediment yield from baseline
Conserv. tillage
Deficit irrigation & Fertilizer red.
Livestock red.
FS
FS & Livestock red.
% Change from Baseline
-9%
-1%
0%
-28%
-28%



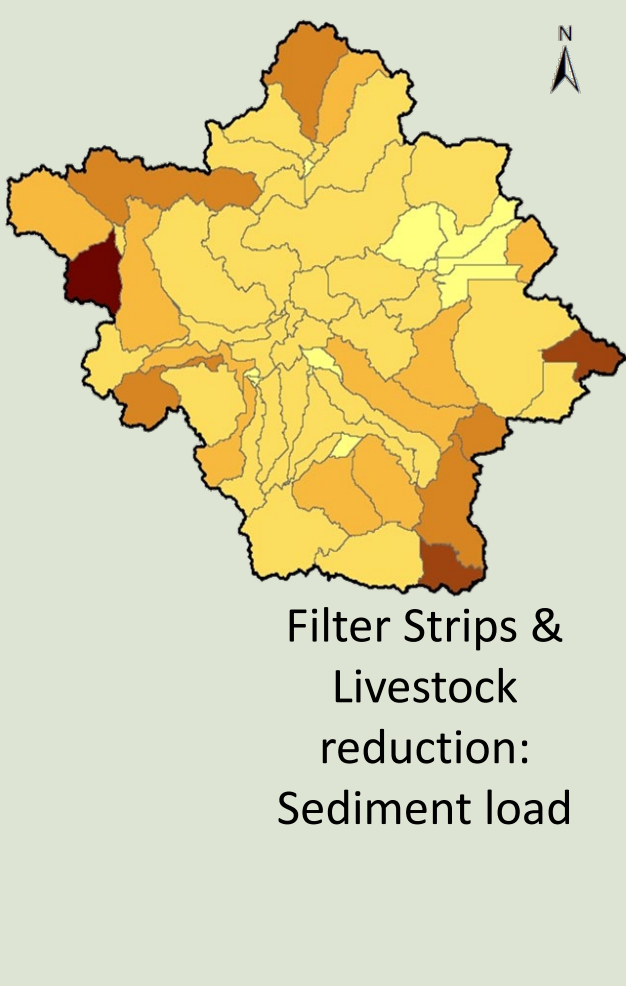
Baseline: Sediment load



Conservation tillage: Sediment load



Filter Strips: Sediment load



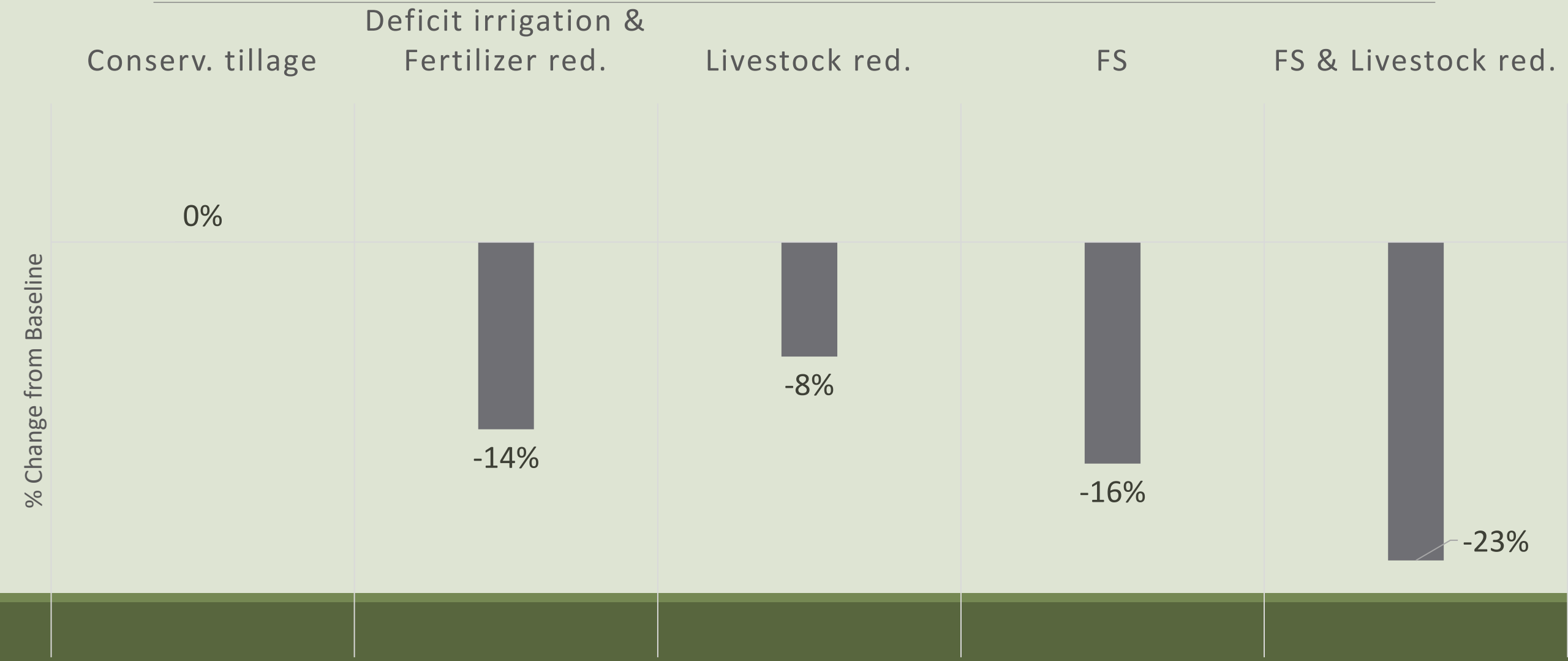
Filter Strips & Livestock reduction: Sediment load

Results

Sediment yield distribution per subbasin

Results

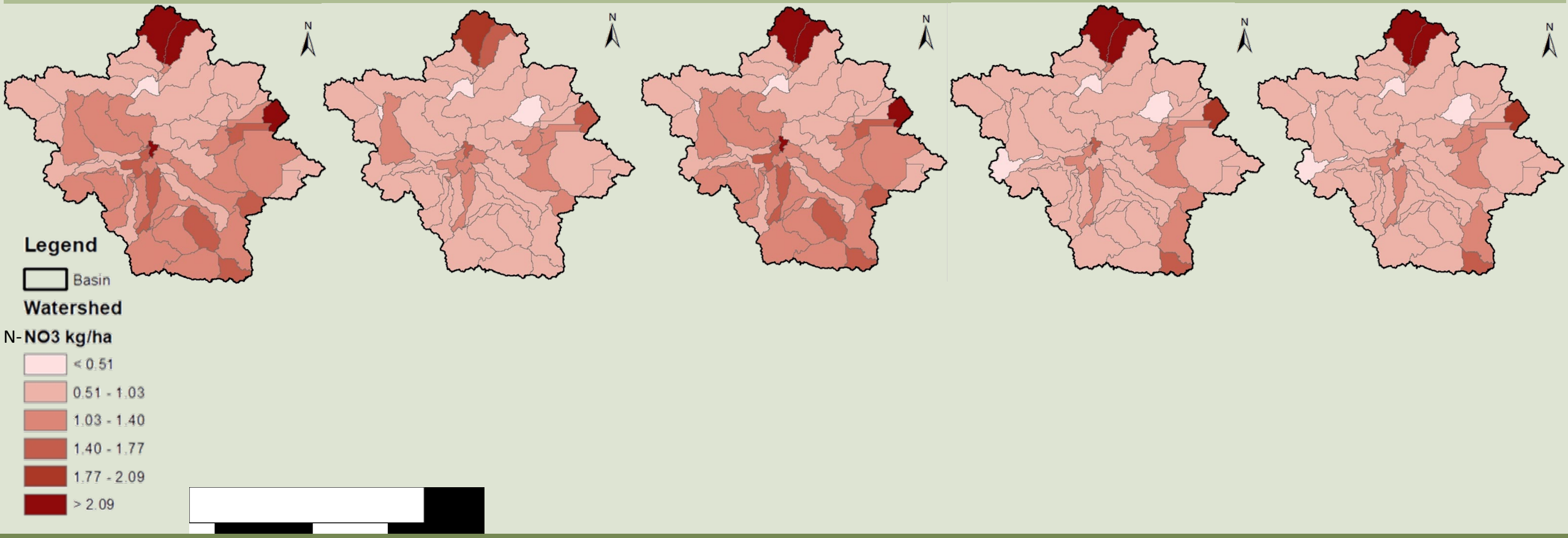
Whole watershed: Difference in N-NO_3 loads from baseline



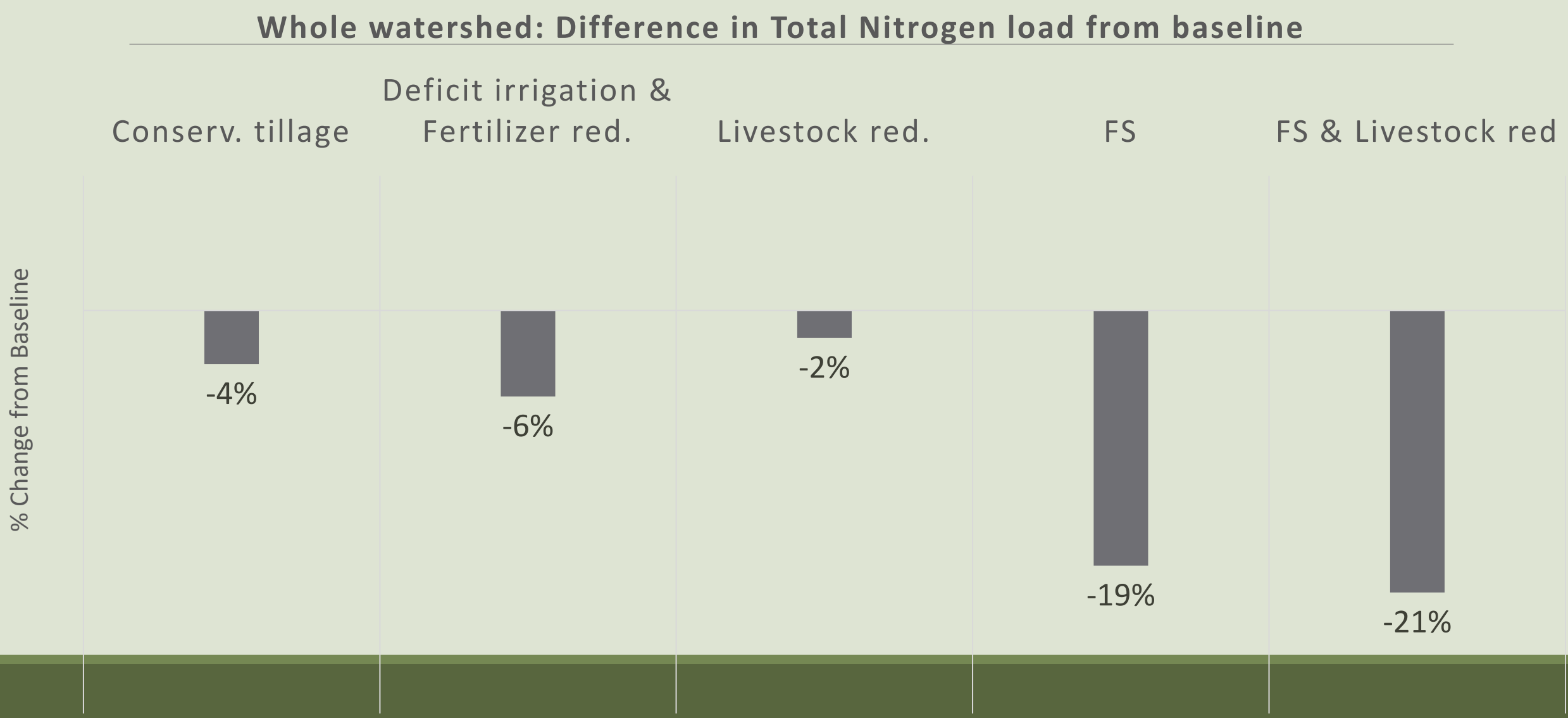
Results

$N - NO_3$ yield distribution per subbasin (kg/ha)

Baseline	Deficit irrigation & Fertilizer red.	Livestock reduction	Filter Strips	FS & Livestock red.



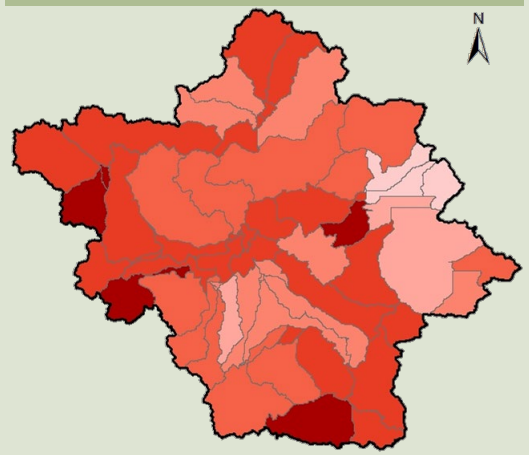
Results


Whole watershed: Difference in Total Nitrogen load from baseline
Conserv. tillage
Deficit irrigation & Fertilizer red.
Livestock red.
FS
FS & Livestock red
% Change from Baseline
-4%
-6%
-2%
-19%
-21%

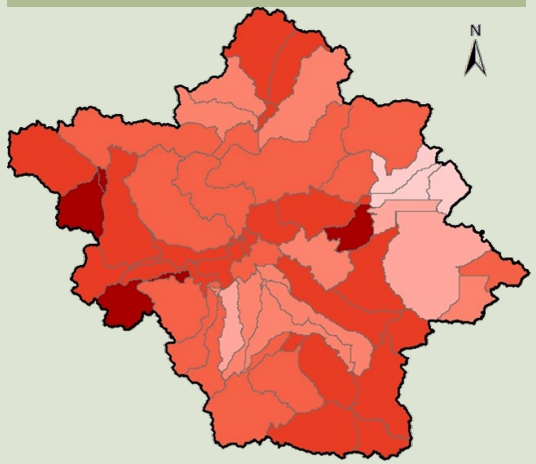
Results

Total Nitrogen yield distribution per subbasin (kg/ha)

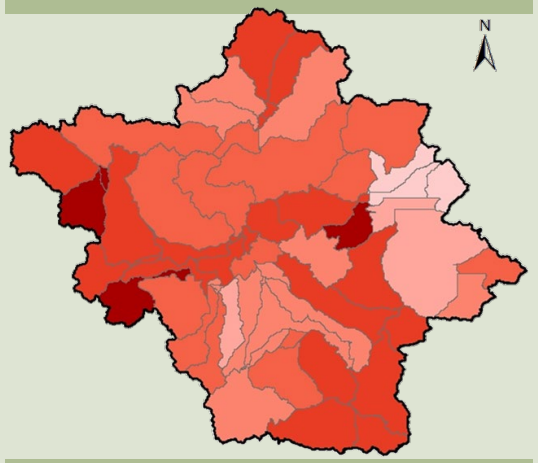
Baseline



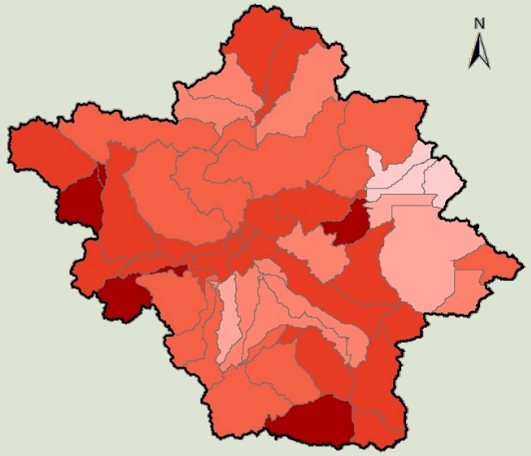
Conserv. tillage



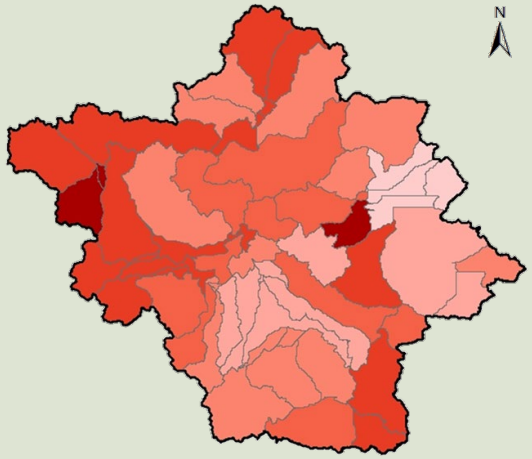
Deficit irrigation & Fertilizer red.



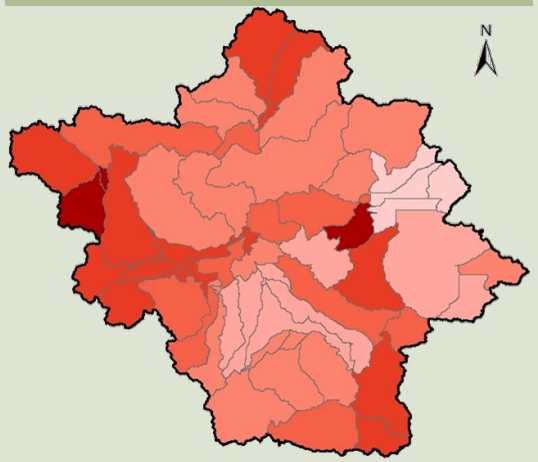
Livestock red.



Filter Strips

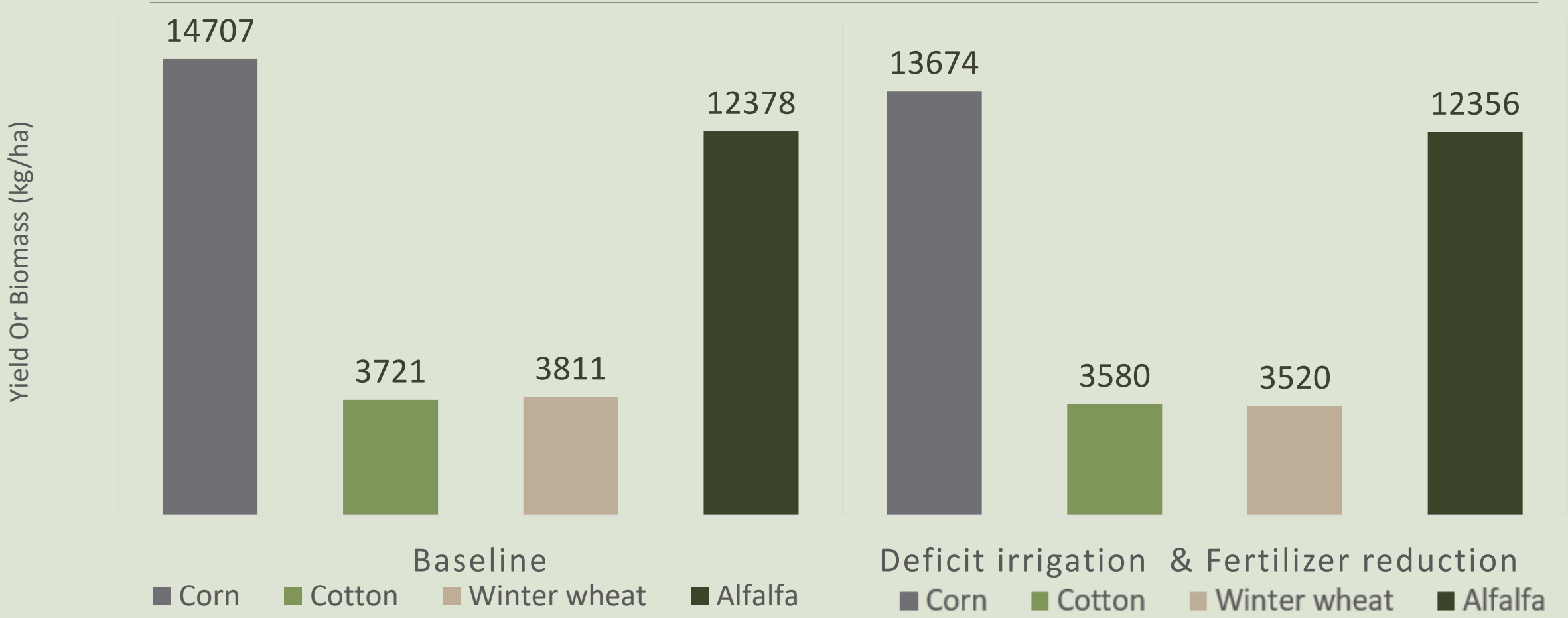


FS & Livestock red



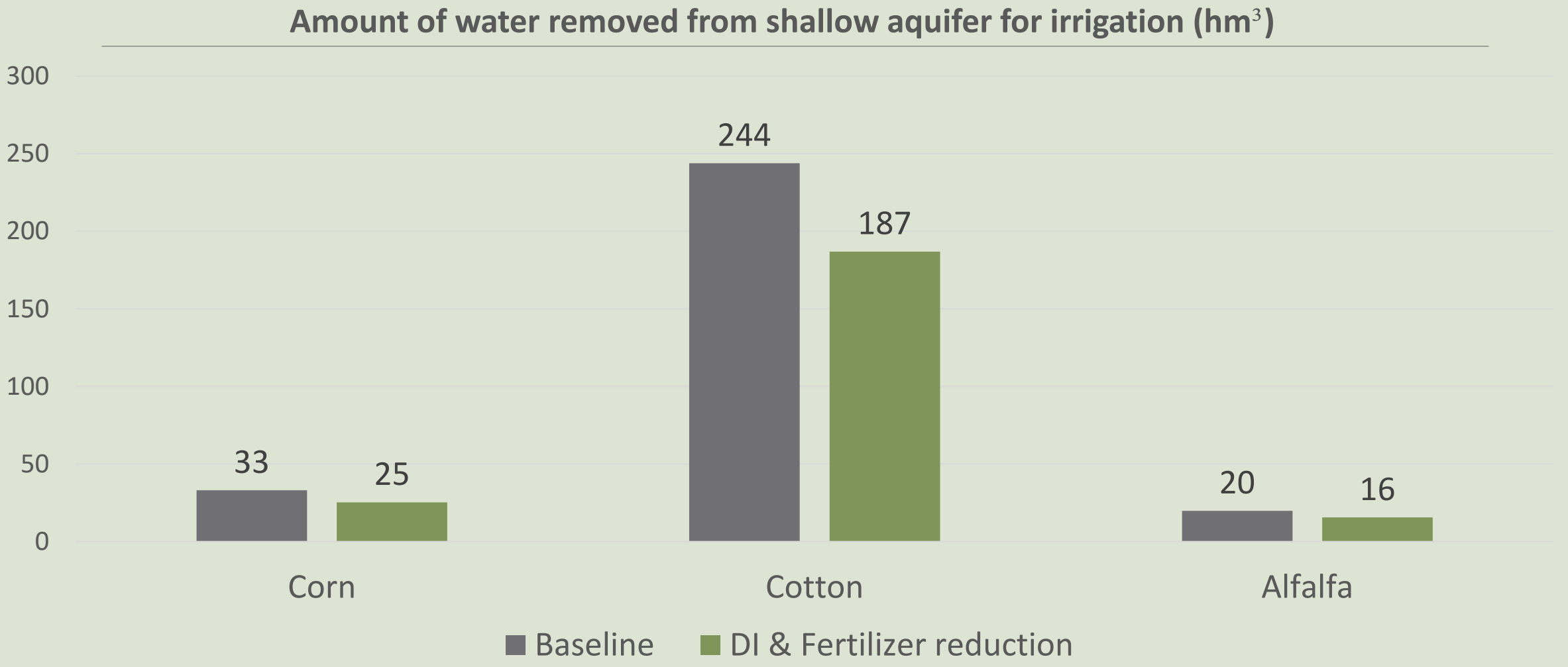
Results

Difference from baseline	
Corn	-7%
Cotton	-4%
Winter wheat	-8%
Alfalfa	-0%



Results

Amount of water saved: 21%



Conclusions

- **Fertilizer reduction** causes **14% reduction in $N - NO_3$** at the watershed level
- **Conservation tillage** causes **9% reduction in sediment yield** at the watershed level
- Implementation of **filter strips with/ without livestock reduction** leads to the **greatest** improvement of **water quality** and **reduction of sediment yield**
- The combination of **filter strips with livestock reduction does not** result in **significantly greater nutrient and sediment reductions** compared to the implementation of **filter strips alone**
- **DI & Fertilizer reduction saves 21%** of the total amount extracted from shallow aquifers and causes a **slight reduction in crop yields**

Further research…

- Improve the modeling representation of agricultural practices
- More BMPs need to be tested at the Pinios river basin related to irrigation, ploughing, livestock management and soil management
- Optimization across the landscape for the optimal BMPs
- Address the socio-economic factors

Thank you for your attention!