Estimating water pollution abatement cost functions using the Soil and Water Assessment Tool (SWAT)

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FCT Fundação para a Ciência e a Tecnologia
COMPETE
QREN Quadro de Referência Estratégico Nacional
UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional
CESAM Centre for Environmental and Marine Studies
ARH Centro Administração da Região Hidrográfica do Centro I.P.
imar
ARH Norte Administração da Região Hidrográfica do Norte I.P.
universidade de aveiro

Outline presentation

- **OBJECTIVES OF THIS STUDY**

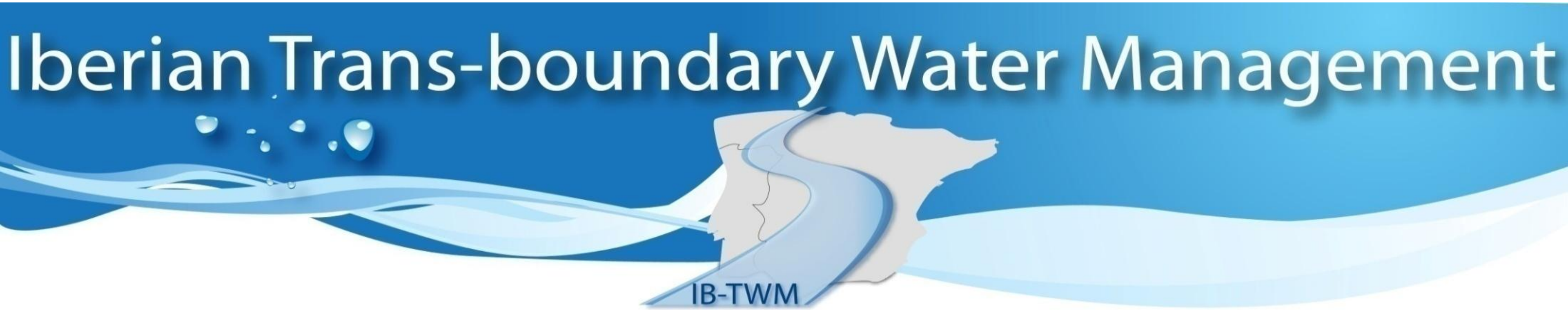
- **CASE STUDY DESCRIPTION :**
  - Vouga catchment – central Portugal;
  - Land use categories;
  - Agro-economic characteristics

- **METHODOLOGY:**
  - estimating water pollution abatement cost functions

- **RESULTS:**
  - Dissolved Inorganic Nitrogen (DIN) delivery per agricultural sector;
  - DIN delivery abatement cost functions per agricultural sector

- **CONCLUSIONS**

INTRODUCTION

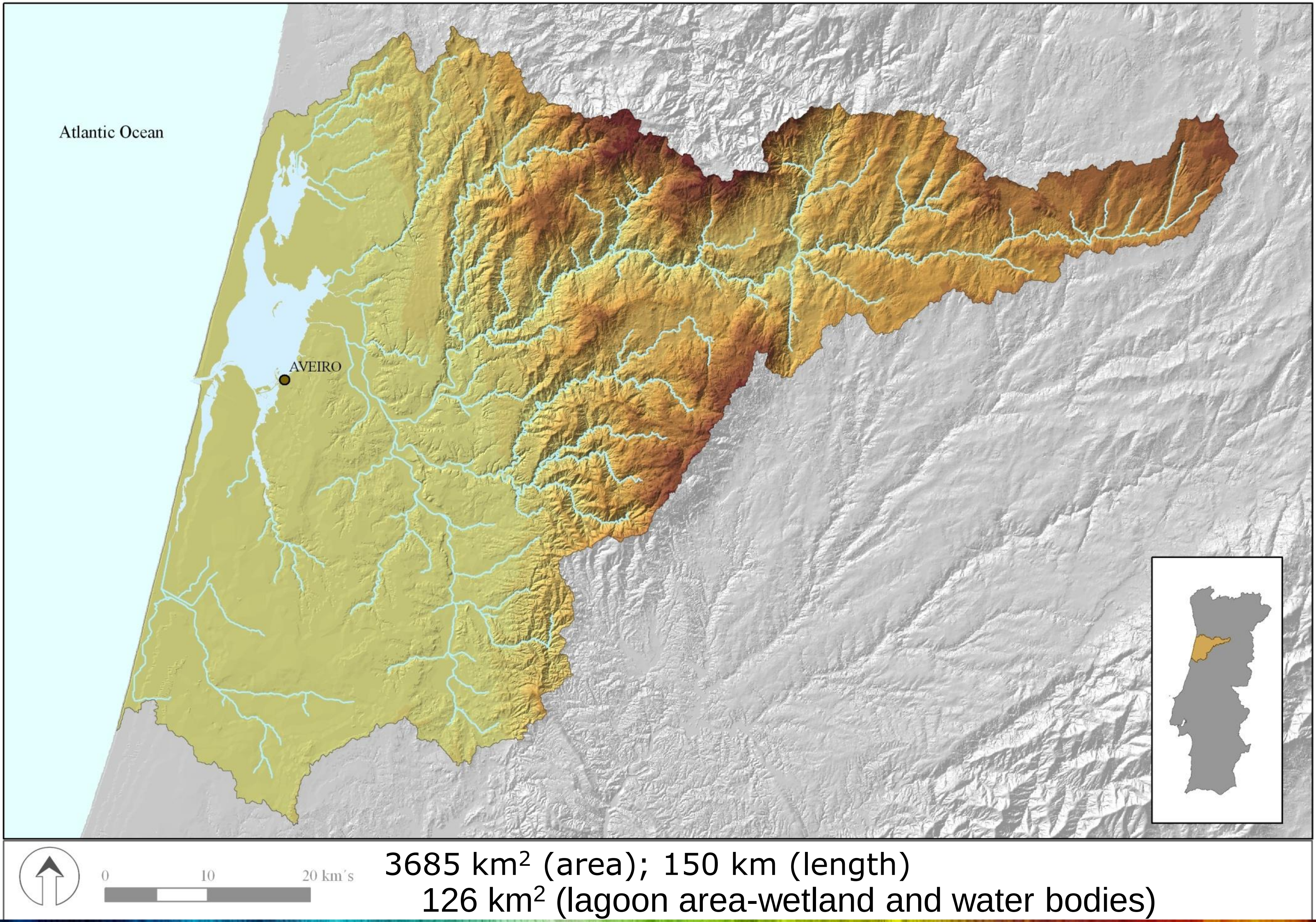


Development and application of an integrated modelling approach for efficient water quality planning and management, for the case of intra (Vouga) and trans-boundary (Minho) river basins in linked catchment and coastal ecosystems.

THIS STUDY: objectives

Determine the costs related to the adoption of Best Agricultural Practices (BAPs) for water quality improvement across agricultural sectors in the Vouga catchment using SWAT.

CASE STUDY DESCRIPTION: Vouga catchment



3685 km² (area); 150 km (length)

126 km² (lagoon area-wetland and water bodies)

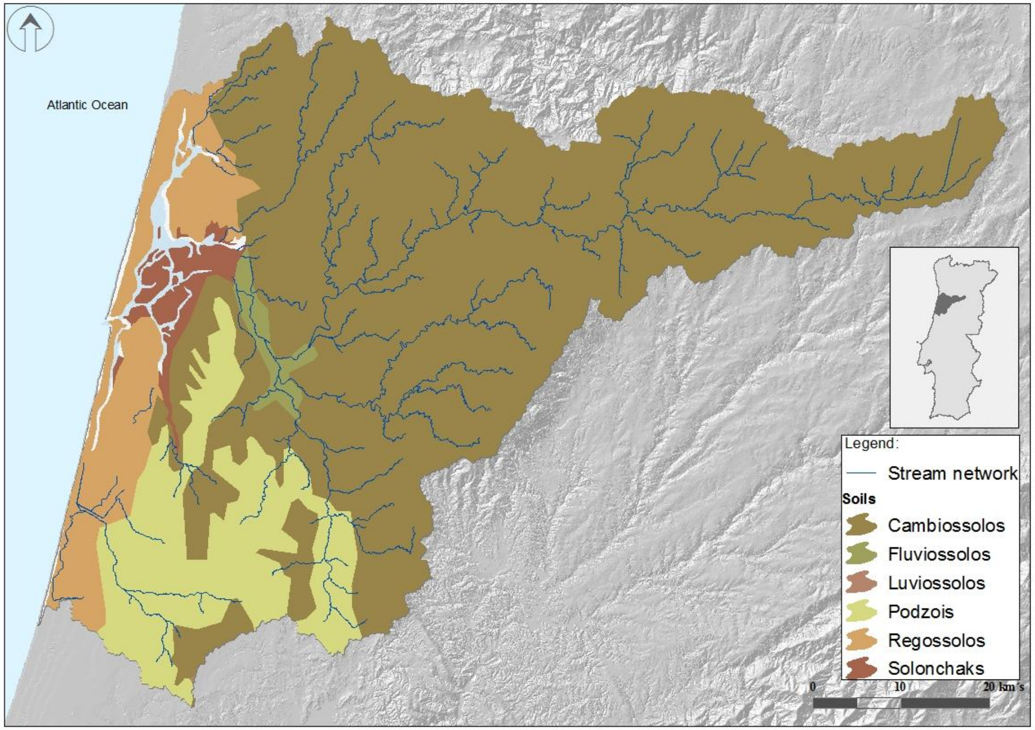
CASE STUDY DESCRIPTION: Vouga catchment

Climatological features (1941-1991)

- Annual rainfall up to 1300mm/yr (October – March: 75% of annual precipitation)
- Average daily temperature:
  - 6.9-10.2ºC (winter)
  - 20.2-21.4ºC (summer)

Soil Types (FAO 74):

4 - Cambisols
1 - Fluvisols
1 - Luvisols
1 - Podzols
1 - Regosols
1 – Solonchaks



CASE STUDY DESCRIPTION: land use categories

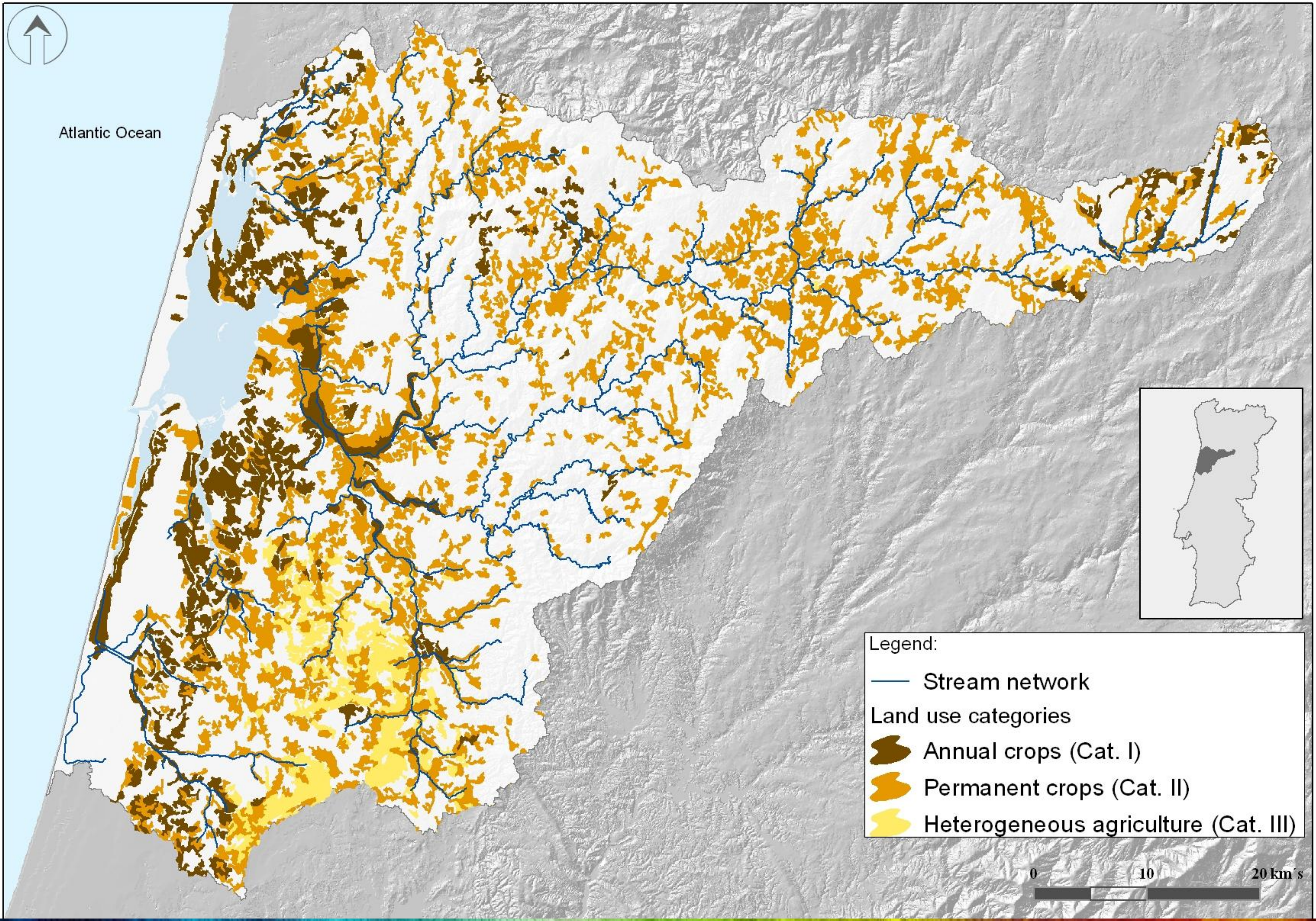
Land use class	Land use category	Area (1000ha)	Area (%)
Artificial surfaces	All	28.6	6.4
Agricultural areas:	Annual crops **(I)**	30.5	6.8
	Permanent crops **(II)**	11.5	2.6
	Heterogeneous agriculture **(III)**	69.3	15.4
	Other	3.1	0.7
Forest and natural areas	All	292.3	65.2
Wetlands	All	7.7	1.7
Waterbodies	All	5.5	1.2
Total			100

Land use areas in the Vouga catchment (CLC, 2006).

Agricultural area - 25% catchment area:

- **(I) -** 7%
- **(II)** 3%
- **(III)** 15%

CASE STUDY DESCRIPTION: land use distribution



CASE STUDY DESCRIPTION: agro-economic characteristics

Cat.	Area	N applied		Agricultural production				Agriculture income
	1000ha	kg/ha	Total t/yr	Yield kg/ha	Production t/yr	Price €/t	Value m€	m€
I	30.5	110.0	3352.7	6020	183,475.0	208.8	38.3	23.0
II	11.5	50.0	572.6	3921	44,907.0	969.2	43.5	26.1
III	69.3	85.3	5905.8	3431	237,667.0	148.5	35.3	21.2
Total	111.3		9831.1				117.1	70.3

(CLC, 2006; FAOSTAT, 2010; Portuguese Agriculture Statistics)

due to their largest production area as well as N application rates

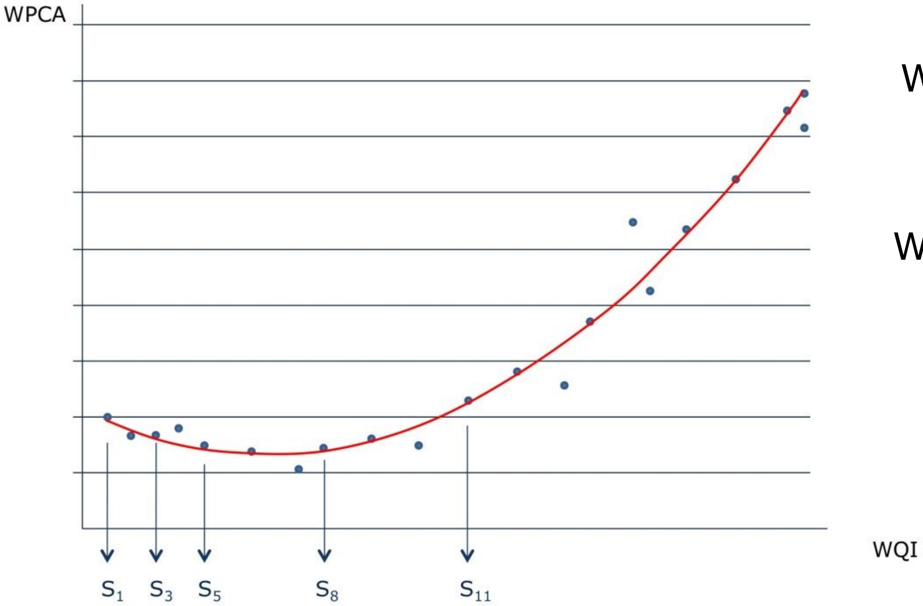
Agricultural income calculated with crop prices and taking in account that production costs represent about 40% of the total production value

Homogeneous distribution across the different categories (between 21 and 26 m€/yr).

METHODOLOGY: estimating water pollution abatement cost functions

Estimate Dissolved Inorganic Nitrogen (DIN) **water pollution abatement cost functions** for each of the agricultural land use categories.

Based on scenarios for a stepwise reduction in **N-fertilizer application** rates and corresponding (SWAT-based) estimates for **water pollution deliveries** (*D*) and **agricultural incomes** (*p*).



Water pollution abatement cost scenarios ($WPAC_{sc}$)

$$WPAC_{sc} = [p\ ]_{Baseline} - [p\ ]_{Scenario}$$

Water Quality Improvement (WQI)

$$WQI = [D]_{Baseline} - [D]_{Scenario}$$

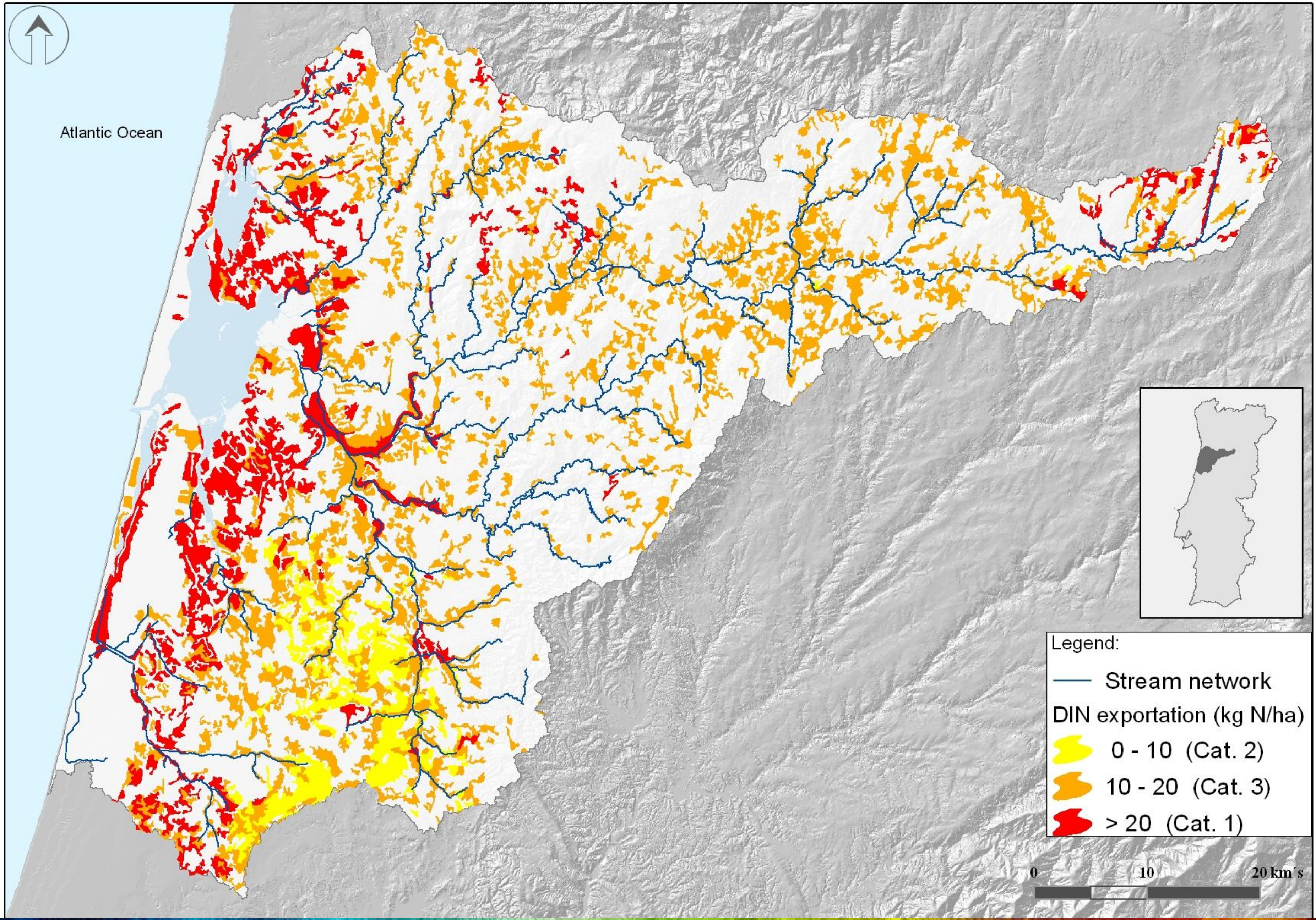
Water pollution abatement cost (WPAC) function:

$$WPAC = \alpha_1 WQI + \alpha_2 WQI^2$$

$\alpha_1 ; \alpha_2$ – SWAT estimated parameters for each category

Roebeling et al. (2009a, 2009b)

RESULTS: base run DIN delivery distribution



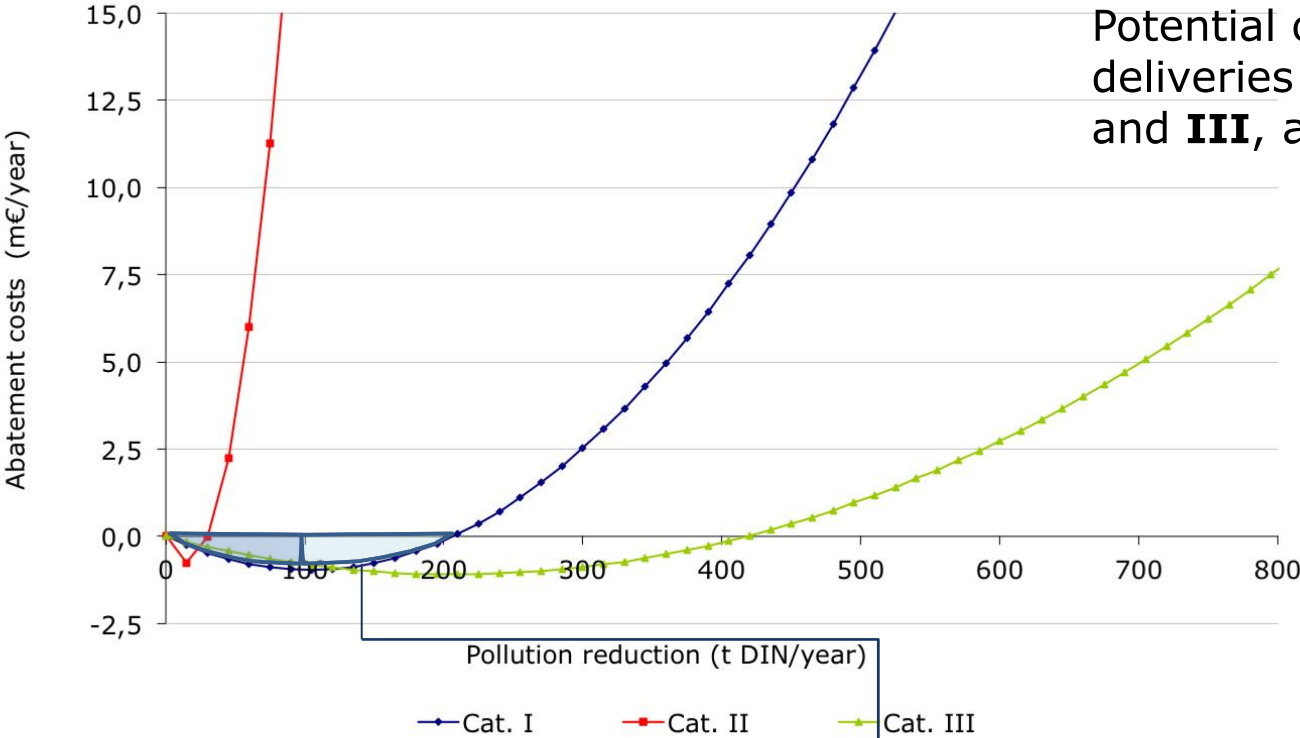
RESULTS: DIN delivery per agricultural sector

- **Category I (Annual crops)** contributes with nearly 35% (~610 tDIN/yr) to DIN delivery, represents 10% of catchment area.
- **Category II (Permanent crops)**contributes with over 5% (~105 tDIN/yr) to DIN delivery, 5% of catchment area.
- **Category III (Heterogeneous agriculture)** contributes with about 60% (~1080 tDIN/yr) represents 15% of catchment area.

↳ Total DIN delivery from the Vouga catchment is ~1800 t/yr.

RESULTS: water pollution abatement cost functions per agricultural sector

Potential opportunities to reduce DIN deliveries are **higher** in **Category I** and **III**, as compared to Category II



A decrease in DIN delivery of up to ~15% results in an increase of 5% in agricultural income for Category I → **'win-win' BAPs:**
(Ecosystems-Producers)

A decrease in DIN delivery of up to ~30% does not result in additional costs.

A decreases in DIN deliveries above these values come at a significant cost to agricultural producers in the Vouga catchment → **'win-lose' BAPs**

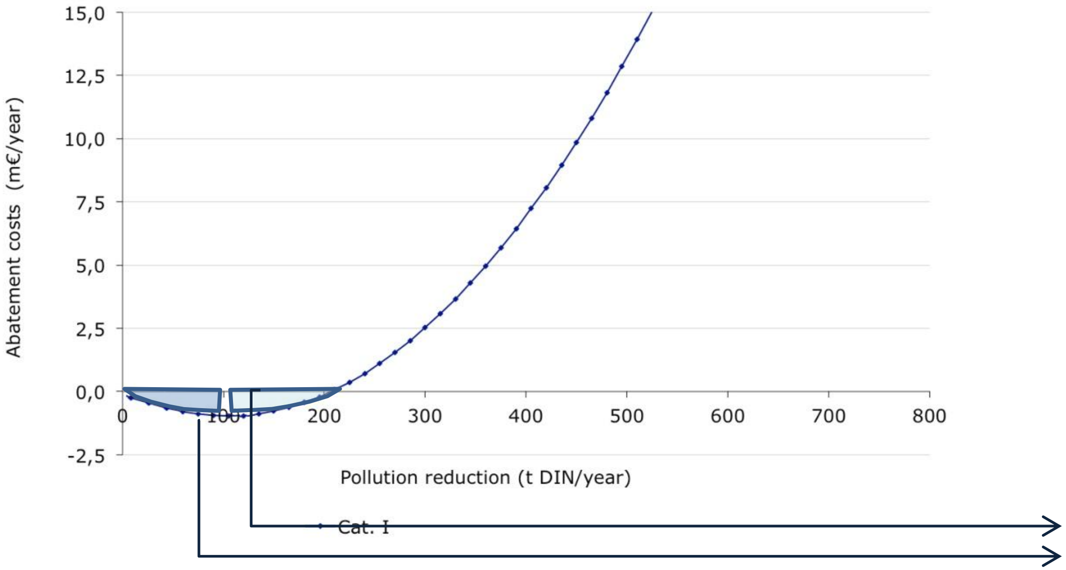
CONCLUSIONS

DIN water pollution abatement cost estimates associated with the adoption of BAPs, allow us to:

- assess the costs related to reduced N fertilizer application;
- establish the relationship between agricultural production and DIN deliveries.

SWAT will provide the framework for this study.

The model will ***run*** for 10 years (2000 to 2010), with a `warm up´ period of 4 years (starting 1996).



SWAT Optimal Scenarios for agricultural production and DIN deliveries.

Stepwise reduction in N-fertilizer application rates

CONCLUSIONS

On-Going WORK:

Data collection/preparation: hydro, climate, soils, data-base, etc.

The first SWAT stages are done ("watershed delineation", "HRU Analysis", "Write input tables", "SWAT Simulation" – ("**RUN SWAT - SWAT run successfully.")**).

Final Stages (sensitivity analysis, auto/manual-calibration, uncertainty analysis, re-run calibrated model) are to be done.

Thank you

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