# MODELING THE IMPACTS OF RELATIVE SEA LEVEL RISE ON DELTAIC RICE FIELDS

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## 1 Introduction

▪ The Ebro Delta (330 km$^2$) contains productive areas of rice fields (210 km$^2$) and wetlands (80 km$^2$). It supports biodiversity and important economic activities (*e.g.* tourism, hunting, aquaculture).

▪ Deltaic dynamics depends on the interaction between the Ebro River and the Mediterranean Sea.

▪ The Ebro Delta is currently subsiding and subject to significant erosion because of the drastic reduction in sediment inputs due to reservoir retention (*ca.* 180 dams across the basin). This is intensified by changes in land use and climate change, such as the reduction of precipitation and sea level rise (SLR).

▪ Main impacts are: coastal flooding, salt stress, shoreline retreat, wetland loss, destruction of infrastructure and crop damage, which is negatively affected by salt intrusion and elevation loss. Furthermore, as rice yield is the most important economic activity in the Ebro Delta, a significant economic and social impact is expected.

## 2 Study area

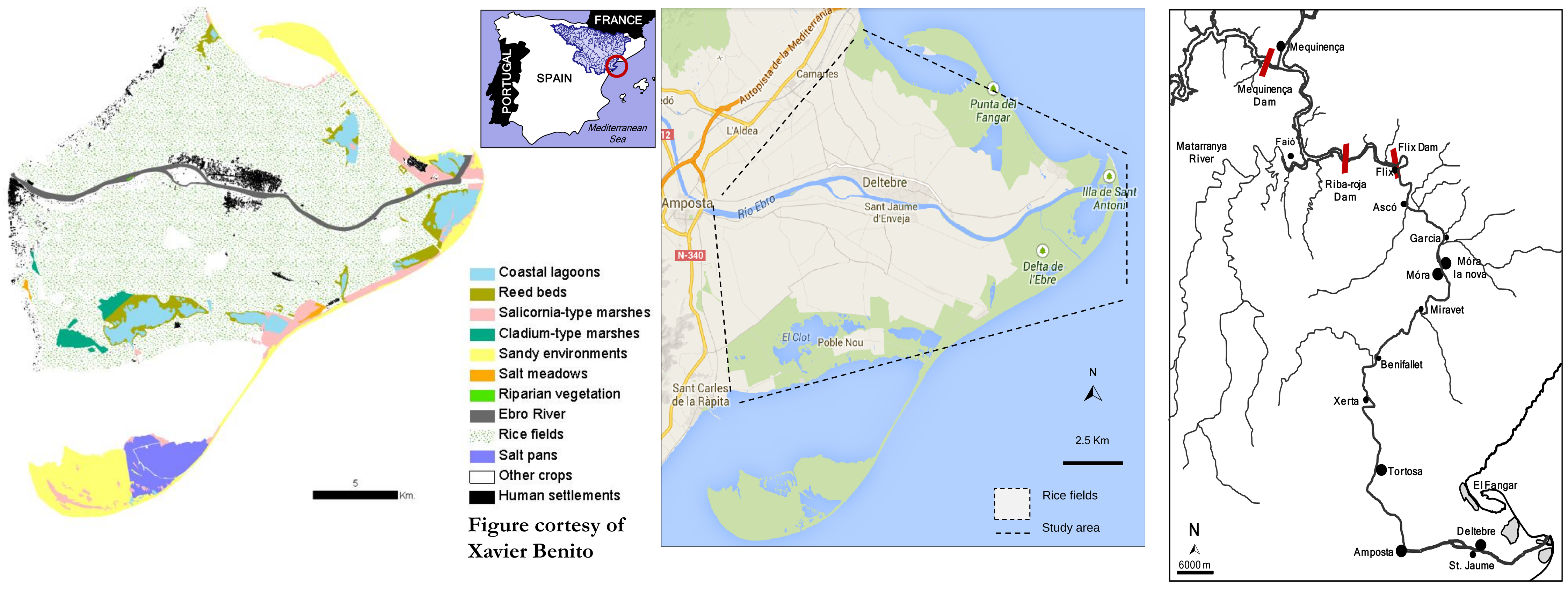


Figure 1- The Ebro Delta is located in Northeastern Spain (Northwestern Mediterranean region). Left: distribution of the main habitats. Right: the three main dams located in the lower Ebro River are marked in red colour. The Ebro River basin has an area of 85,550 km$^2$ and is 928 km long.

## Objectives

a) Modeling the impacts of RSLR on rice yield (and economic output) in the Ebro Delta due to salinization.

b) Evaluating effects of RSLR across space using geographic information systems.

c) Simulating future high-end scenarios of SLR based on IPCC data with and without adaptation measures.

## 3 Methodology

▪ Developing a soil salinity (ECe, dS m$^{-1}$) and rice yield model which couples data from Geographic Information Systems (GIS) and field data, with Generalized Linear Models (GLMz).

GIS database:
▪ Elevation (Digital Elevation Model, DEM, 1×1 m)
▪ Water bodies (*e.g* Ebro river and mouth)
▪ Soil geology, right and left hemideltas, inner edge and shoreline

Derived parameters:
▪ Distance to Ebro river mouth and old mouths
▪ Distance to inner border, nearest border and shoreline

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Field data:
▪ 1400 agricultural parcels distributed across the two hemideltas.
▪ ECe and rice yield data

Statistical tool:
▪ GLMz, multi model inference techniques

Soil salinity prediction

SLR scenarios (IPCC):
▪ RCP 4.5 (T < 2°C)
▪ RCP 8.5 (T > 2°C)
▪ Average SLR 2081-2100: 0.47 m (4.5) – 0.63 m (8.5)

Rice yield
▪ Surveys with farmers: kg Ha$^{-1}$ and rice variety

Spatial variation Ebro Delta

Table 1- Results of the GLMz analysis to estimate soil salinity (ECe).

| Variables | Coefficients | SP | Bias |
|---|---|---|---|
| Intercept | 0.60 | | 0.10 |
| Clay Presence | -0.11 | 1 | -0.02 |
| Distance to Ebro River (m) | 0.10 | 1 | -0.05 |
| Distance to Inner Border (m) | 0.05 | 1 | -0.06 |
| Distance to Old Mouth (m) | 0.003 | 0.30 | 0.07 |
| Winter flow (m$^3$ s$^{-1}$) | -0.26 | 1 | -0.01 |
| Elevation (m) | -0.60 | 1 | -0.16 |

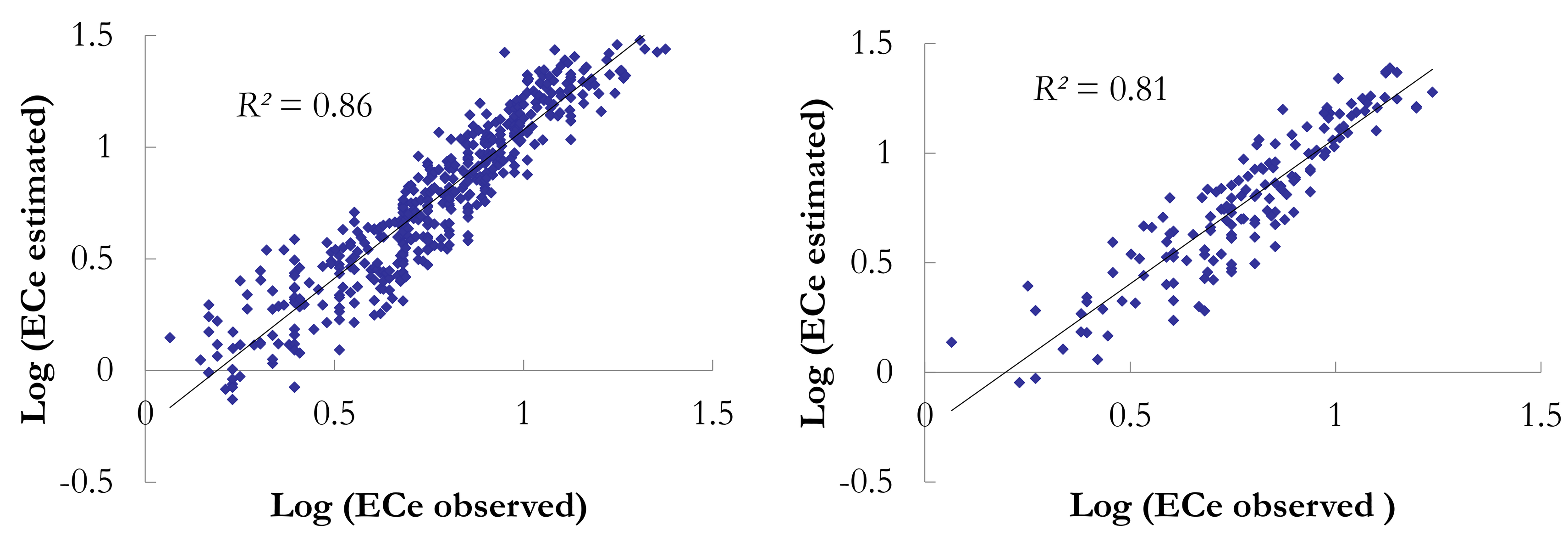
N = 2; best model showed an AICc weight of 0.70

24 variables were not selected *e.g* distance to the mouth, to the coast and sand presence

## 3.1 Model development

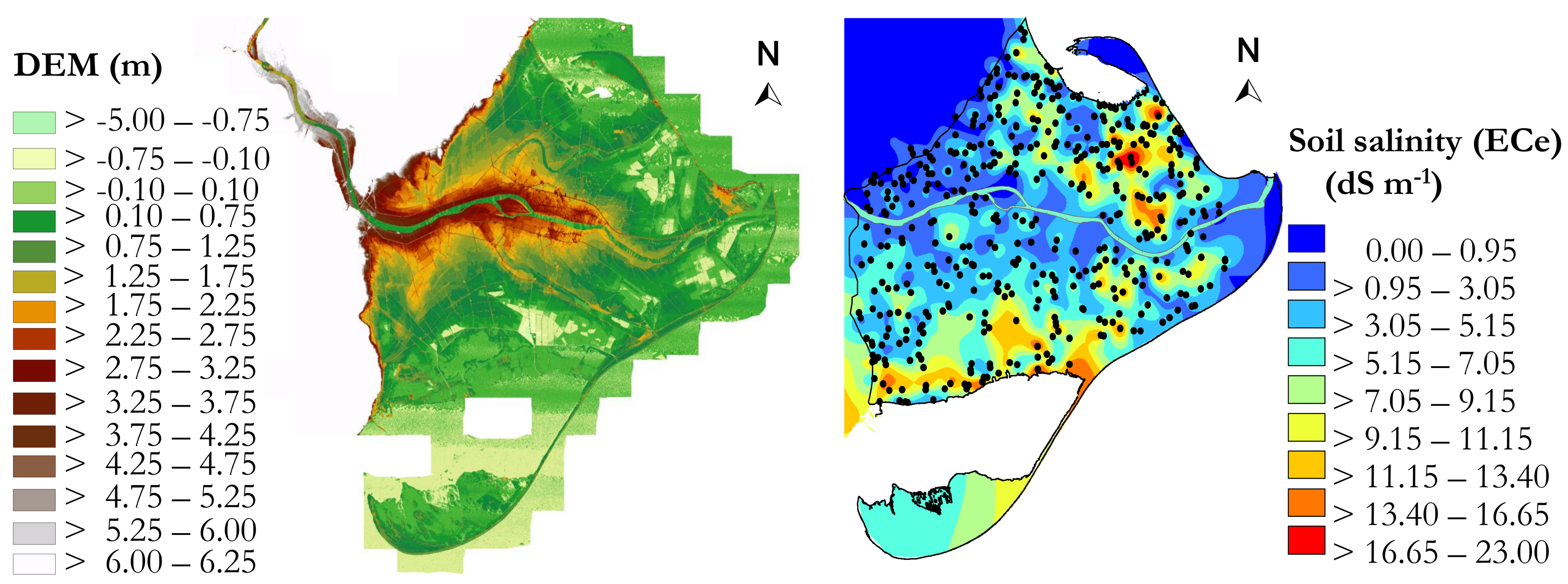
Model Estimation and Calibration

Model Validation




▪ 75 % of the data were used in the estimation and calibration process and 25 % was used to validate the model.

## 4 Results




▪ Rice fields furthest to the inner delta border have less yield; the highest yield is found in the fields located near the bank of the river.

▪ Surface elevation is highly related to soil salinity (ECe), and therefore, to rice yield (Casanova et al. 2002). ➡ $\boxed{\text{YIELD}_{max} = 1 - 0.25 \times \text{ECe}}$

▪ Under a RSLR scenario the model predicts a reduction in rice yield related to an increase in soil salinity, which will be larger in areas near the coast and lower near the Ebro River. Moreover the coastal retreat due to sediment deficit and RSLR will also affect rice yield.

▪ According to the model results a significant impact will take place in the Ebro Delta economy, that has to be dealt with adaptation measures.

▪ The model can be useful for rice farmers and decision makers in order to identify the most vulnerable areas and to quantify future impacts.

## 5 References

▪ Casanova, D., Boixadera, J., & Llop, J. (2002). Development and Applications of a Soil Geographic Database: A case study in a deltaic environment under rice cultivation. *Journal of Spatial Hydrology*, *2* (1).

## 6 Acknowledgements

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RISES-AM- EU Research Project

SEVENTH FRAMEWORK PROGRAMME