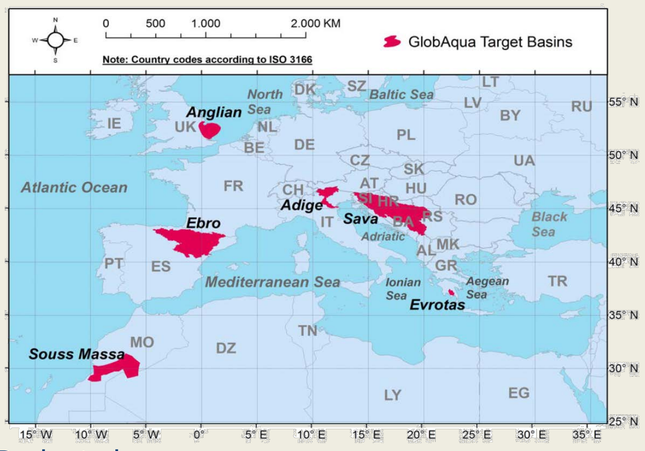
Modelling integrated scenarios of changes in climate, land use and water management for the development of anticipatory Programmes of Measures in European river basins

Verena Huber García, Ralf Ludwig
Swen Meyer, David Gampe
Department of Geography, LMU Munich

THE GLOBAQUA PROJECT

- It is a five-year EU-FP7 project that analyses the effects of multiple stressors on aquatic ecosystems under water scarcity in selected river catchments across Europe.



1. Adige – 12000 km² - IT
2. Ebro – 85550 km² - ES
3. Sava – 97713 km² - SI, HR, BA, RS
4. Evrotas – 2418 km² – GR
5. Anglian – 3188 km² - UK
6. Sous Massa – 28000 km² - MA

- Project aims:
  1. To understand the mechanisms of multiple stressors, their interactions with present species and their effects on the functioning, stability and resilience of aquatic ecosystems.
  2. Improve current water management practices and policies and adapt them to future conditions by taking into consideration the influence of multiple stressors. This is carried out by means of scenario analyses.

SCENARIO DEFINITION

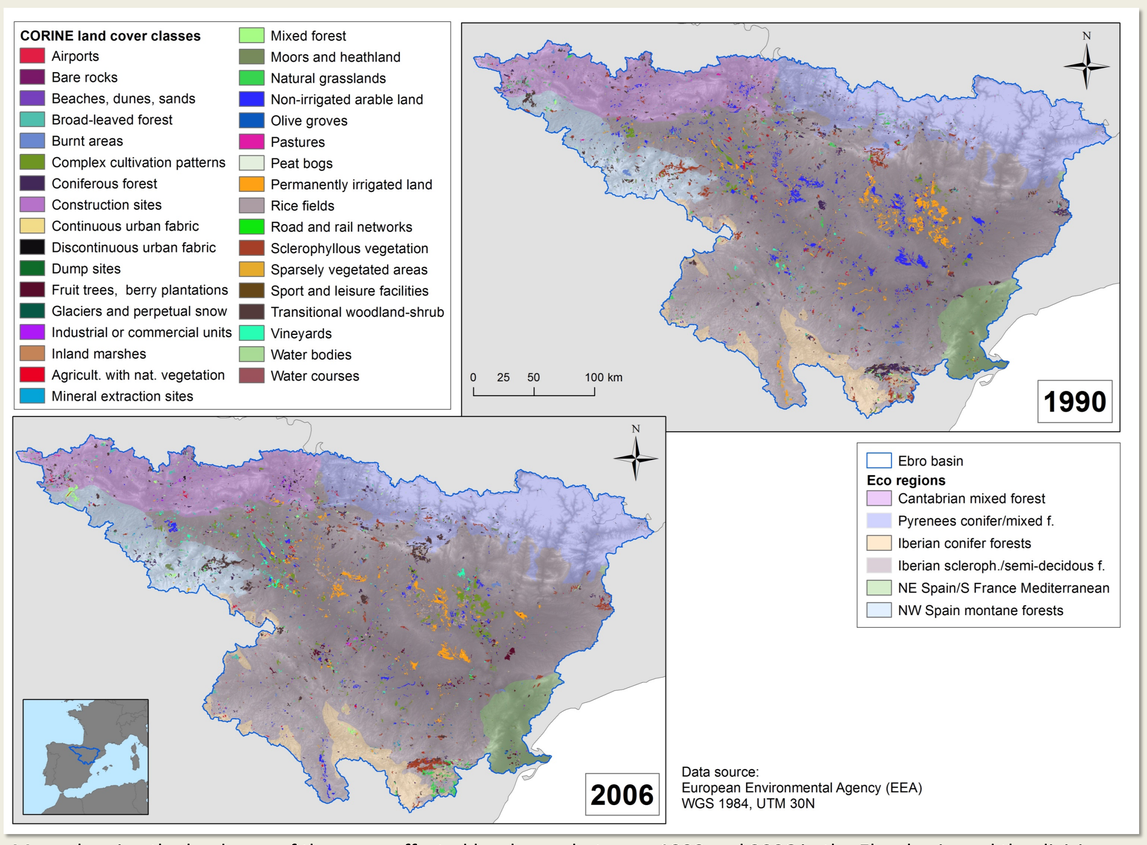
- A modelling framework is set up to develop integrated scenarios of changes in land use, climate and water management.
- The scenarios are based on the new Representative Concentration Pathways (RCPs) and Shared Socio-economic Pathways (SSPs). Four scenarios have been defined for GLOBAQUA:

	Myopic ★ SSP 5: (Mit. Challenges Dominate) Fossil-fueled Development RCP 8.5	Sustainable ★ SSP 1: (Low Challenges) Sustainability RCP 4.5	Inequality ★ SSP 4: (Adapt. Challenges Dominate) Inequality RCP 4.5	Middle of the road ★ SSP 2: (Intermediate Challenges) Middle of the Road RCP 4.5
Population growth	-	-	+	+
Irrigated surface area	++	--	++	0
Protected areas	0	+++	--	+

- Factors describing the scenarios are evaluated and adapted to the regional scale in stakeholder workshops and by expert knowledge.
- The scenarios are modelled in a spatially distributed manner for each study site.
- The model outcomes set the boundary conditions for all subsequent hydrological and water quality modelling activities.
- Programmes of Measures are developed and tested for efficiency within the modelling framework.

ANALYSIS of PAST LAND USE/COVER CHANGES (LUCC)

- LUCC is considered to be a major stressor on water quantity, water quality and aquatic ecosystems.
- LUCC detection analyses were carried out for all case studies based on CORINE Land Cover data to understand changes that have happened in the past. Results for the Ebro basin, located in NE Spain, are shown below.



Data source:
European Environmental Agency (EEA)
WGS 1984, UTM 30N

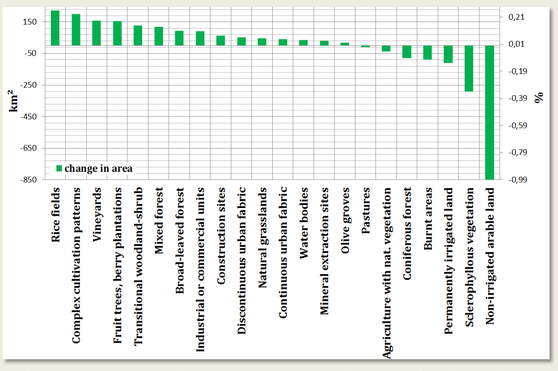
Maps showing the land uses of the areas affected by change between 1990 and 2006 in the Ebro basin and the division of the case study in ecological regions.

Ecoregion: Iberian scleroph./semi-decidous forest
Total area: 51355 km²

Land cover classes 1990	Changed area [km²] in 1990	Land cover classes 2006: Permanently irrigated land	Complex cultivation patterns	Sclerophyllous vegetation	Non-irrigated arable land	Trans. woodland-shrub, heath	Vineyards	Rice fields	Fruit trees and berry plantations	Natural grasslands	Coniferous forest	Agricult. with nat. vegetation	Mine, dump and construction sites	Industr., com., transp. units	Urban fabric	Broad-leaved forest	Open spaces with little or no veg.	Mixed forest	Water	Olive groves
changed area [km²] in 2006		755.4	603.9	456.7	439.8	369.6	230.4	222.4	169.2	130.9	106.9	91.1	90.4	74.8	62.8	54.4	54.1	34.6	25.3	20.3
Non-irrigated arable land	1183.4	658.2	133.3	20.1	0.0	7.2	96.0	60.6	81.3	4.6	1.8	27.9	34.8	26.2	12.4	1.8	1.8	0.4	9.4	5.1
Permanently irrigated land	874.4	0.0	391.0	1.0	199.3	0.3	29.9	156.1	26.0	0.1	0.6	6.9	11.9	19.3	18.6	7.8	0.4	0.1	2.6	1.3
Sclerophyllous vegetation	459.5	5.9	7.2	0.0	24.3	218.0	1.7	0.5	3.9	89.0	31.7	26.3	19.1	4.2	2.8	8.3	11.5	3.3	1.4	0.4
Complex cultivation patterns	393.1	48.4	0.0	10.3	148.9	2.3	86.6	0.7	40.6	5.4	1.1	15.3	2.9	8.3	9.9	1.1	0.9	0.0	0.8	8.8
Coniferous forest	284.8	0.6	1.3	153.2	2.9	85.5	0.1	0.0	0.2	8.6	0.0	1.7	1.4	0.1	0.4	0.8	13.3	12.7	1.4	0.6
Trans. woodland-shrub, heath	259.6	0.4	0.4	137.3	3.8	0.0	0.3	0.1	0.3	14.4	57.9	3.4	1.4	0.1	0.0	17.8	10.4	10.9	0.7	0.3
Agricult. with nat. vegetation	139.1	26.9	6.4	35.6	18.4	2.8	11.0	3.6	5.2	2.7	1.8	0.0	8.9	6.0	2.8	0.4	3.7	0.0	1.5	1.1
Vineyards	82.6	2.6	46.5	0.6	16.8	0.0	0.0	0.0	10.6	0.0	0.0	1.3	1.5	1.8	0.8	0.1	0.1	0.0	0.2	0.0
Open spaces with little or no veg.	75.3	0.4	0.2	39.4	2.6	23.9	0.0	0.1	0.1	0.0	0.3	1.3	2.3	0.6	0.1	0.8	0.0	0.0	2.9	0.2
Natural grasslands	71.4	1.3	0.6	26.6	10.0	8.1	1.4	0.3	0.0	0.0	2.4	4.2	1.6	1.6	0.3	10.5	1.4	1.4	0.0	0.0
Broad-leaved forest	63.4	2.6	0.6	14.5	2.6	15.6	1.8	0.4	0.2	4.6	0.8	0.5	1.8	0.7	0.5	0.0	6.6	5.9	3.4	0.0
Mixed forest	38.4	0.1	0.0	16.1	1.2	5.8	0.0	0.0	0.0	0.6	8.4	0.4	0.1	0.0	0.0	4.0	1.3	0.0	0.6	0.0
Fruit trees and berry plantations	33.6	4.6	10.8	1.1	4.5	0.1	0.6	0.0	0.0	0.5	0.1	0.1	1.8	1.4	4.8	0.0	0.6	0.0	0.1	2.6
Mine, dump and construction sites	11.4	0.0	0.0	0.5	1.6	0.0	0.0	0.0	0.3	0.0	0.0	1.8	0.0	2.1	3.0	0.0	1.9	0.0	0.2	0.0

Results of the change detection analysis (in km²) in the inner Ebro basin, one of the ecological subregions.

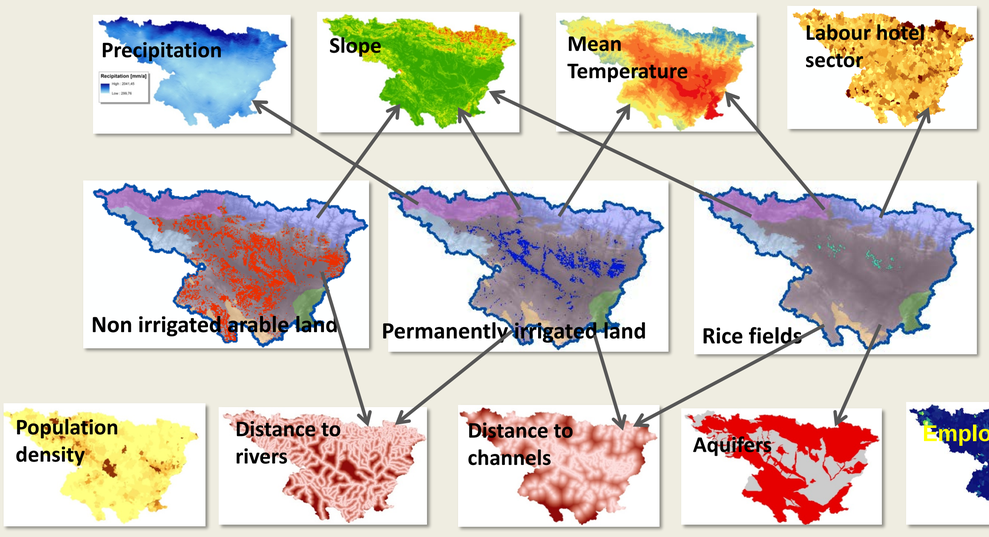
- There has been a notable expansion of water intensive land uses in the last decades, located mainly in the inner Ebro lowlands and coastal areas.
- The abandonment of agricultural land and the associated reforestation trend that started in the 1960s is still taking place in marginal regions.
- Urbanisation has been happening around bigger cities and along the coast, increasing the water demand in these areas.



Changes in area between 1990 and 2006 of selected land use classes in the Ebro basin.

DETERMINATION of DRIVERS of CHANGE

- To investigate the drivers of changes in land and water use a wide range of possible driving factors including bio-physical as well as socio-economic variables were taken into account.
- Due to their great extent and heterogeneity, some of the study sites, e. g. the Ebro, were subdivided into ecological regions according to the European Environmental Agency (EEA) to form more homogenous units.

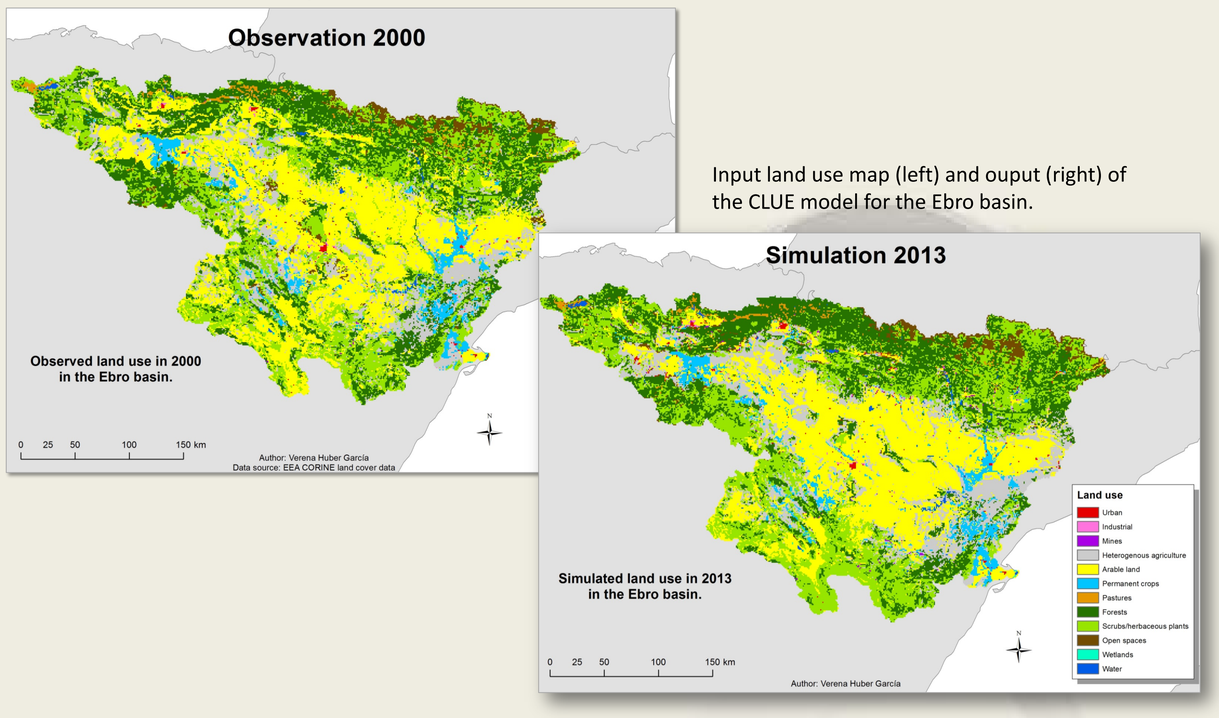


Schematic illustration of the relations between drivers and 3 land use classes in the inner Ebro basin.

- The determination and ranking of drivers was carried out applying a multiple logistic regression analysis to the spatial distribution of each land use/cover.
- The example shows which are the important drivers for 3 selected land uses in the inner Ebro basin.

MODELLING LAND USE CHANGE

- The land use change model CLUE (Conversion of Land Use and its Effects, Verburg & Overmars, 2009) has been set up to model a first baseline scenario for the Ebro basin. A new CLUE version is currently tested in collaboration with ALTERRA and the University of Wageningen.
- The results of the multiple logistic regression analysis and the description of the scenarios serve as inputs to the model.



Input land use map (left) and ouput (right) of the CLUE model for the Ebro basin.