Challenges in cost-effectiveness analysis when comparing mitigation measures

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AGRICULTURES & TERRITOIRES
CHAMBRE D'AGRICULTURE POITOU-CHARENTES

AGENCE DE L'EAU ADOUR-GARONNE
ETABLISSEMENT PUBLIC DU MINISTERE DU DEVELOPPEMENT DURABLE

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Overview

Why using Cost-Effectiveness Analysis

- Appropriate spatial and temporal scales
- How to deal with spatial heterogeneity ?

Bioeconomic modelling of farming activities

- Linkages with the SWAT model
- Data
- How costs are calculated
  - Dual values in Bioeconomic modelling
  - Comparaison of Agricultural Gross Margins between scenarios

Comparing Costs with Effectiveness

- CEA ratios
- Mapping of results and ratios

Case studies

Devising environmental mitigation programmes: … a complicated exercise

Varying spatial and temporal scales

- Characteristics of agricultural production

  Soil types, slopes, farming systems, proximity to streams...

- Stochastic climatic events within the implementation period of measures

  Rainfalls, temperature, infection pressure,.. affecting yields

- Fluctuation of market commodities prices + changes of EU subsidies

  Changes of practices and crops at risk

  ➡ Compensation of profit losses (if any) when implementing measures variable

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Why Cost-effectiveness analysis ?

CE analysis useful in comparing mitigation measures

- Provides a rationale for decisions to be taken
  - at the level of agricultural areas for drinking water abstraction
  - at the river basin level

- Costs and Effectiveness should be compared on a common spatial and temporal scale
  - Basin, sub basin and watershed levels (most relevant scales)
  - Hydrological simulation period (scale used for quantifying)

Water and pesticide flows and concentration at the outlets

Total costs

Costs versus Effectiveness

Effectiveness of measures assessed

- for medium-term goals by the use of indicators (pressure, practices intensity or risk of transfer)
- for final goals (impacts) where models are required

Discounted costs

Single useful quantitative indicators for selecting measures

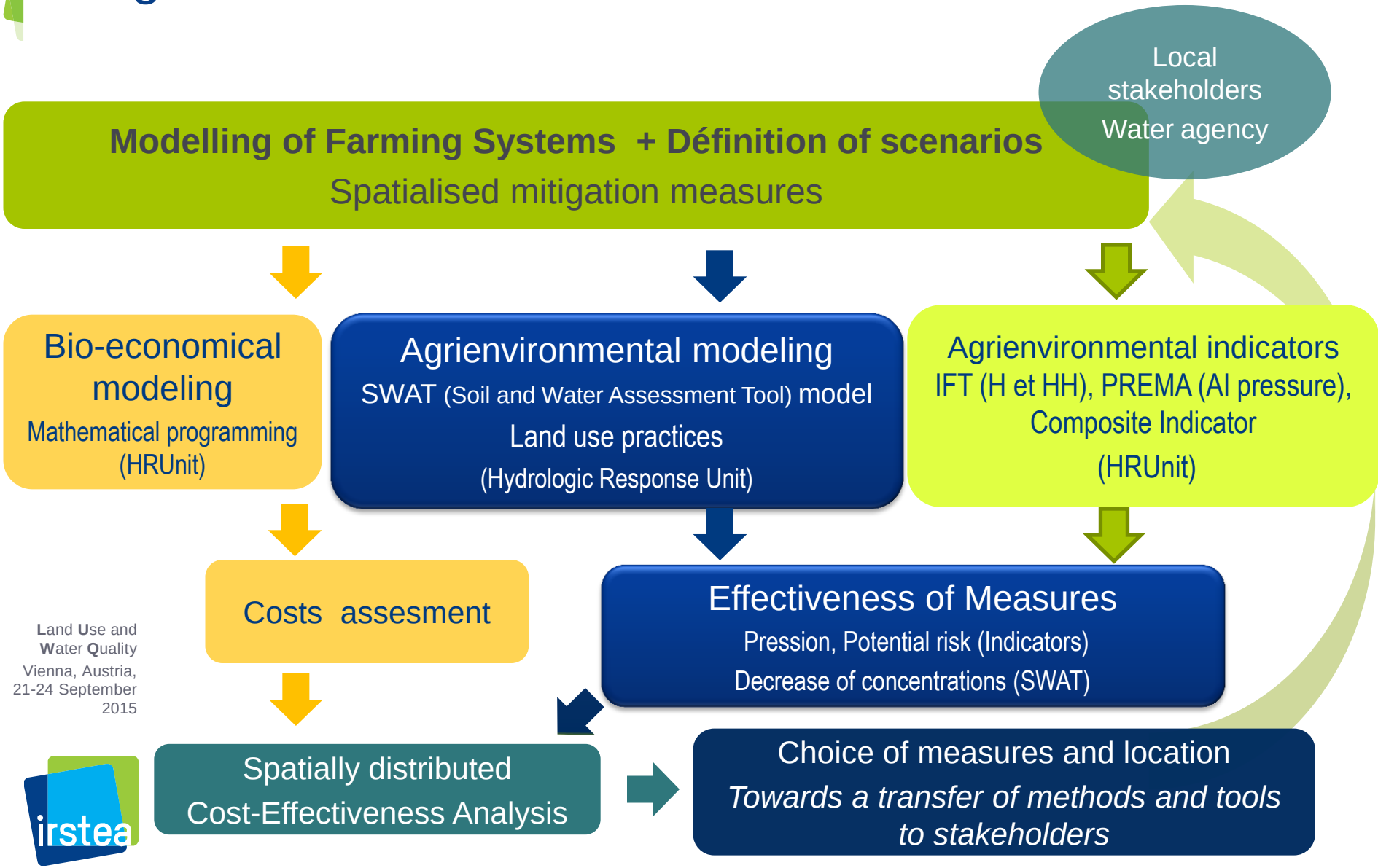
$$\frac{Discounted\ sum\ of\ annual\ costs\ (€)}{Concentration\ reduction\ (\mu g.l^{-1})\ or\ indicator\ values}$$

can be calculated at different scales within a river basin.

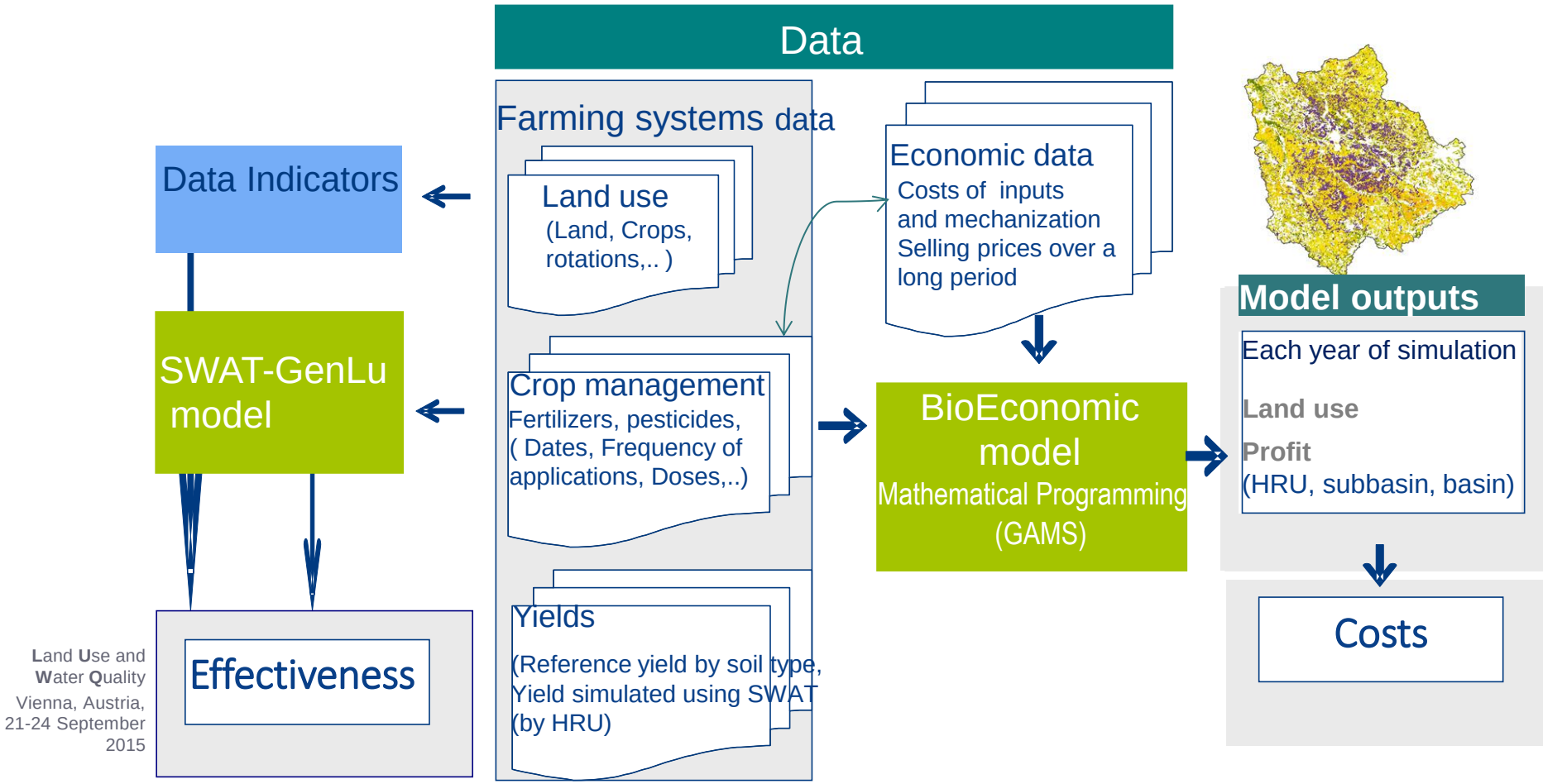
Sensitivity analysis needed

Ratios to be handled carefully, because of the deterministic approach

Integrated Assessment Framework



Linking economic modelling with SWAT model (data)



Bio-economic modelling

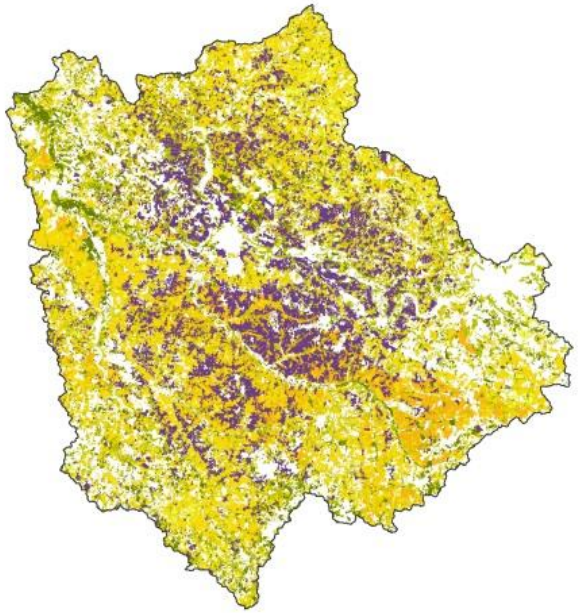
Farming systems heterogeneity is addressed by using bio-economic modelling to appraise marginal and total costs of implementing measures.

Data availability

Model “representative” (average) farms and/or “type” (modal) farms.

Geographical information on farm plots and management practices is lost.

We overcome these problems by calculating costs at the Hydrological Response Unit : hydrological units level used by the SWAT model (soils/landuse/practices)



Bio-economic modelling

Alternative form of aggregation

combines farm plots in each spatial unit together, treating them as a single entity

ensuring consistency with the environmental modelling

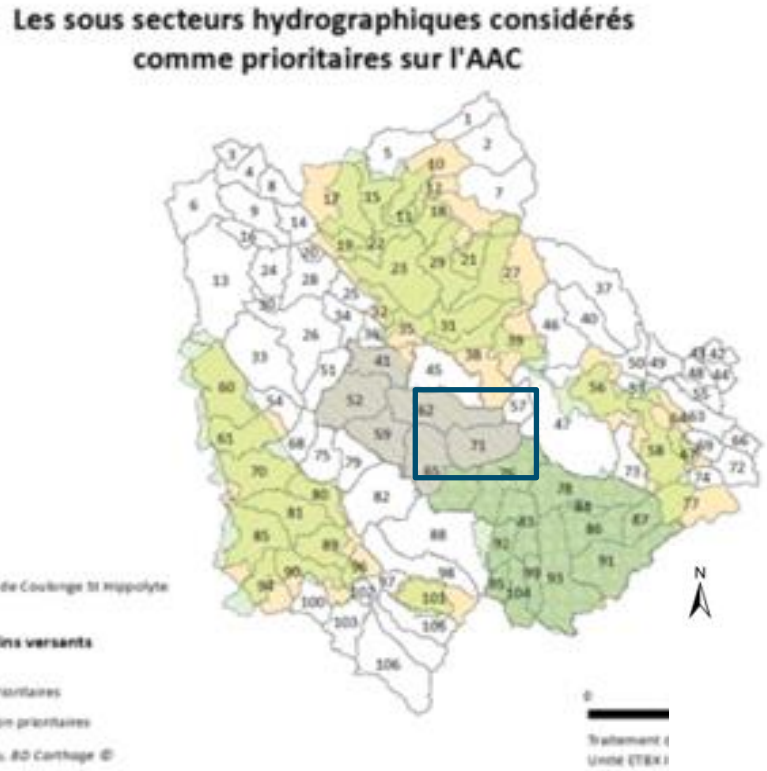
- Each HRU: a single entity with a crops sequence+practices

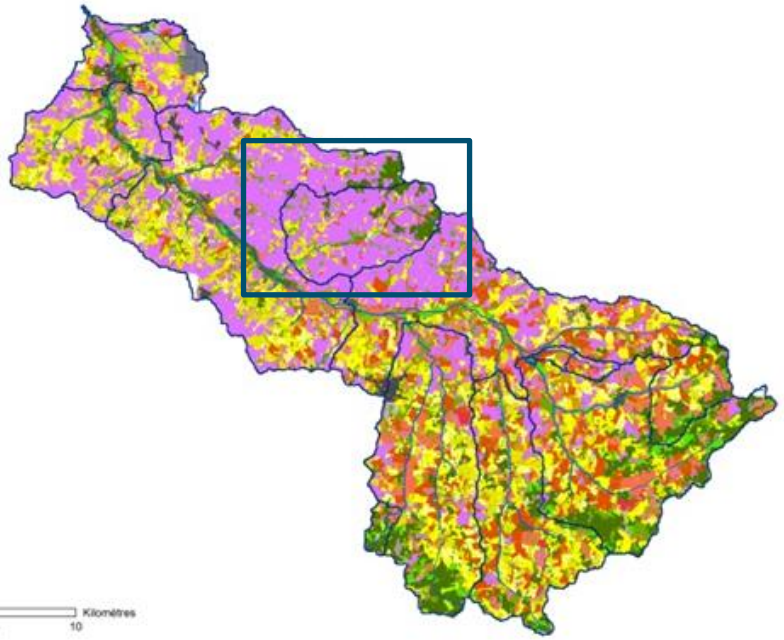
Linear input/output analysis

- Leontief production functions: description of the production possibility set within a HRU.
- For each output, number of techniques (crops and practices with and without measures) in competition,
- Subject to constraints from the availability of inputs and/or attached to measures

Each combination of constraint levels and production techniques results in a single solution.

HRU: common calculation unit (SWAT-Bio-economical models)





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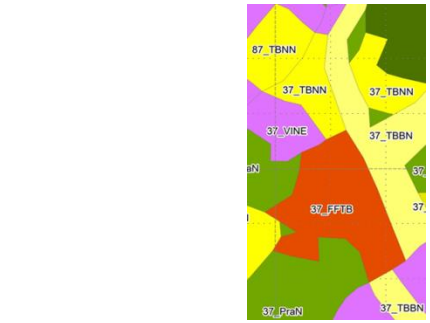

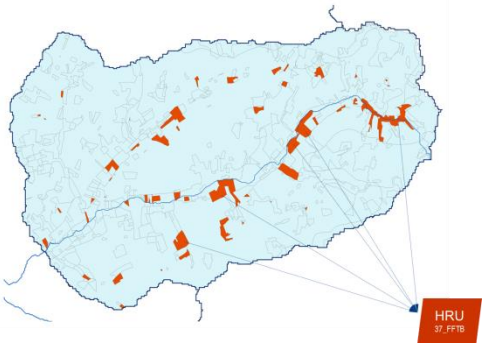

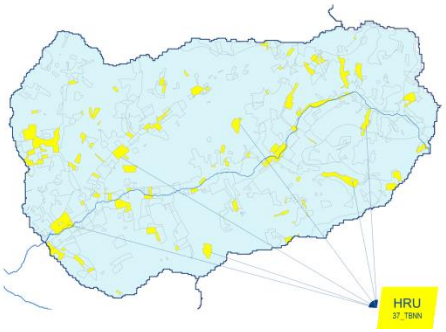

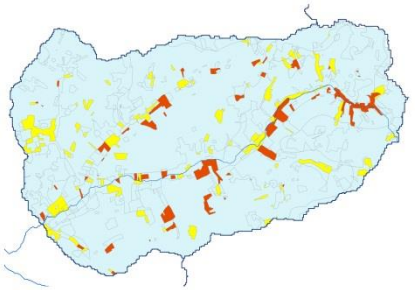

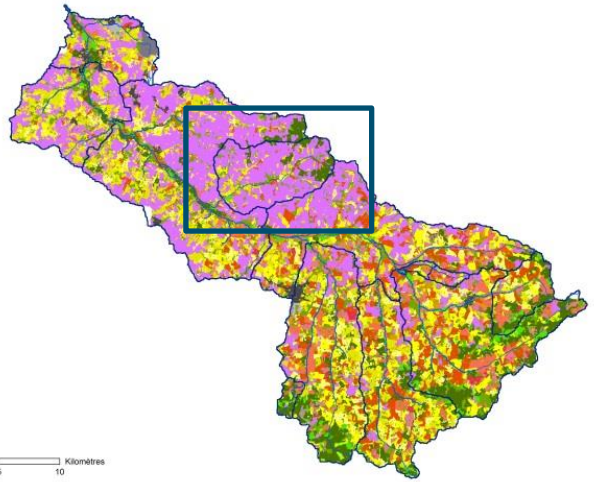

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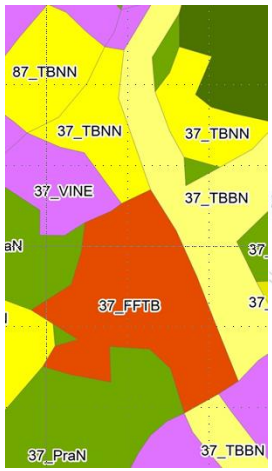

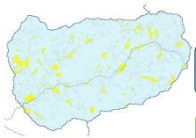

Rotation 87_TBNN

Crop T	Crop B
ITK T std	ITK B std

Rotation 37_TBNN

Crop T	Crop B
ITK T std	ITK B std

Rotation 37_FFTB

Crop F	Crop F	Crop T	Crop B
ITK F1 std	ITK F2 std	ITK T std	ITK B std

Average Variable Costs of practices by crop

Yields by crop and HRU (SWAT) / soil type

Gross Margin $_{hru,\ scenario}$

Expected GM $_{hru,\ scenario}$

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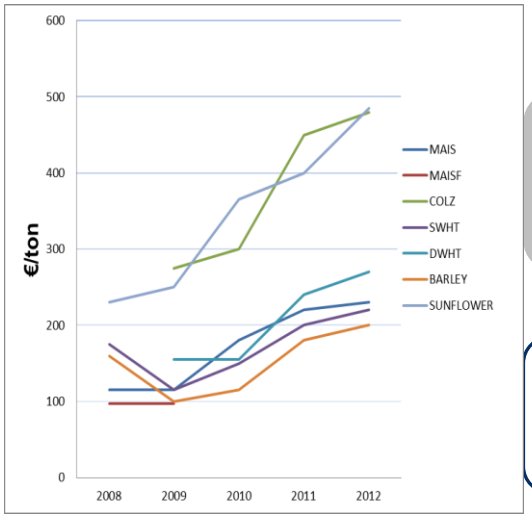


Random market prices

Variance of Gross Margin

$$Expected\ Utility = Expected\ GM - 1/2\,\beta V(GM)$$

Method for calculating costs of scenarios

MAXIMISE

$E(GM)_{HRU,\ scenario\ 0}$ + $E(GM)_{HRU,\ scenario1}$ + $Incentive_{\ scenario1}$

$$\left[inc_{Sx} \times X_{Sx,hru} - C_{Sx,hru}(X_{Sx,hru}) \right]$$

Marginal costs of the measure C'

Optimal area with measure(s) X^*

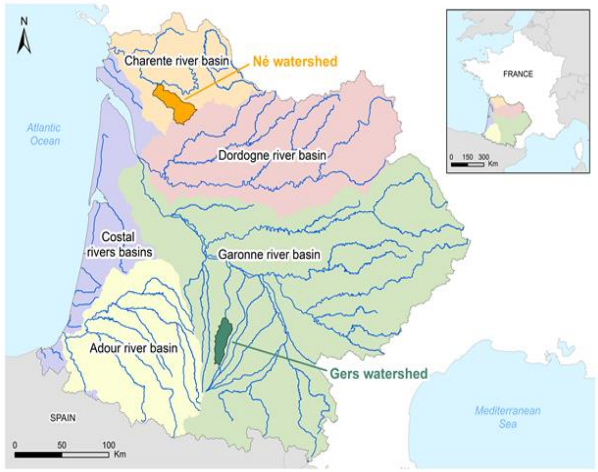
$$\frac{\partial\left(inc_{Sx} \times X_{Sx,hru} - C_{2,hru}(X_{Sx,hru})\right)}{\partial X_{Sx,hru}} = \left[-C'_{Sx,hru}(X^*_{Sx,hru}) + inc_{Sx} \right] = 0$$

Integrating marginal costs by HRU, by sub basin

TOTAL COST of the measure(s) for sub-basin and river basin

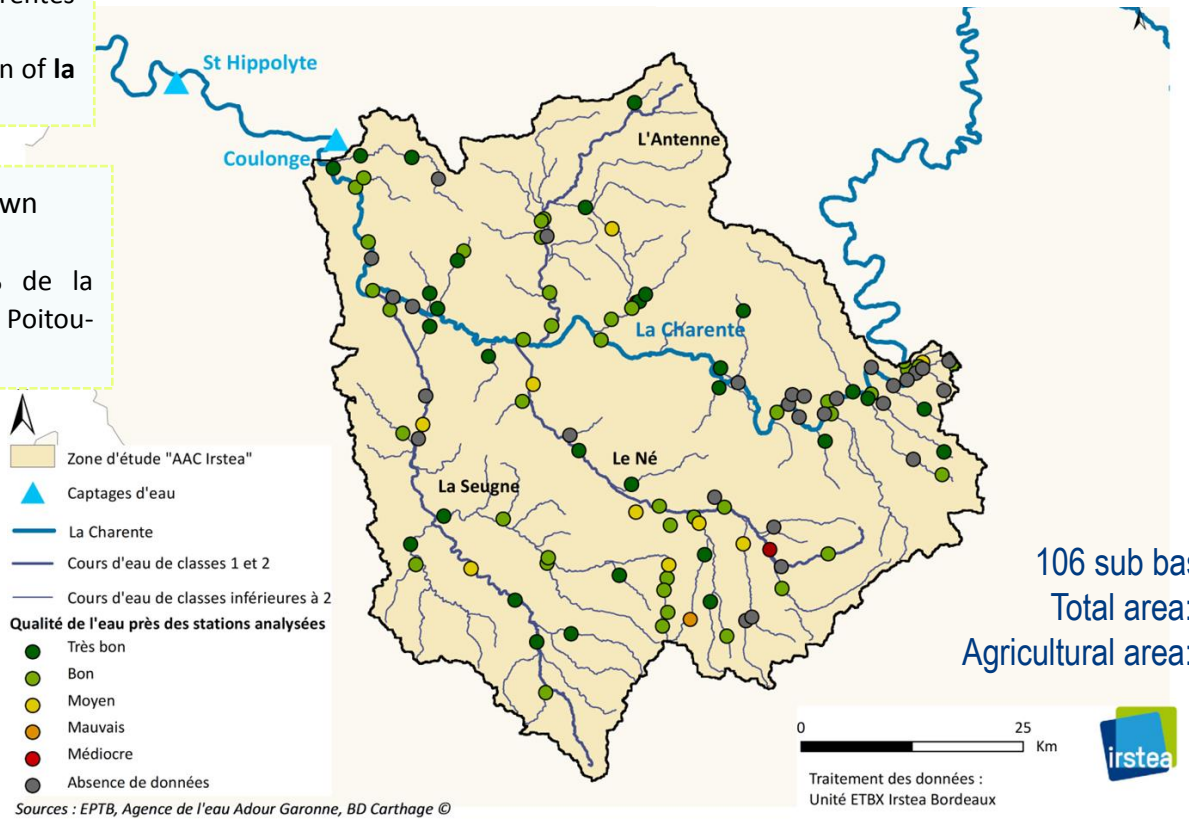
Case Studies

Agricultural catchments for abstraction of drinking water within the Garonne river basin
- Côteaux de Gascogne (Upper stream of the Gers rivers)
- Charente river Basin (sub basins and catchment areas)



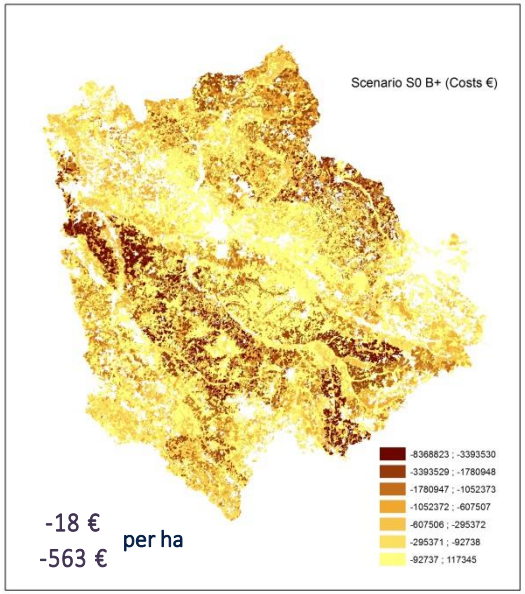
COULONGE : withdrawn
5-6 millions m^3 /year
90 000 people (5 % of the population of Poitou-Charentes region in 2013)
Water supply for the town of **la Rochelle**

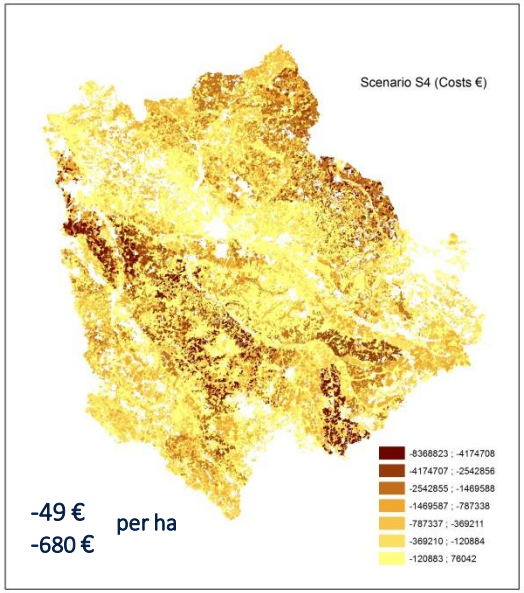
ST HIPPOLYTE : withdrawn
6,6 millions* m^3 /year
200 000 people 11 % de la population of the Poitou-Charentes region)



106 sub basins (SWAT)
Total area: 367 000 ha
Agricultural area: 260 000 ha

Discounted costs for the simulation period

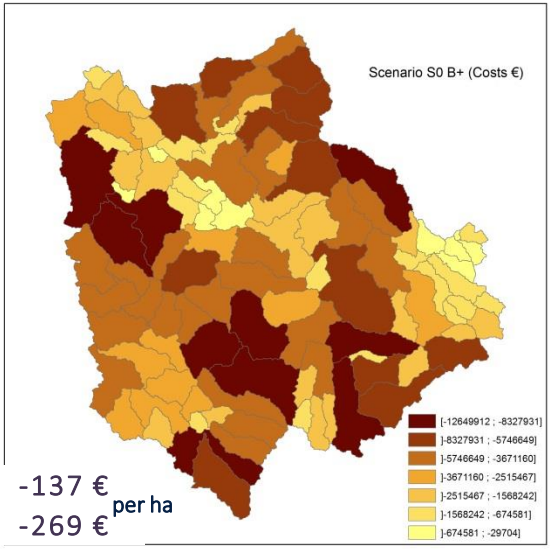


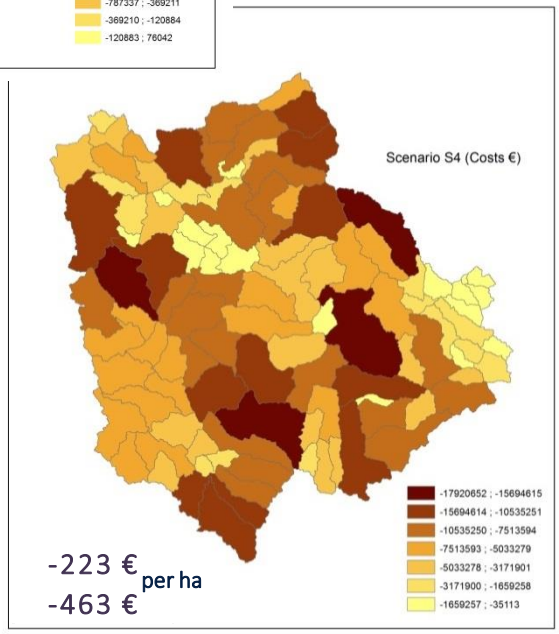


Costs calculated with reference to the baseline scenario

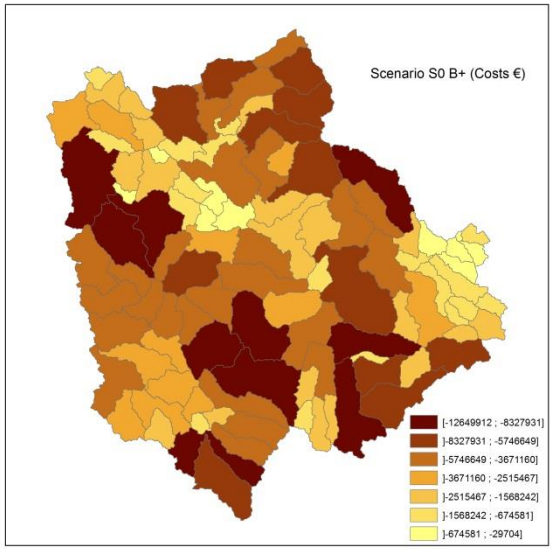
HRU

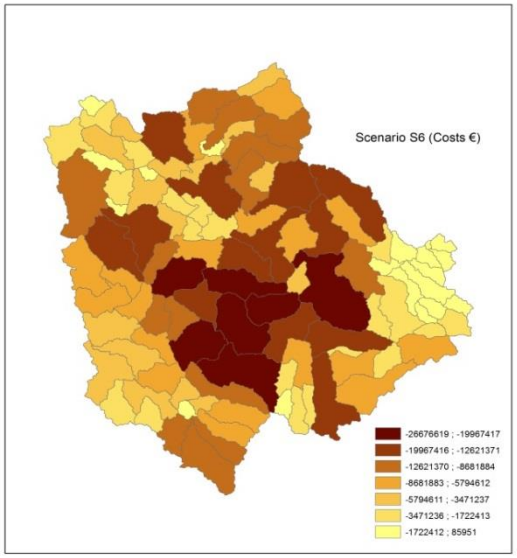
SubBasin

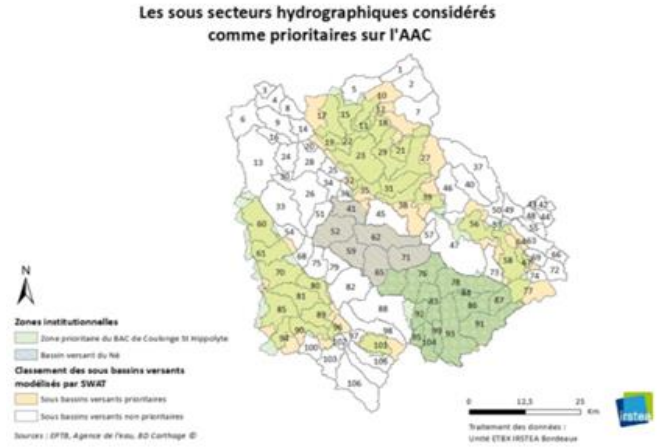




Comparison of costs at the sub-basin level







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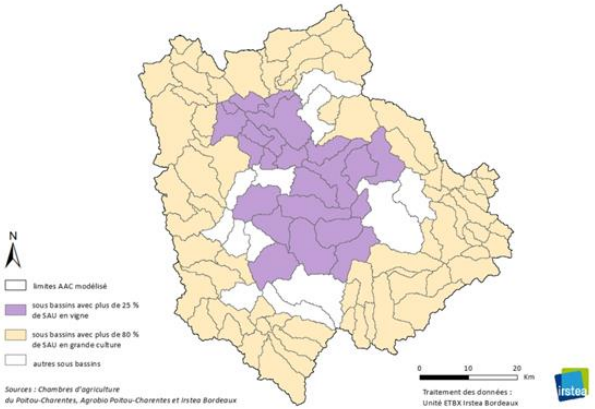
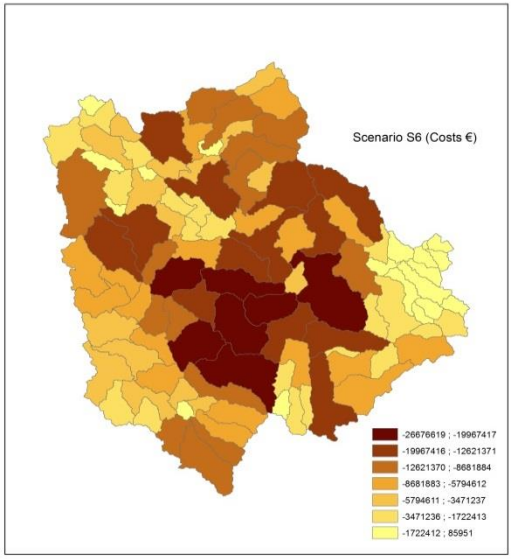
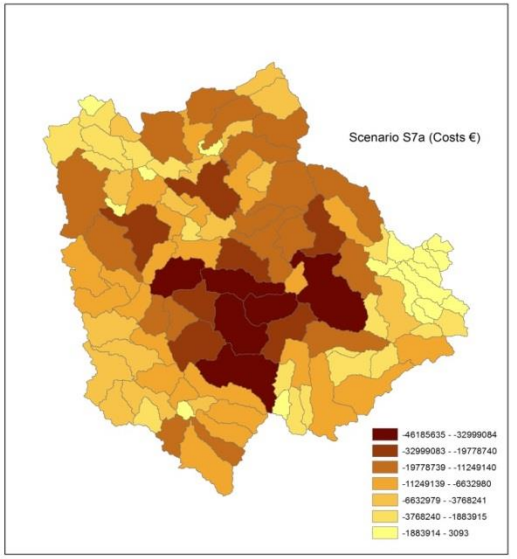


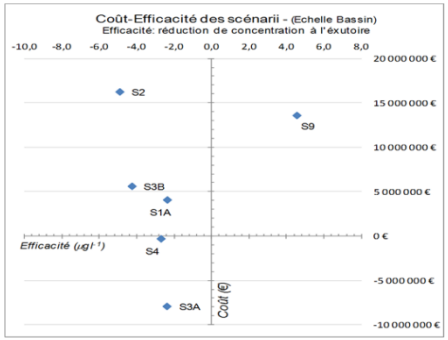


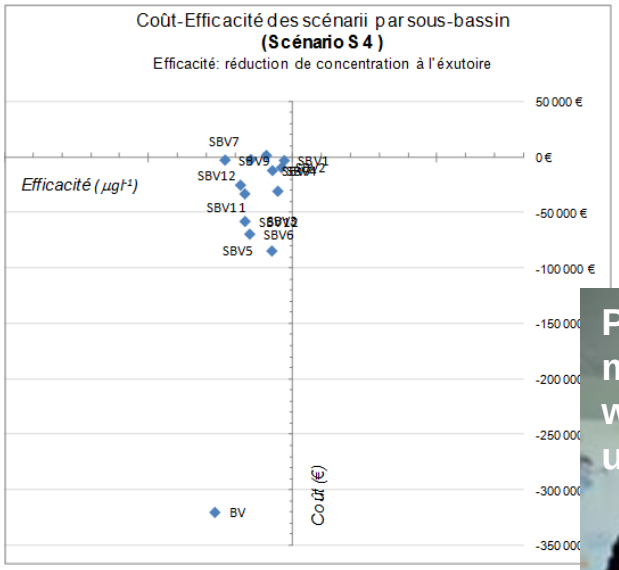


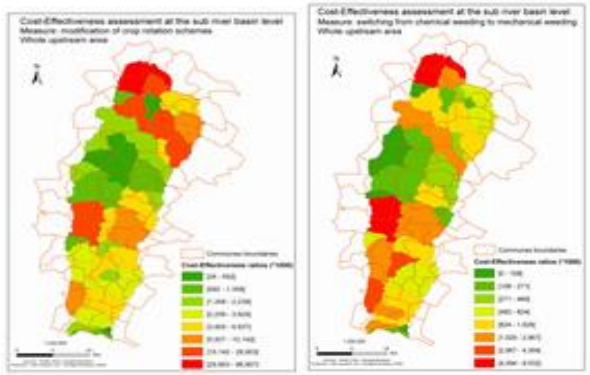
Conclusion

Results show that it is possible
to classify scenarios based on their Cost-effectiveness
represented graphically

- maps with spatially distributed cost-effectiveness ratios
- scatterplots







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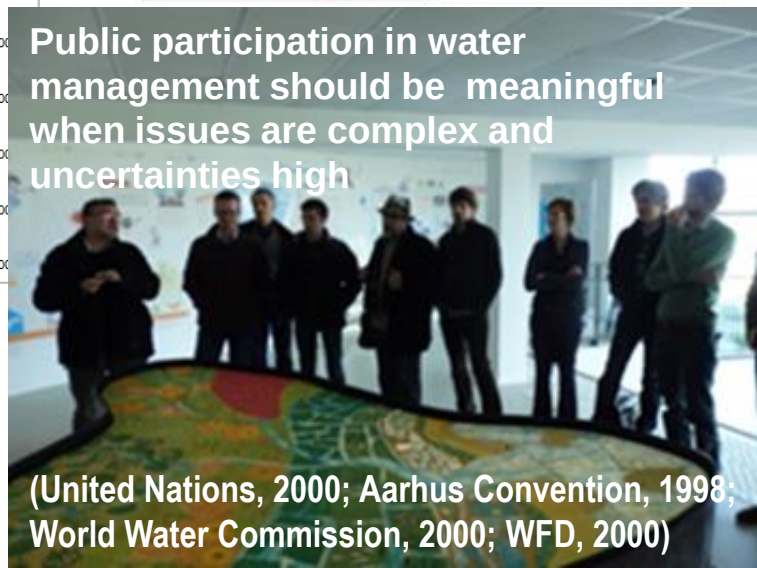

allowing for rational discussion
between stakeholders.

More information

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