Economic aspects of the European Water Framework Directive: experiences and challenges in agricultural catchments

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The James Hutton Institute

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Background

- The use of economic tools and principles is one of WFD's most relevant and innovative aspects: economics at the service of achieving good ecological status (GES)

- This has generated a great deal of research and implementation questions that set the agenda of European water management

Background

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WFD Phase 1 (completed):

- Economic characterisation of water uses
- Scenarios of supply and demand and economic impacts
- Potential for cost recovery of water services

WFD Phase 2 (due by end 2009):

- Program of Measures and Basin Plans
- Estimation of environmental benefits and disproportionality

Aims

- Discuss the key research questions and approaches taken
- Zooming in on agricultural catchments
- Identify challenges ahead
- Give a flavour of the James Hutton Institute research program

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Cost-effectiveness analysis of the Program of Measures

CEA of Programs of Measures

- Member States are requested to make judgements about the most cost-effective combination of measures to attain GES
  - Cost-Effectiveness Analysis (CEA) adopted in most national guidelines as a decision rule based on comparison of costs and outcomes (effects) of measures
- Step-wise procedure:
  - Set up a target (GES) & identify the relevant measures
  - Estimate cost & effectiveness
  - Rank measures according to C/E ratio
  - Choose the least costly combination of measures to achieve the target

Zooming in: The Guadalquivir RB

- Largest of Southern Spain (57,527 km^2 ; 4.5 million people)
- Great pressure on the water resource
- More than 85% of water is consumed in irrigation per year

- River Basin Plan: Strong focus on water saving measures
- No previous experience in Spain of CEA of water management

Berbel et al. (2011): CEA of water saving measures in Guadalquivir

- Target: To achieve GES but also to meet supply and demand
  - How to define GES in these conditions
  - Pressure Index: determined through expert consultation

$$I_e = \frac{D}{(R - F_e)}$$

D → Consumption

$(R - F_e)$ → Available resources – Environmental flow

    - A water body is considered to be below GES when $I_e < 0.6$

- Measures: selected in the WFD's public participation process
  - Technical measures (e.g. modernisation of irrigation systems)
  - Economic measures (e.g. volumetric billing in agriculture)
  - Other (e.g. extension services for farmers; increase groundwater control)

Berbel et al. (2011): CEA of water saving measures in Guadalquivir

- Cost: what costs? Spanish legislation:
  - annual equivalent costs (investment, operation & maintenance)
  - non-financial (social) costs to be included "if possible"
  - "difficult" = "not possible": only financial CEA
- Effectiveness: to be measured in terms of "impact reduction", e.g. Increased flow (litres per second)
  - If not possible, to be measured in terms of "pressure reduction" (e.g. saved water)

Berbel et al. (2011): CEA of water saving measures in Guadalquivir

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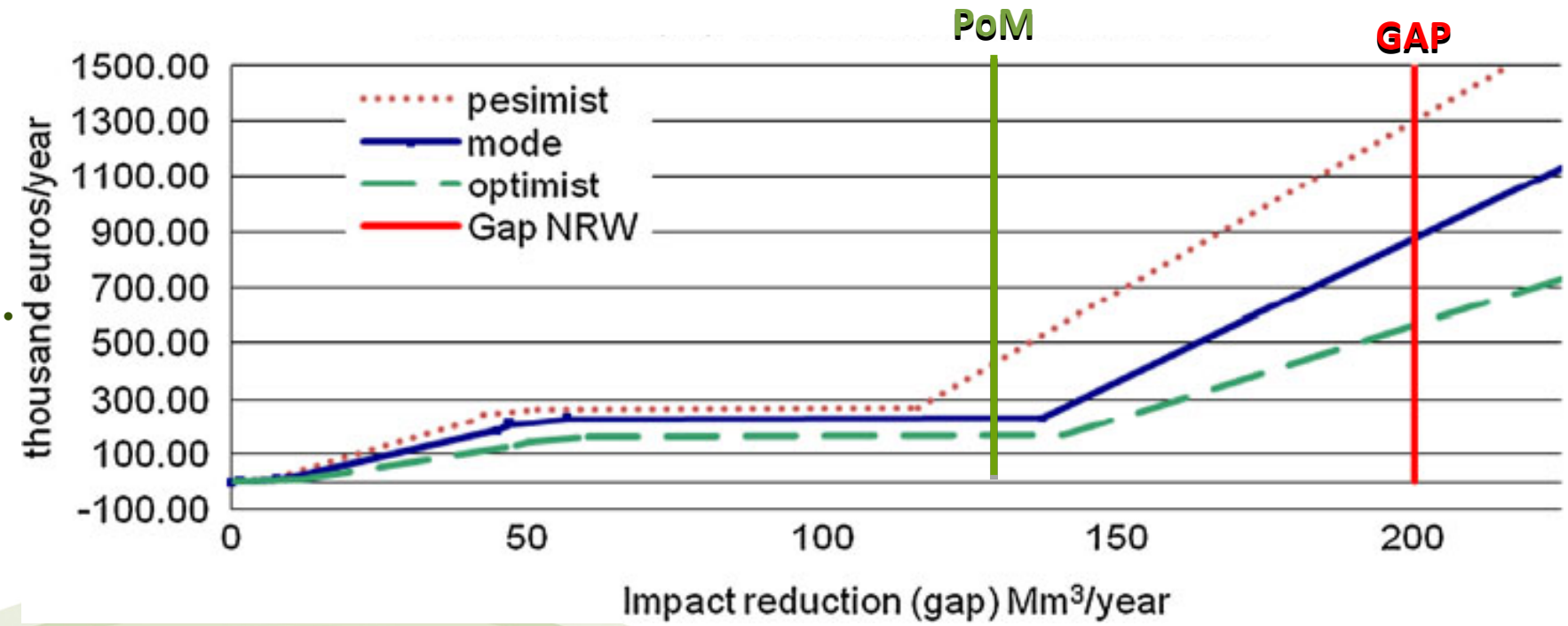
- Rankings of cost-effectiveness ratios in terms of pressures and impacts are not the same (return flows; fragmentation)

Water-saving measures	CE pressure reduction (€/m^3)	CE impact reduction (€/m^3)
Improvement of urban distribution networks	0.48	9.87
Modernisation of irrigation systems	0.66	4.88
Service cost recovery in urban sector	1.05	1.94
Service cost recovery in irrigation	0.11	1.10
Volumetric billing for irrigation	0.16	1.05
Extension services for irrigators	0.39	2.42
Subtotal[a]	0.57	3.96
Strict groundwater abstraction control	0.02	0.07
Total	0.32	1.68

- Potentially leading to sub-optimal choices in terms of attaining GES
- Synergic effects of measures (e.g. volumetric billing is easier in modernised irrigation systems)

Berbel et al. (2011): CEA of water saving measures in Guadalquivir

- Uncertainty only treated merely as a sensitivity analysis
  - Quantitative gap needed for GES not attained by PoM



- Withdraw irrigation rights: great costs increase & socially unacceptable
- Introduction of dynamic irrigation quotas: delay on achieving GES

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Environmental benefits

Environmental Benefits

- The WFD allows for derogation of good ecological status if the costs to achieve it are disproportionately costly
- Need to compare the costs of PoM with the benefits of the GES (CBA)
- Need to include environmental benefits
- Research questions:
  - What actually are environmental benefits?
  - How do we measure them?
  - Can we transfer values across sites reliably?

Environmental Benefits

- **What actually are environmental benefits?**
  - No definition in the WFD
  - Several interpretations
  - *Environmental benefits: the welfare gain resulting from the improvement of water quality from the current to the good ecological status* (Brouwer et al. 2010)
- **How to measure them?**
  - In environmental economics: welfare improvements are measured through individual's willingness to pay (WTP)
    - WTP is an indicator of welfare change associated with and environmental change; not a way of putting a price
  - Because a substantial part is expected to be non-market benefits: stated preferences techniques

Environmental Benefits

Stated preferences techniques:

Hypothetical markets in which a defined environmental change is proposed in a survey to a representative sample of the relevant population and ask them if they would be willing to pay for it and how much

- Assumption: people would pay as much as it keeps them in the same level of welfare

- Two main techniques: contingent valuation and choice experiments
- Construction of an hypothetical market = defining a *valuation scenario:*
  - How the ecological status is defined and presented to the public

Zooming in

- The FP6 AquaMoney Project : largest research initiative for the estimation of environmental benefits at the EU level (guidelines for practitioners)

- ***How to transfer benefit estimates across sites reliably?***
  - Primary valuation is costly in time and money
  - Use values from a study site for a policy site (transfer errors)
- Three groups with a common valuation design:
  - Water Quality (Northern-Central Europe and UK)
  - Water Scarcity (Italy, Greece, Spain)
  - Ecological Restoration-Flood Protection (Danube:

Bateman et al. (2009): Water Quality Group

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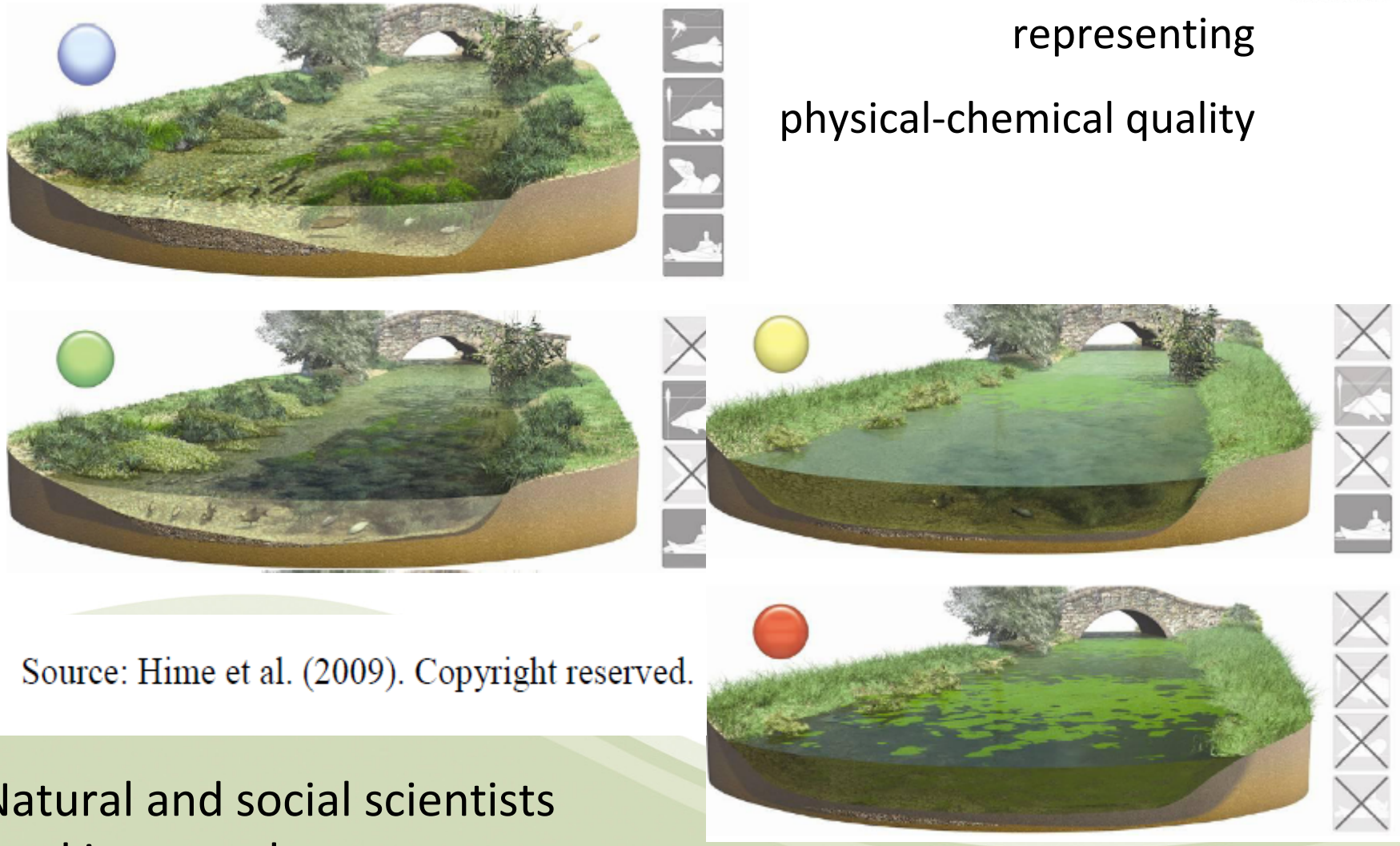
Water quality ladder

representing

physical-chemical quality



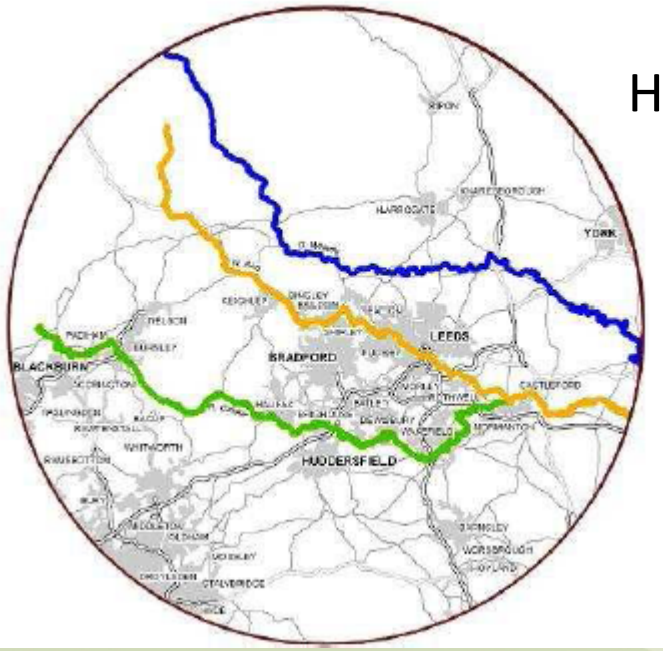
Source: Hime et al. (2009). Copyright reserved.

Natural and social scientists working together…

Bateman et al. (2009): Water Quality Group

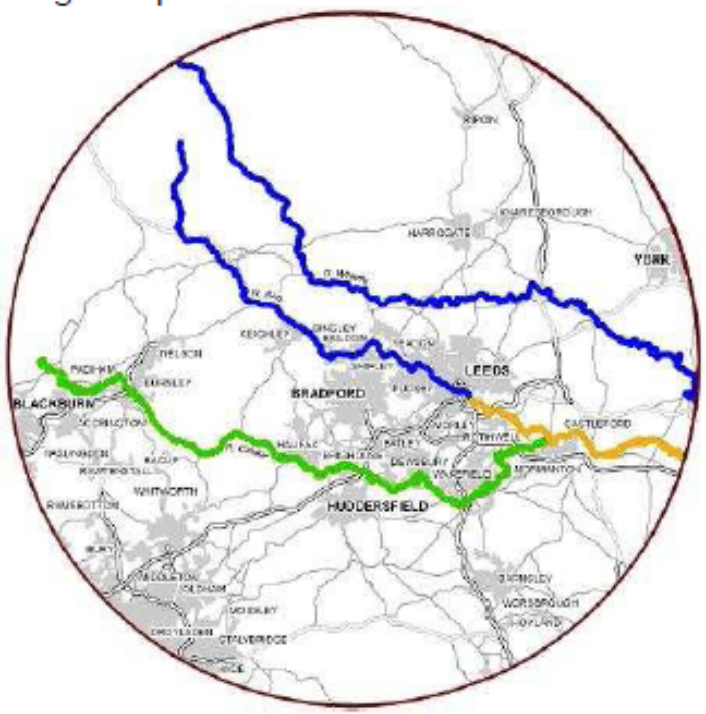
How much are you willing to pay for this improvement? (contingent valuation)

Status quo



Humber, UK

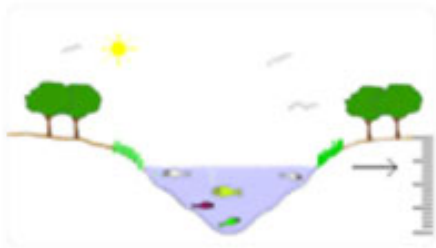
Larger improvement



Spatially explicit valuation design: looking at distance decay and substitution effects

Martin-Ortega et al. (2011): Water Scarcity Group

- Choice experiment: What option do you prefer?

SITUATION A	SITUATION B	NO MEASURES ARE TAKEN
1 out of 10 years 	3 out of 10 years 	4 out of 10 years 
moderate 	good 	poor 
80 € per year	40 € per year	0 € per year

Brouwer et al (2010): Ecological Restoration in the Danube

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	Option A	Option B	Status Quo
Flood frequency	Once every 25 years	Once every 25 years	Once every 5 years
 **Water quality**	Good 	Very good 	Moderate 
 **Increase in water bill**	€ 3 (25 Cent / month)	€ 10 (83 Cent / month)	No additional payment
I choose: (Please tick as appropriate)	**Option A** ☐	**Option B** ☐	**Neither** ☐

Some idea of the type of results

- The population perceives a significant welfare increase due to the improvement of the water status (significant WTP)
  - E.g. Guadalquivir WTP values aggregated across river basin's population indicate total benefits of € 250 million/year
- We are also able to study preference heterogeneity:
  - how different factors (socio-economic and contextual) affect the perceived value
- And value transferability across sites and countries
  - Value functions yield substantially lower transfer errors than univariate transfers
  - if based on theoretically driven variables and not best-fit principles

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Disproportionality Analysis

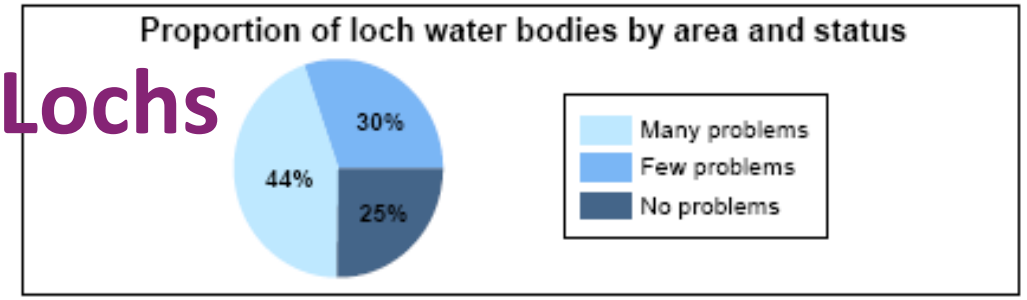
Disproportionality Analysis

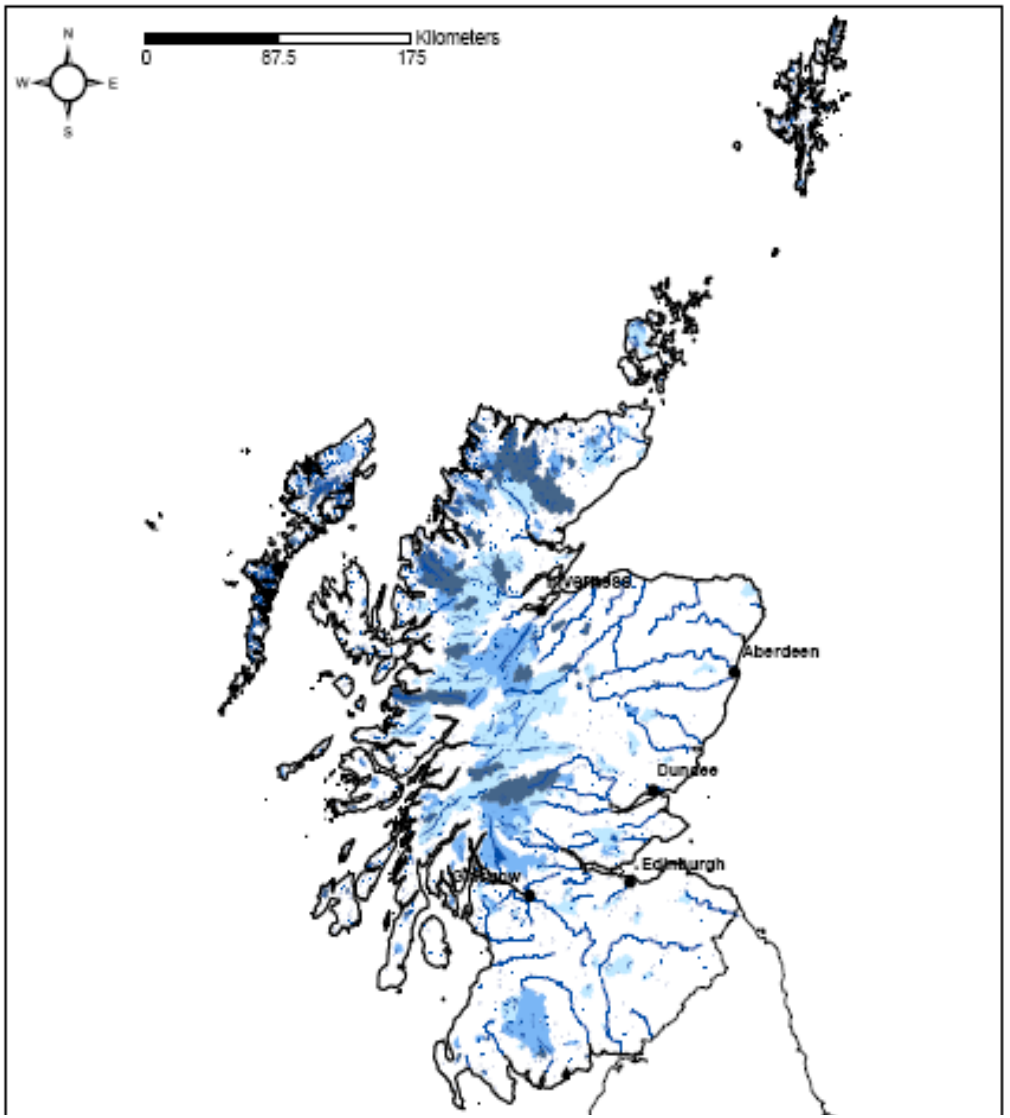
- Significant progress has been made in the estimation of the costs of the measures (CEA) and the environmental benefits of the WFD
- These two elements need to come together in a Cost Benefit Analysis
- Much less addressed by research and policy

Zooming in: Scottish Lochs

- Of the 209 loch water bodies :
  - 66 below moderate status
  - 54 downgraded because of total P concentration

- The approach of the Scottish regulatory authority (SEPA) has been to rely on CEA alone
  - Assuming that the definition of GES defines what mitigation is proportionate – reconsider if costs seem particularly high or if concern is raised





Vinten et al. (*sub.*): National scale DA of Phosphorous mitigation in Scottish Lochs

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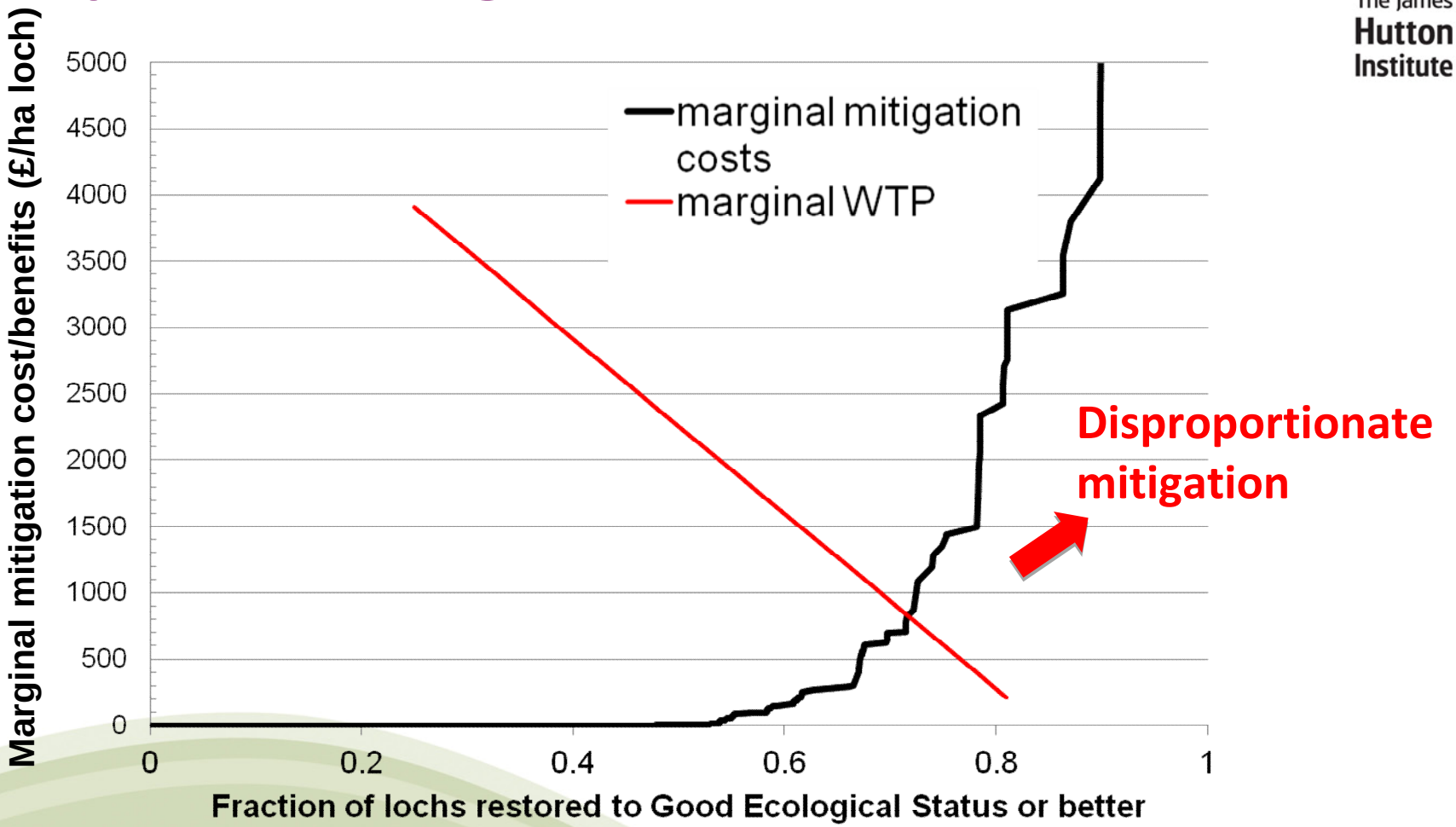
- Cost-assessment of P pollution mitigation measures for managed grassland, rough grazing, arable land, sewage and septic tank sources
  - Producing mitigation costs per loch area to give a national scale marginal mitigation cost curve
- Benefit assessment of GES based on stated preferences (choice experiment) (Glenk et al. 2011):
  - Marginal benefits per loch area
  - At the national scale

Vinten et al. (*sub.*): National scale DA of Phosphorous mitigation in Scottish Lochs



72% lochs mitigated proportionately at cost of £5.7m/y (including "mop-up" mitigation). Additional 28% could be mitigate disproportionately at £184.2m/y

Vinten et al. (*sub.*): National scale DA of Phosphorous mitigation in Scottish Lochs

- The analysis overcomes the presumption of the regulator about GES defining what mitigation is proportional
- Gives a basis for prioritisation of efforts across lochs
- The issue of scale:
  - WFD does not determine DA's scale (river basin, water body level?)
  - National (or RB) is good if ecological standards adopted by the regulator constitute reliable local estimates
  - But local specificities (about benefits and local stakeholder views) are lost
  - Need of local valuation studies: relevance of the catchment level

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Conclusions & Remaining challenges

Conclusions

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- The WFD is a clear example of the need for interdisciplinary research:
  - Need to develop socio-ecological tools and frameworks for complex problem solving
- Great opportunity for science-policy interaction
- Significant level of advancement (eg. AquaMoney, ChREAM in UK, several projects in Spain, Macaulay's Catchment Program 2006-2011, etc.)

Remaining challenges

- Challenges related to the refinement of the methods (Mode 1 normal Science). Examples:
  - More sophisticated ways of dealing with effectiveness and cost uncertainty
  - Technical improvements in valuation of environmental benefits: substitute effects, scale, spatial heterogeneity of preferences, etc.
  - How to improve value transferability to reduce errors

➢ *How to do what we already know better and better*

Remaining challenges

Mode 2 science challenges: interdisciplinary and participatory approaches to address wicked in uncertain context

- How to operationalize the Ecosystem Services Approach. E.g:
  - How can the ES approach help designing valuation scenario to produce more accurate welfare estimates?
  - Is there a mismatch between the scale of ES provisioning and the scale at which they are better valued by the public?
  - Services trade-offs
- Keep on challenging assumed principles. E.g:
  - How to include: social acceptability & equity issues, account for synergic effects of measures and multiple benefits (e.g. cultural)
  - is CEA the best method? Are there better multicriteria alternatives?
  - Beyond disproportionality assessment: compensation, PES

Remaining Challenges

- How do we co-construct knowledge with stakeholders?
  - Despite the active involvement between science and policy, there is a divergence between scientific prescriptions and policy approach.
    - E.g. In Scotland: only CEA needed?; In Spain: Environmental benefits not included in DA, etc.
    - Time lag (we were doing the research at the same time that outcomes were needed)
    - Lack of experience and preparedness (e.g. Spain: shift from engineering to ecological approach)
  - Co-constructing knowledge and pratice with stakeholders at multiple levels. Two directions:
    - Gathering local knowledge
    - Effective knowledge transfer

Remaining challenges: The James Hutton Research Program

- Catchment & Coastal Theme (Marc Stutter)
- Scottish Government Research Program:
  - Theme 1: Assessment of ecosystem services to inform policy making
    - WP: Assessing the monetary and non-monetary value of ecosystem services at catchment level
    - WP: Policy application of an Ecosystem Approach at a range of scales (including river basin plans)
  - Theme 2: Water and renewable energy
    - WPs: Cost-effectiveness of measures to manage water quality and flooding (including multiple benefits) (DTC)
- EU FP7 Project REFRESH: Adaptative Strategies to Mitigate the impacts of Climate Change in Freshwater Ecosystems (coupling hydrological modelling and economic analysis for CEA and DA of WFD)
- CREW: Centre for Expertise for Water: delivery mechanism at the science, policy and practice interface

For more info on The James Hutton Research Program:

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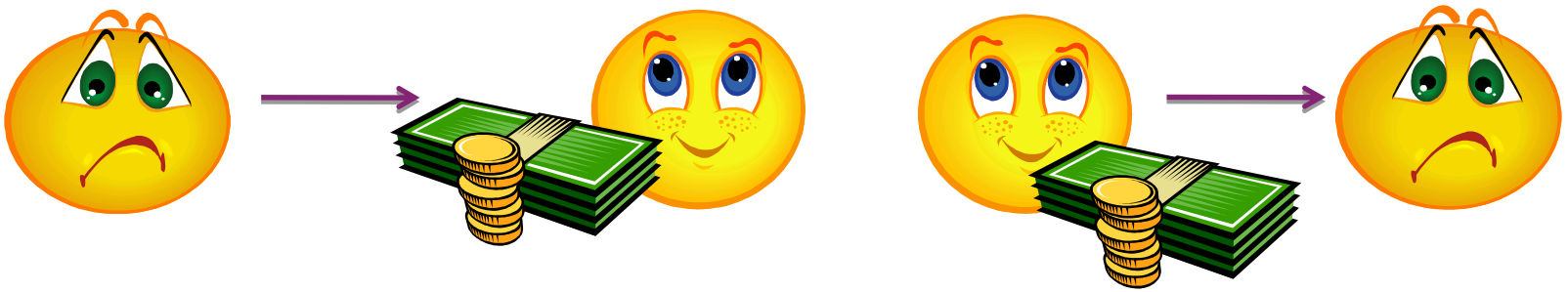
Methodological Approach

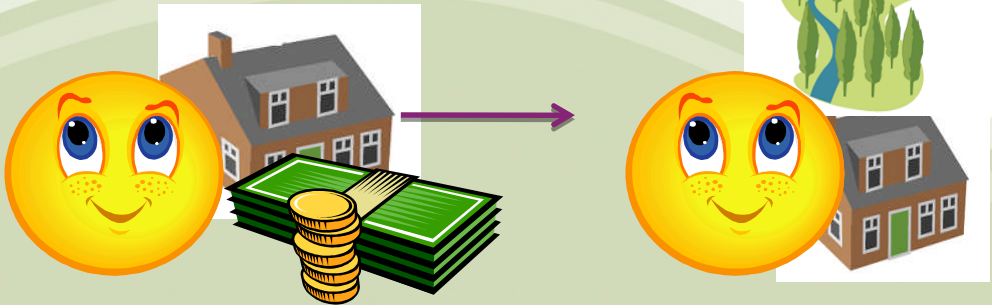
- Money doesn't make you happy, but at equal conditions:



- An environmental improvement increases your welfare in a certain amount 'X':

= ↑ **X welfare**

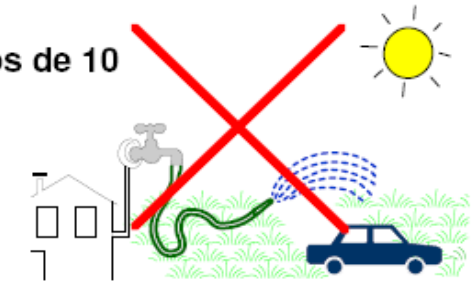
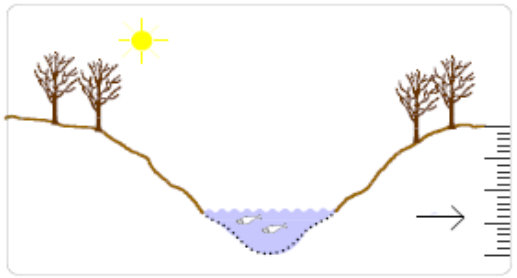
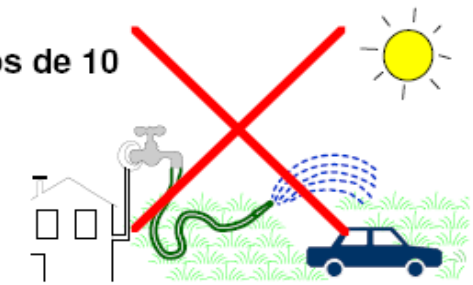
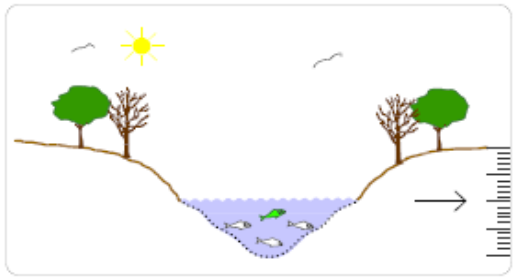
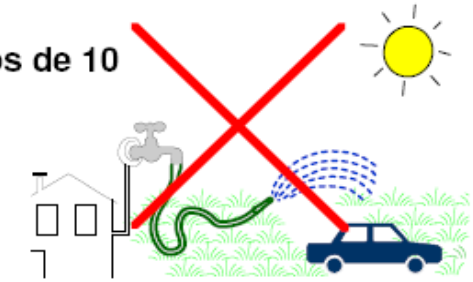
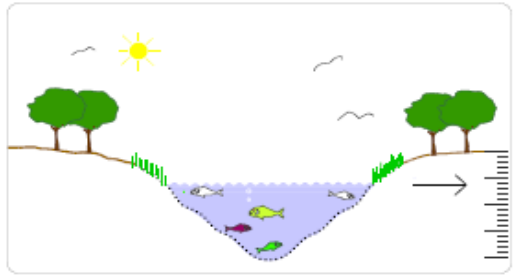
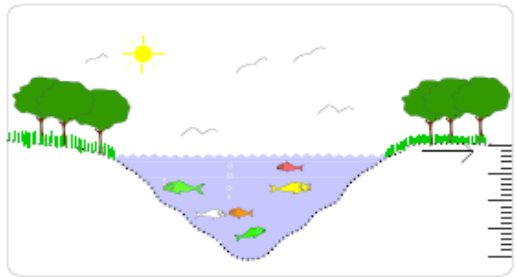
- If asked to pay for the environmental change you would only pay the amount of money that would maintain your welfare at the same level



= X welfare

WTP as an indicator of welfare change

Water Scarcity (Martin-Ortega et al. 2011)

Situación actual	4 años de 10 	 mala
1	3 años de 10 	 moderada
2	2 años de 10 	 buena
3	1 año de 10 	 muy buena

Some idea of the types of results

- The population sees a significant increase on their welfare due to the improvement of the water status
- We are able to estimate benefits for different policy scenarios. Example: Guadalquivir (South Spain) water scarcity reduction scenarios:

Table 5 Non-market benefits of water policy scenarios

Scenario	Frequency of household water restrictions	Ecological status	Consumer surplus (€ /household per year)	Std. error	Increase over average current water bill (%)[a]
1	1 year out of the next 10	Low (baseline)	118.60	12.14	48.02
2	4 years out of the next 10 (baseline)	Very good	10.88	5.30	4.40
3	1 year out of the next 10	Very good	129.48	11.77	52.42

➢WTP values for households are aggregated across the total population affected. Total benefits raise up to around € 200 million/year > costs of water saving measures in the river basin*

Some idea of the types of results

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Table 6 Conditional Logit model with interactions

Variables	Interaction model 1: income effect		Interaction model 2: effect of water scarcity perception	
	Coef.	Std. error	Coef.	Std. error
Attributes				
ASC	2.36[c]	0.21	2.29[c]	0.21
Frequency of water restrictions	0.51	1.14	−1.32[b]	0.62
Good ecological status	0.34[c]	0.10	0.12	0.13
Very good ecological status	−0.47	0.32	0.46[c]	0.11
Cost	−0.04[c]	$2*10^{-3}$	−0.04[c]	$2*10^{-3}$
Income * Frequency of restrictions	−0.96[b]	$4*10^{-5}$	–	–
Income * Very good ecological status	0.41[b]	$1*10^{-4}$	–	–
Considers water scarcity a problem in the region * ASC	–	–	0.47[b]	0.23
Assumes to suffer water restrictions in the future * Frequency of water restrictions	–	–	−0.69[a]	0.52
Believes water allocation to the environment should have priority in case of scarcity * Very good ecological status	–	–	0.45[b]	0.15
Num. observations[d]	1,348		1,416	
Log likelihood	−1,222.38		−1,196.42	
R^2	16.2%		18.2%	

[a]Significant at the 10% level, [b]significant at the 5% level, [c]significant at the 1% level

[d]Observations equal to 354 respondents * 4 choice occasions per respondents (minus missing values)