Socio-Economics of Biodiversity: Nature, People and Institutions

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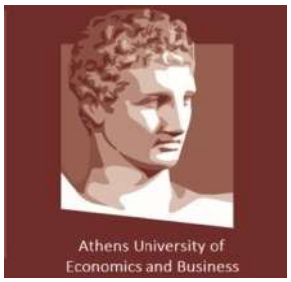

ICRE8 & ONGOING RESEARCH

ICRE8: International Centre for Research on the Environment & the Economy, www.icre8.eu

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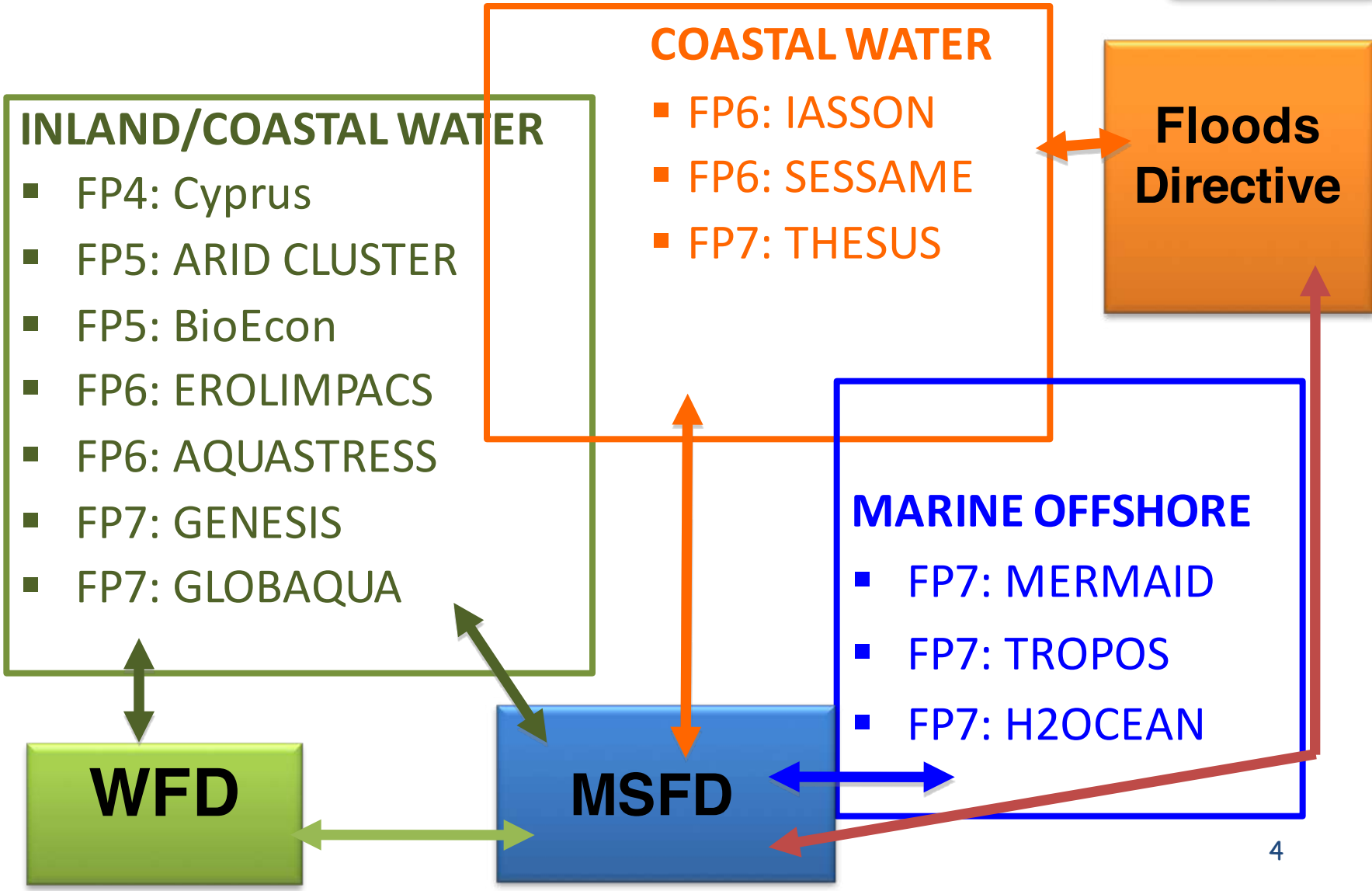
- Research Centre, Interdisciplinary Research on:
  - Environment — Economy
  - Energy — Eco-innovations
  - \+ electronic versions (hence E8)

Founder and Scientific Director: Phoebe Koundouri
Strategic Management Board: Bateman, Chichilnisky, Dasgupta, Gollier, etc.
Scientific Collaborators: 20 core researchers at ICRE8 premises in Athens, network 70 established researchers (Europe, USA, Asia, Australia)

History of ICRE8: ReSEES, since 1997:
- 20 million euros of research funding
- Collaborators:150 Universities/Research Institutions & 500 researchers
-200 published peer-reviewed research papers and books
- Geographical distribution: Europe, US, Latin America, Africa, Asia, Australia
- **ReSEES** influenced policy & attracted mass media coverage all over the world

EC DG-Research



Full Titles DG-Research Projects

http://www.icre8.eu/icre8-projects

FP4

1. CYPRUS: Integrated Water Management in Cyprus: Economic and Institutional Foundations

FP5

2. ARID CLUSTER: Strengthening complementarity and exploitation of results of related RTD projects dealing with water resources use and management in arid and semi-arid regions
3. BIOdiversity and Economics for CONservation

FP6

4. EUROLIMPACS: Evaluate Impacts of Global Change on Freshwater Ecosystems
5. AQUASTRESS: Solving Water Stress Problems by Integrating New Management, Economic and Institutional Instruments.
6. IASSON: Sustainable Development of the Mediterranean and Black Sea Environment
7. SESAME. Southern European Seas: Assessing and Modeling the changes in Ecosystems
8. e-LUP, Simulating Land Use Processes

FP7

9. GENESIS: Groundwater and dependent Ecosystems: New Scientific basis on climate change and land-use impacts for the update of the EU Groundwater Directive
10. THESEUS: Innovative coastal technologies for safer European coasts in a changing climate
11. MERMAID: Innovative Multi-purpose Offshore Platforms planning Designing and Operation
12. GLOBAQUA: Managing the Effects of Multiple Stressors on Aquatic Ecosystems Under Water Scarcity

Recent Water & Biodiversity Projects

EXAMPLES INTER ORG

- World Bank:
  Arsenic Contamination, Bangladesh, India
- World Bank:
  Water Pricing, China, Bangladesh
- WWC: Green Water Growth: Egypt, China, Nepal, Australia
- OECD:
  Economic Instruments to Protect Freshwater Resources in Lake BaikalBasin.
- IIED:
  Integrated WM Methodologies

EXAPLES NATIONAL GOVT

- Greece Climate Change Review
- UK, EA: Economic Value of Groundwater
- Finalnd, MoE: Agricultural use of Water and CAP
- Greece, MoE: ASOPOS RB
- Cyprus, MoE: WFD Atrs 5 & 11
- Abu Dhabi, MoE: Economic Valuation of Groundwater
- Namibia, MoE: Groundwater Pricing

Sample of Projects on Other Public Goods

- WHO: Assessing Fairness of Greek Health System Financing
- UK Treasury & DEFRA: Discounting for LR CBA
- World Bank: Governments of Cyprus, Ukraine and Moldova: Public Investment Assessment process
- DIFID: South Africa: Incentives for Leaded Gasoline
- EC-DG-Environment:
  - The impact of REACH on the environment and human health
  - EU Chemicals Directive: Economic Evaluation
- Cyprus DoE: Amiantos Mines
- Greece DoE: CBA mining-metallurgical installation Hellas Gold
- Bank of Greece: Report on Climate Change
- The Hashemite Kingdom of Jordan: Waste Management
- EC-FP7: OpenAIRE: Open Access Scientific Information

ICRE8's Research Tools include:

- mathematical economic modeling and econometrics
- financial analysis
- socio-economic analysis
- environmental valuation
- political and institutional analysis
- integrated environmental-economic modeling
- cost-benefits analysis
- multi-criteria analysis
- risk analysis
- geographical information systems
- multi-stakeholder mediations techniques
- game theory
- information technology decision making tool development
- Etc.

Sustainable Development and Biodiversity

Total Economic Value

Costs Benefit Analysis

Sustainable/Green Development (SD): Why do we care?

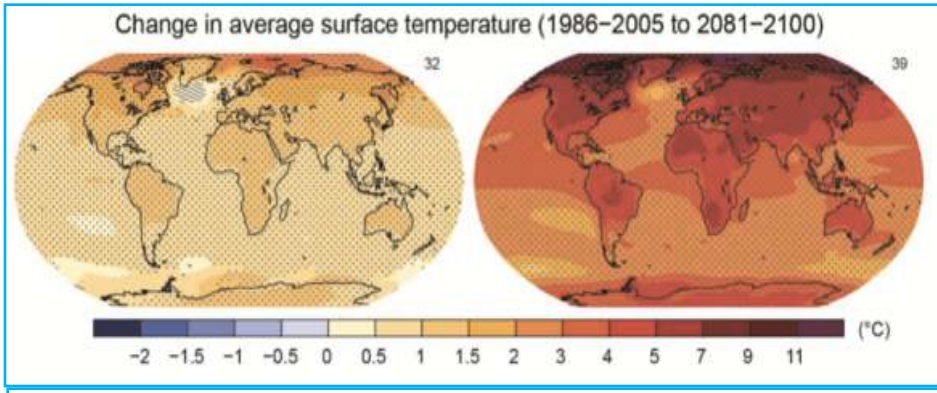
- **SD**: a pattern of resource use
  - that aims to meet human needs
  - while preserving the environment
  - so that these needs can be met not only in the present, but also for future generations.

- **Any other development path puts the society**
  - **consumers**
  - **producers**
  - **businesses, including financial institutions**

  on self-destructing rotations.

VALUES need to be Investigated & Measured

- Resources are limited.
- People's wants are unlimited.
- Trade-offs when allocating resources.
- Resource allocation affects wellbeing.



IPCC Fifth Assessment Synthesis Report

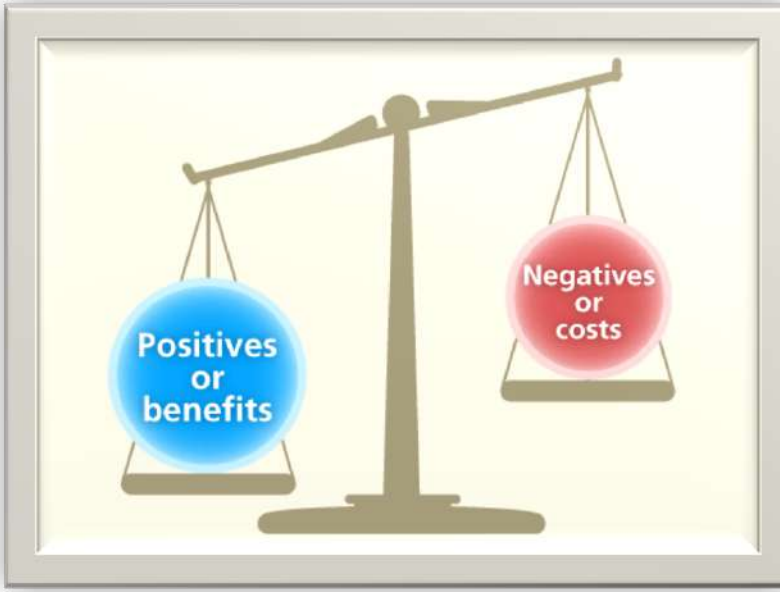
The possible outcomes of our choices today: land temperatures in the event of substantial mitigation action (left) and in the absence of mitigation action (right).

Source: http://www.carlocarraro.org/

- 1840s, Jules Dupuit: How to make public choices on investments no commercial returns?
  - Consumer's surplus: CS
  - Producer's surplus: PS

- CBA Thinking:
  ΔCS measures WTP: BENEFITS
  ΔPS measures WTAc: COSTS
  TOTAL ECONOMIC VALUE

Policy: CBA Guide European Commission
Other decision-making process exist…



CBA is the Leading Tool for Project, Policy, Program Appraisal

- 19th century: Theoretical origins; 1930s, USA: water-related investments; Since 1960s CBA enjoyed fluctuating fortunes, but now recognized as the major appraisal technique for public investments and public policy.

The Theoretical Foundations of CBA; The Stages of a Practical CBA; Total Economic Value (TEV); Revealed Preference for Valuing Non-Market Impacts; Stated Preference (CVM & CM) for Valuing Non-Market Impacts; The Value of Ecosystem Services; Valuing Health and Life Risks; Benefits Transfer; Discounting & Temporal Framing; Spatial Framing; Equity and CBA; Sustainability and CBA; Uncertainty and CBA; The Political Economy of CBA; Multi-Criteria Analysis & Interdisciplinary aspects

Total Economic Value: The Central Concept in CBA

ICRE8's focus interest: To refine the theoretical models and empirical methods towards:

A. Better understanding of the concept and determinants of the total economic value of ecosystem goods and services.

B. More accurate modelling of this value.

C. More robust estimation and forecast of this value.

D. More efficient integration of this value in interdisciplinary resource management and policy-making.

Is there a dominant driving force shaping Economic Values and Allocation of Resources?

My research points to 'Information'!

Crucial Questions to be answered:

- Does relevant information exist?
- Who owns it?
- Who understands it?
- How is it diffused over time/over space?
- How to handle information uncertainty?
- Do we face risk or deep uncertainty?
- How people react to information uncertainty?
- How we deal with information uncertainty in the LR?

It is important to explicitly incorporate the level, quality & dynamics of information in the theoretical and empirical attempts to measure values.

Required Information is truly Interdisciplinary!

Valuing Ecosystems and Biodiversity (TEEB) for CBA

- "Making nature's values visible": mainstream the values of biodiversity and ecosystem services into decision-making at all levels.

- **Major Challenges:**

- Interdisciplinary
- Valuation is an estimation of a snapshot
- Spatial and Temporal Frameworks
- Uncertainty about present & future of stocks and flows of ES

Spatial frames in ES-based CBA

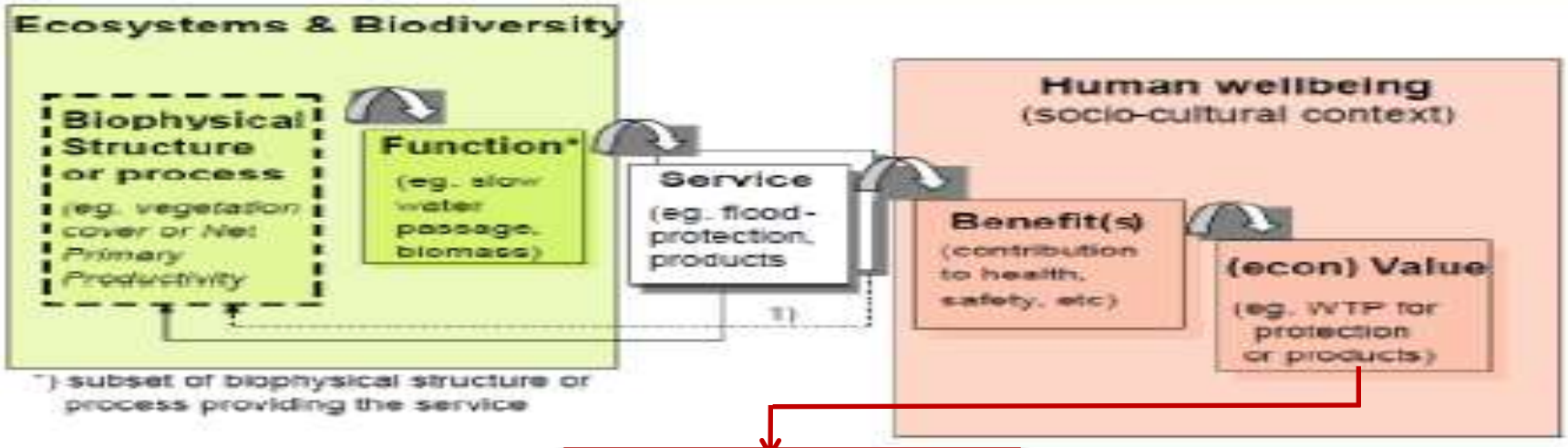
- Knowledge of how and where ecosystem services are generated, altered and experienced is often insufficiently detailed.
- Risk adopting spatial boundaries that do not encompass all the impacts of a planned change.
- GIS-based spatial analysis is needed.

TEMPORAL FRAMES IN ES-BASED CBA

- What is the relevant time horizon?
- Preferences for or against an impact may change through time and this "relative price" effect also has to be accounted for.
- C/B not known with certainty so that risk (probabilistic outcomes) and uncertainty (when no probabilities are known) have to be taken into account.
- Co-evolution of social-ecological systems is not predictable.
- Choice of temporal scale of analysis determines to what extent the interests of future generations are included in the analysis.
- This choice involves the selection of an appropriate discount rate.

Total Economic Value (TEV)

- Provides a systematic tool for considering the full range of impacts on the environment and on human welfare.
- TEV reflects the preferences of individuals.
- Preferences can be studied and estimated by stated preference methods and revealed preference methods
- Quantifying the impacts of environmental degradation and natural resource non-optimal management, on human welfare is essential for the development of well-informed investments and policies.



Total Economic Value ES-related Goods & Services

USE & OPTION VALUES

- Agriculture — Production Analysis
- Residential — Demand Analysis
- Industrial — Value Transfer
- Health — Lab experiment
- Recreation — Choice Experiment

PASSIVE VALUES

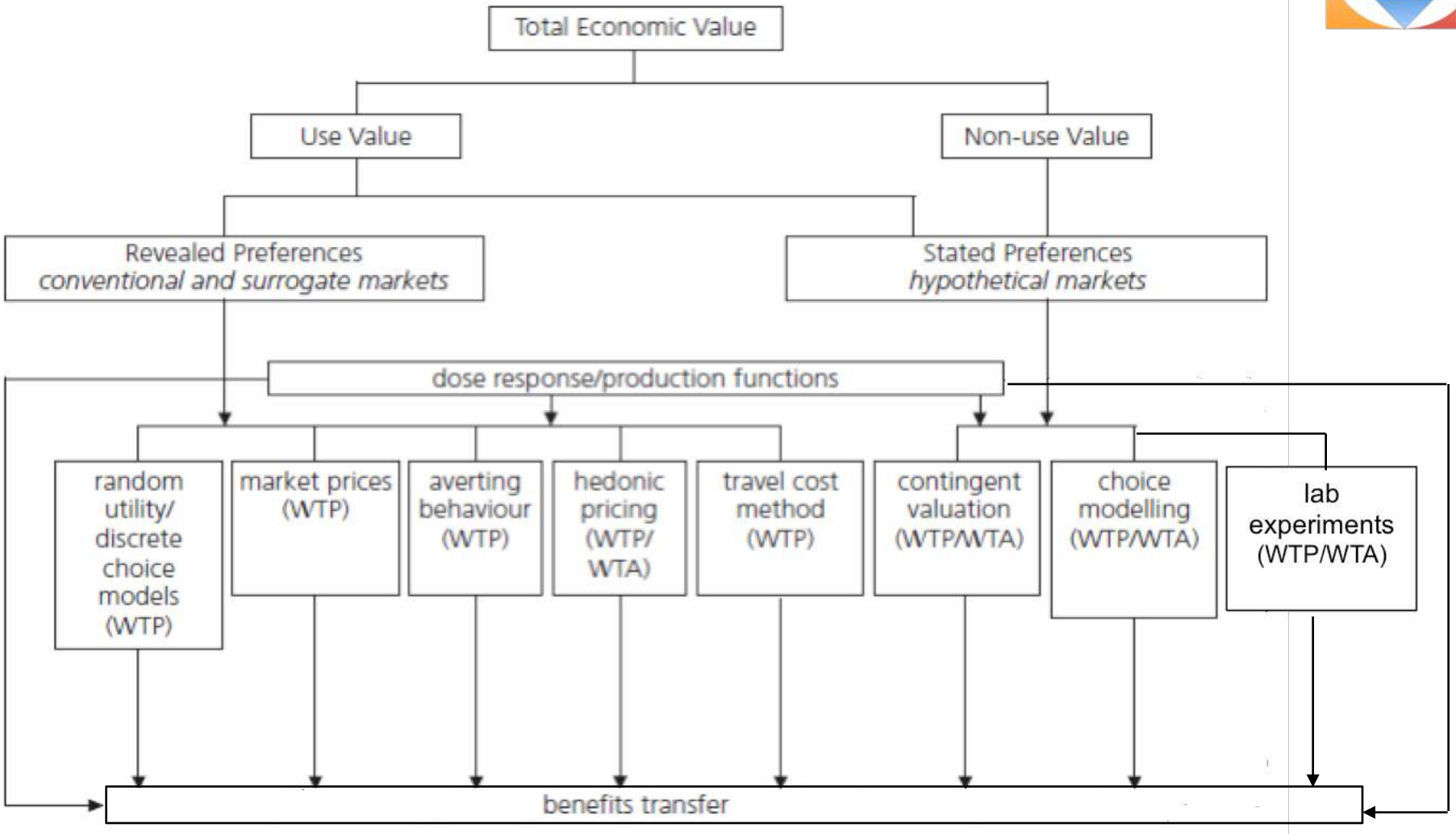
- Existence Value — Choice Experiment
- Bequest Value — Choice Experiment
- Warm Glow — Lab Experiment
- Altruistic — Lap Experiment

DSS: CBA (GIS + Over time: CC scenarios)

Institutions + Policy Recommendations

Is it straightforward to derive Economic Values? Market Failure

- Environmental & Natural Resources are Public Goods
- Environmental Degradation (Quality/Quantity) is an Externality
- Not explicitly traded in any market
- No market price exists to reveal: TOTAL ECONOMIC VALUE
- We need to retrieve TEV via WTP
- Market and Non-market Valuation Methods


Total Economic Value
Use Value
Non-use Value
Revealed Preferences
conventional and surrogate markets
Stated Preferences
hypothetical markets
dose response/production functions
random utility/ discrete choice models (WTP)
market prices (WTP)
averting behaviour (WTP)
hedonic pricing (WTP/ WTA)
travel cost method (WTP)
contingent valuation (WTP/WTA)
choice modelling (WTP/WTA)
lab experiments (WTP/WTA)
benefits transfer

SNAPSHOT OF SELECTED PROJECTS RESULTS

http://www.theseusproject.eu/

Innovative technologies for safer European coasts in a changing climate

European Commission

FP7, THEME 6 - Environment, including climate

Budget: (6,530,000 €)

The Economic Valuation of Climate Change Effects on Coastal Ecosystems: A Choice Experiment


ECOSYSTEM SERVICES

CONTENTS

Context

- Santander Bay in Northern Spain (Cantabria)

- Pressures:
  - Expanding population settlements
  - Expanding recreation facilities
  - Expanding industrial settlements
  - Increasing shellfish and marine & agricultural activities
  - Expanding transport facilities
  - Impacts of climate change on biodiversity, health, beach size

Application

- Elicit the value people place on
  - Improvements in biodiversity
  - Improvements in recreational opportunities
  - Decreases in the health risks associated with the presence of alien jelly species

  - **METHOD: Choice Experiment**
- Any good can be described in terms of its attributes and their levels.
- Experimental design theory is used to generate different profiles of the public good in terms of its attributes and their levels. (Ngene)
- Profiles assembled in choice sets which are presented to the respondents, who are asked to state their preferences.
- Monetary cost and benefit attribute and the random utility framework allow the estimation of welfare indicators (WTP/WTAc) based on the levels of attributes.

Attribute	Levels	
Biodiversity	Low: The area for shell fishery is altered by climate change and is not suitable for current type of fisheries anymore. The Bay of Santander is no longer a stop for migrating birds and invertebrates Medium: The shell fishery area is preserved but reduced and the Bay is no longer a stop for migrating birds and invertebrates High: Current level of biodiversity is preserved	
Number of days beaches are closed because of Medusa Portugessa outbreaks	5 days per year 10 days per year 15 days per year	
Beach Size (recreation)	Low: The 4 main beaches in Santander will reduce from 3 km long that are now to pocket ones. Pocket beaches and beaches located at the flood prone Somo split will disappear due to erosion High: Renurishment of the main beaches in Santander and pocket beaches will preserve their size throughout the year	
Additional annual cost to your household	0 euros per year 50 euros per year 75 euros per year	100 euros per year 125 euros per year 150 euros per year

Example of choice card

Assuming that the following 3 management strategies were the only choices you had, which one would you prefer? Remember that any money you spend to these options is money that you could spend on other things and that your responses will be used to assist policy formulation.

	Alternative 1	Alternative 2	Alternative 3 (no policy action)
Biodiversity	Medium	High	Low
Number of days beaches are closed because of Medusa Portugesa outbreaks	5	15	15
Beach Size	High	Low	Low
Additional annual cost to your household	125	50	0
I prefer	☐	☐	☐

The survey

- Target population = all the persons over 18 years old living in one of the cities of the Santander bay area
  - Sampling based on 2 quotas: gender + age and repartition of the inhabitants between the different municipalities
- Interviews conducted in specifically-chosen locations, such as commercial centers, industries, schools, etc.
- 300 people interviewed. 266 questionnaires used in econometric analysis
- Questionnaire: http://www.aueb.gr/users/koundouri/resees/lectures.html

The questionnaire

- Perceptions re. CC, mitigation and adaptation actions:
- Most serious problems currently facing Santander = floods and marine pollution
- Ranking in perceived assets at risk: wildlife, tourism, health and recreation

- Valuation questions
  - 6 choice cards + 3 alternatives

- Socioeconomic conditions of the respondents

Table 3
Descriptive statistics of the sample.

Number of respondents	84
Personal characteristics	
Age (mean)	43
Female (% of women)	59.0
Occupation (% full time)	69.9
Number of people per household (mean)	3.2
Children (% of household with children)	55.4
Education (% with university degree)	10.8
Household income (% below €2000)[a]	68.3
Distance of the house from the beach (mean, in km)	2.9
Goods and services threatened nowadays by CC	
Recreation from the beaches (mean score)	2.9
Biodiversity in the coastal and marine ecosystem (mean score)	3.5
Tourism and local infrastructure (mean score)	3.4
Human Health (mean score)	3.3

Consequences of CC	
Increase in frequency and extend of floods...	
... in the next 5 years	2.4
... in the next 30 years	3.4
... in the next 60 years	3.8
Increase in frequency and extend of storms...	
... in the next 5 years	2.9
... in the next 30 years	3.4
... in the next 60 years	3.8
Reduction of the size of the beach	
... in the next 5 years	2.6
... in the next 30 years	3.6
... in the next 60 years	4.2
Intergenerational equity and financial contribution questions	
Current generations should protect the environment to ensure that future generations can continue enjoying the benefits from the goods it provides	4.5
Intergenerational equity should be an important consideration for policy making	4.3
I would financially contribute to actions aiming to mitigate CC even if benefits are to be received by future generations	3.7
I prefer enjoying the present and don't spend a big part of my time worrying about the future	2.2

[a] According to the Spanish National Statistics Institute, the average annual income of Spanish households reaches €25,732 in 2009 i.e. €2144 per month

$$Pr_{ijt} = \int \left(\frac{\exp \beta_i X_{jt}}{\sum_k \exp \beta_i X_{kt}} \right) f(\beta|\theta)\, d\beta$$

Econometric Results: Mixed Logit

Table 4
RPL estimation results.

Attribute	Coefficient (St error)
Utility parameters	
Medium biodiversity	1.79***(0.22)
High biodiversity	1.63***(0.21)
Beaches are closed for 10 days/year	1.10***(0.23)
Beaches are closed for 5 days/year	1.32***(0.27)
High recreation	0.80***(0.17)
Price	−0.04***(0.01)
ASC	−3.60***(1.24)
Age (respondent's age)	0.06**(0.03)
Female (1 if respondent is female)	−0.24(0.65)
Child (1 if household has children)	−0.60(0.57)
Random parameters' standard deviations	
Medium biodiversity	1.79***(0.22)
High biodiversity	1.63***(0.21)
Beaches are closed for 10 days/year	1.10***(0.23)
Beaches are closed for 5 days/year	1.32***(0.27)
High recreation	0.80***(0.17)
Price	0.04***(0.01)
Log likelihood	−450.74
Pseudo Rsq	0.186
Observations	504

** Indicates significance at 5%.
*** Indicates significance at 1%.

$$WTP = \frac{-b_{attribute}}{b_{payment}}$$

WTP estimation

Table 5
WTP estimation.

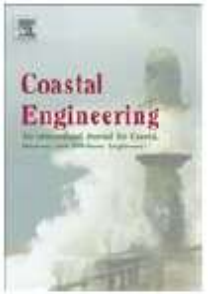
Attribute	WTP (in 2011 Euros) [95% confidence interval]
Medium biodiversity	41.51[30.84 54.96]
High biodiversity	37.63[27.56 50.76]
Beaches are closed for 10 days/year	25.23[15.76 34.94]
Beaches are closed for 5 days/year	30.33[19.66 42.40]
Recreation high	18.77[11.92 26.39]

Knowledge of the value people place on goods and services sustained by marine ecosystems is important in assessing the cost-effectiveness of the proposed measures.

Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: www.elsevier.com/locate/coastaleng



Promoting resilient economies by exploring insurance potential for facing coastal flooding and erosion: Evidence from Italy, Spain, France and United Kingdom

Osiel González Dávila [a,*], Mavra Stithou [a], Gianluca Pescaroli [b], Luca Pietrantoni [b], Phoebe Koundouri [a,g], Pedro Díaz-Simal [c], Bénédicte Rulleau [d], Nabil Touili [d], François Hissel [e], Edmund Penning-Rowsell [f]

Overview of main theoretical perspectives on insurance in flood risk management.

Four European contexts are analyzed using data derived from surveys and interviews from:

- France
- United Kingdom
- Italy
- Spain

Economic Instruments for Coastal Management: The Example of Flood Insurance

- Support to accelerate economic and social recovery following a disaster (coastal resilience).

- Impact limitation by using pricing or restrictions on availability of coverage to discourage new development in hazard-prone areas.

- Affect the redistribution of damage costs across the population and through time, both in the short and long term.

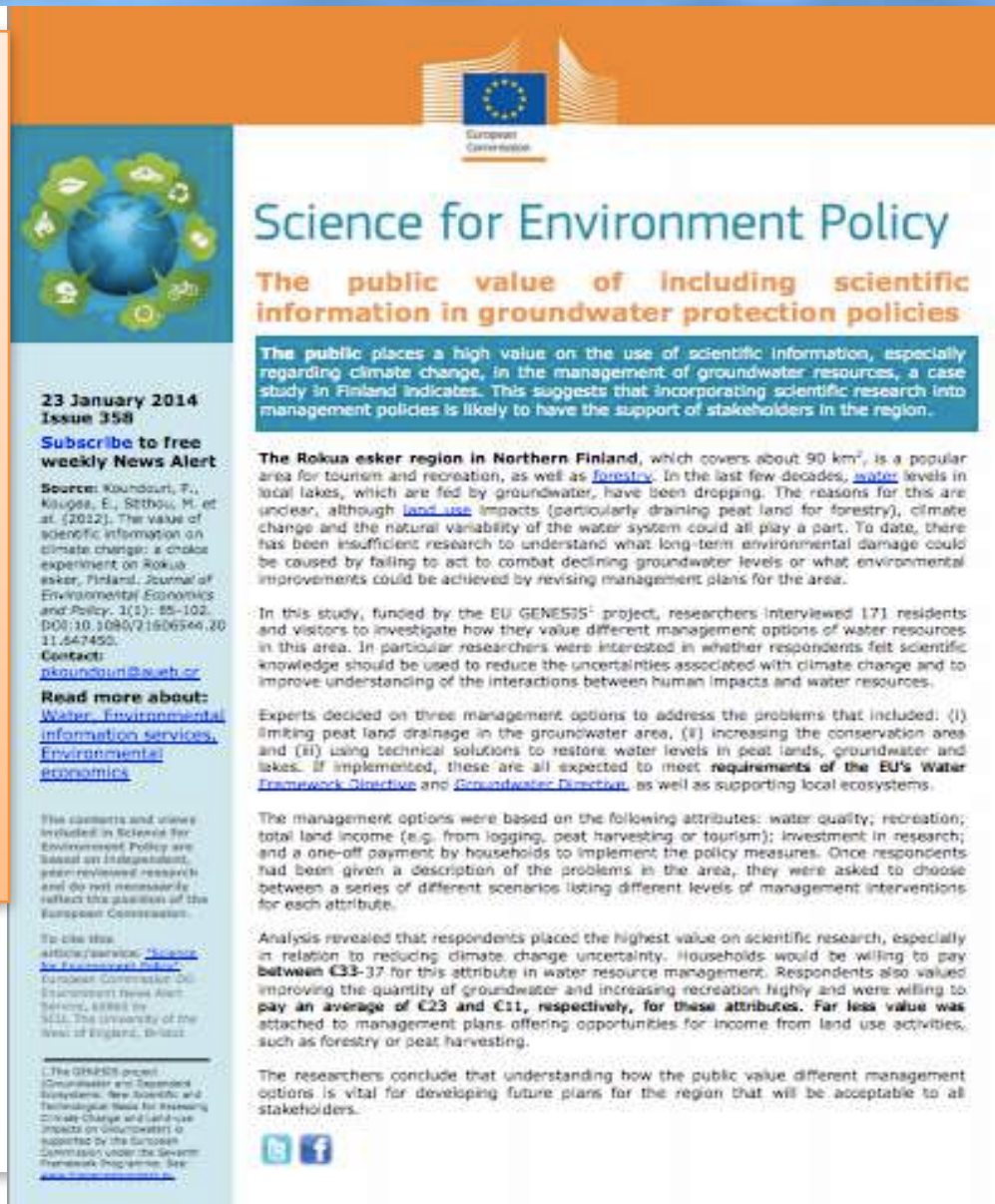
- Long-run risk impacts could affect the overall damage function by discouraging new buildings in high risk areas.

GENESIS
groundwater and dependent ecosystems

European Commission
FP7, THEME 6 - Environment, including climate
Budget: 9,170,000 €

Koundouri et al. JEEP2011:
The value of scientific information on climate change: a choice experiment on Rokua esker, Finland

The general public values Scientific Information & recognizes its contribution optimal design of CC adaptation policies



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Source: Koundouri, P., Kougea, E., Stithou, M. et al. (2012). The value of scientific information on climate change: a choice experiment on Rokua esker, Finland. Journal of Environmental Economics and Policy. 1(1): 85-102. DOI:10.1080/21606544.2011.647450.
Contact: pkoundouri@aueb.gr

Read more about: Water, Environmental information services, Environmental economics

Science for Environment Policy

The public value of including scientific information in groundwater protection policies

The public places a high value on the use of scientific information, especially regarding climate change, in the management of groundwater resources, a case study in Finland indicates. This suggests that incorporating scientific research into management policies is likely to have the support of stakeholders in the region.

The Rokua esker region in Northern Finland, which covers about 90 km², is a popular area for tourism and recreation, as well as forestry. In the last few decades, water levels in local lakes, which are fed by groundwater, have been dropping. The reasons for this are unclear, although land use impacts (particularly draining peat land for forestry), climate change and the natural variability of the water system could all play a part. To date, there has been insufficient research to understand what long-term environmental damage could be caused by failing to act to combat declining groundwater levels or what environmental improvements could be achieved by revising management plans for the area.

In this study, funded by the EU GENESIS[1] project, researchers interviewed 171 residents and visitors to investigate how they value different management options of water resources in this area. In particular researchers were interested in whether respondents felt scientific knowledge should be used to reduce the uncertainties associated with climate change and to improve understanding of the interactions between human impacts and water resources.

Experts decided on three management options to address the problems that included: (i) limiting peat land drainage in the groundwater area, (ii) increasing the conservation area and (iii) using technical solutions to restore water levels in peat lands, groundwater and lakes. If implemented, these are all expected to meet **requirements of the EU's Water** Framework Directive and Groundwater Directive, as well as supporting local ecosystems.

The management options were based on the following attributes: water quality; recreation; total land income (e.g. from logging, peat harvesting or tourism); investment in research; and a one-off payment by households to implement the policy measures. Once respondents had been given a description of the problems in the area, they were asked to choose between a series of different scenarios listing different levels of management interventions for each attribute.

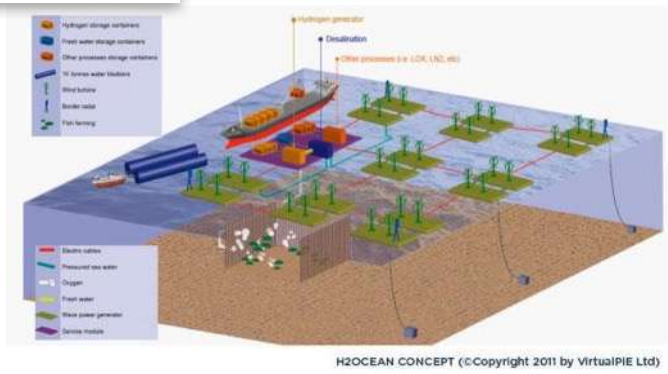
Analysis revealed that respondents placed the highest value on scientific research, especially in relation to reducing climate change uncertainty. Households would be willing to pay **between €33-37** for this attribute in water resource management. Respondents also valued improving the quantity of groundwater and increasing recreation highly and were willing to **pay an average of €23 and €11, respectively, for these attributes. Far less value was** attached to management plans offering opportunities for income from land use activities, such as forestry or peat harvesting.

The researchers conclude that understanding how the public value different management options is vital for developing future plans for the region that will be acceptable to all stakeholders.

OCEAN 2011-1: Multi-use Offshore Platforms
DG Research-FP7, Budget: 20,000,000 euro

Development of a wind- wave power open-sea platform equipped for hydrogen generation with support for multiple users of energy

http://www.h2ocean-project.eu/



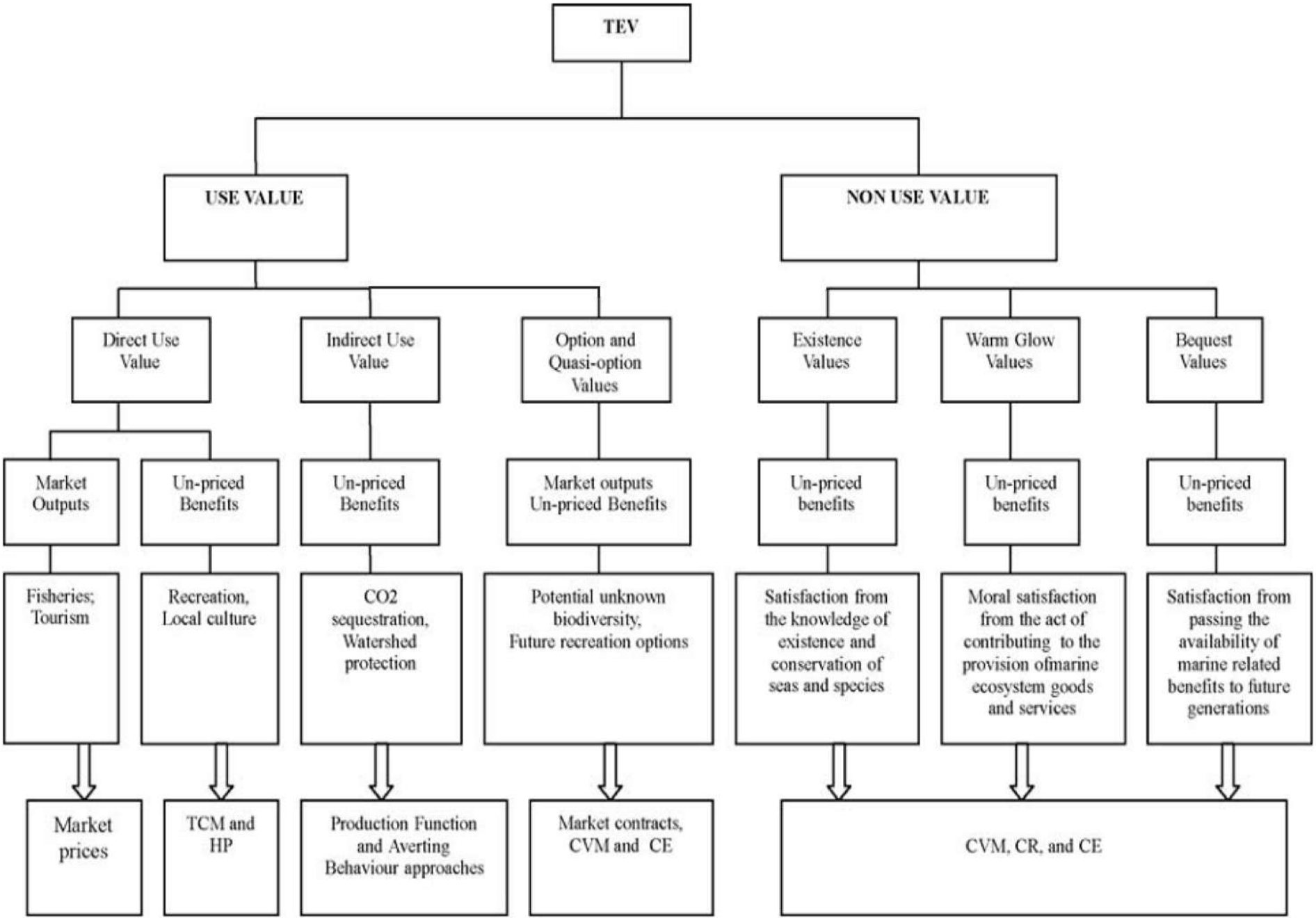
Innovative multi-purpose offshore platforms: planning, design and operation

http://www.mermaidproject.eu/

Modular multi-use deep water offshore platform harnessing and servicing Mediterranean, subtropical and tropical marine resources

http://www.troposplatform.eu/

TEV Example: Marine Resources



MISEA: Methodology for Integrated Socio-Economic Assessment based on Marine Ecosystem Services

- EU Marine Strategy Framework Directive (MSFD): good environmental status of the EU's marine waters.
- MISEA provides decision-makers with a decision tool to assess whether a MUOP project increases ***overall social welfare*** and hence should be undertaken.
- MISEA electronic decision tool:

Engineers, Lawyers, Institution & Stakeholders Analysts

A. Technical Feasibility Assessment (TFA)

Ecologists and Marine Scientists

B. Environmental Impact Assessment (EIA)

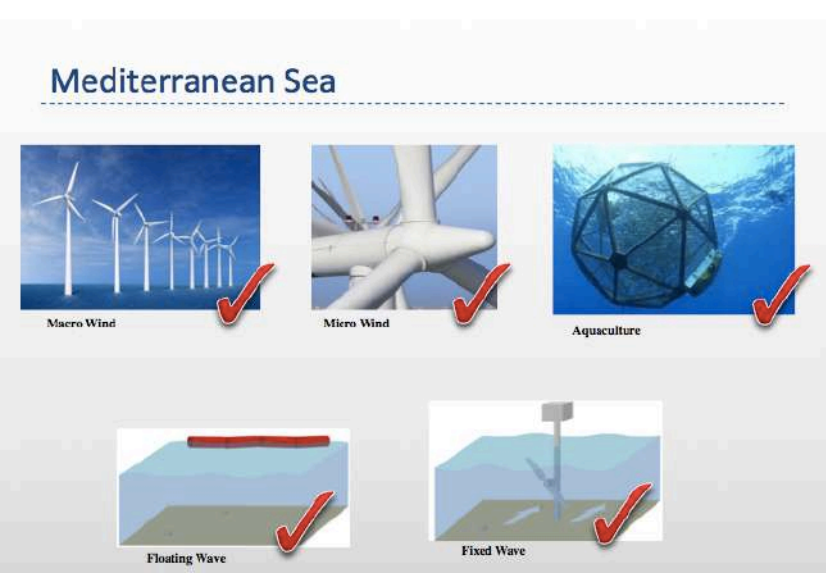
Economists

C. Financial and Economic Assessment (FEA)

D. Social Cost Benefit Analysis (SCBA)

Results:

http://www.madgik.di.uoa.gr/mermaid/?q=datasets



Benefit Transfer Method
Economic Valuation MOP Environmental Effects

• Effects: Biodiversity, Invasive Species, Renewable Energy, Eutrophication, Cultural and Recreational Values
EVRI™ DATABASE: Studies: Scientifically Sound, Relevant, Rich in detail

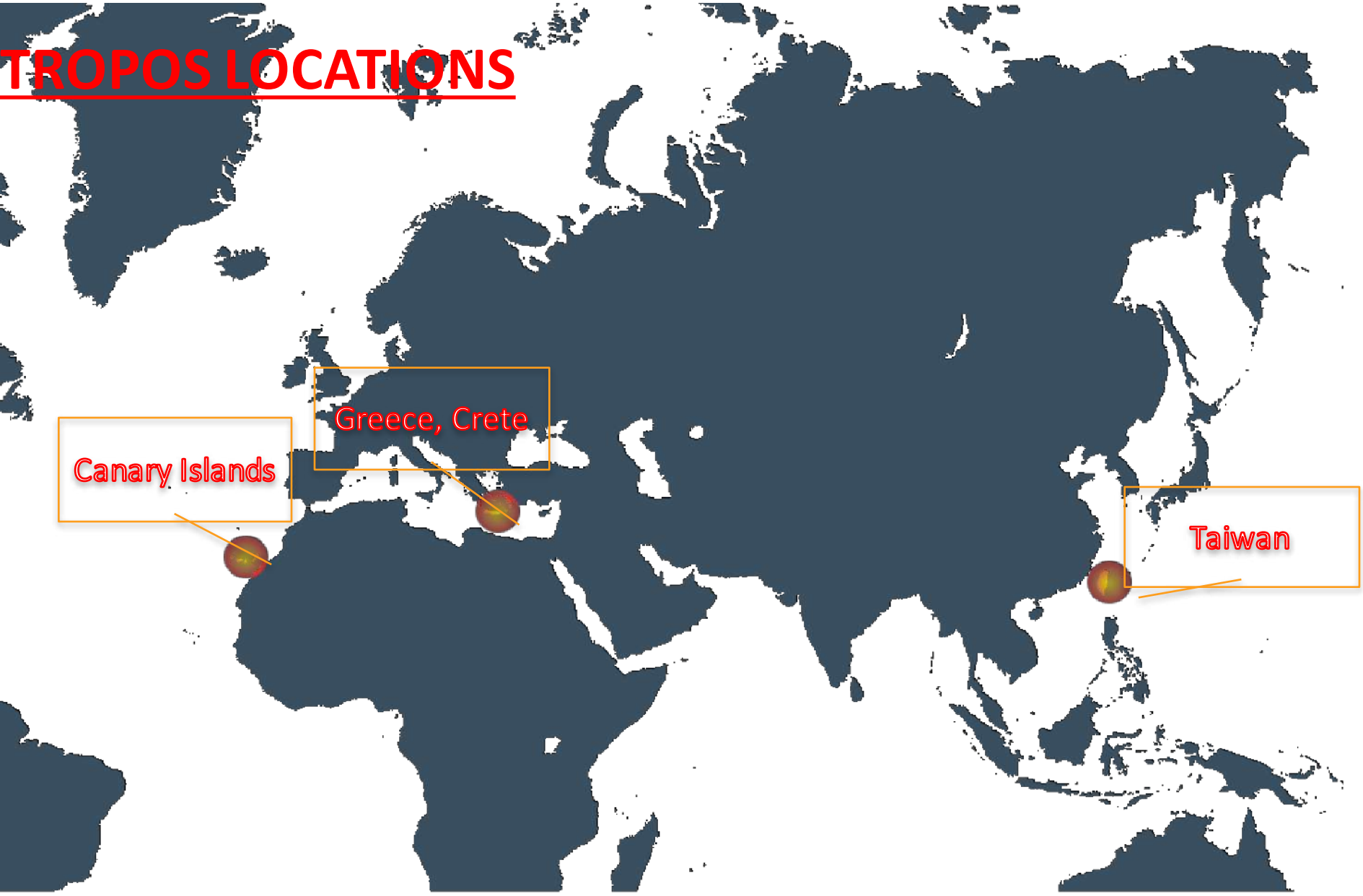
• Main Criteria:
i) the water body being a marine area
ii) focus on specific ecosystem services and their impacts
iii) location specific studies

• Adjust (time, income, GDP, Env. Conditions)
Willingness to pay to mitigate the negative effects
Willingness to pay to obtain the positive effects

Benefit Transfer Method
Economic Valuation MOP Environmental Effects

	Effects	WTPs Adjusted	Values Transferred	Authors
-	Mammals (Caretta Caretta, Monachus Monachus) – residents, tourists (Average Value)	76,51 €/household (one time payment)	70.61 €/household (one time payment)	Kaval P. et al. (2007)
-	*US studies marine mammals*	*40,97 €/household (lump sum payment)*	*61 $/household (lump sum payment)*	*Loomis et al. (2014)*
-	Bottlenose dolphin	19,83€/household/year	23.17$/household/year	Hageman (1986)
-	Harmful Algal Blooms	53,98€/household/year	45.79€/household/year	Stolte W. et al. (2003)
-	*Reduce Eutrophication*	*69,36*€/household/year *(average value)*	62.44€/household/year *(average value)*	*Ahtiainen H. et al. (2014)*
+	No Air pollution (energy projects)	23,74 €/household/year	£13.84/household/year	Bergmann et al. (2004)
+	Renewable Energy Sources	42,68€/household/year	43.09€/household/year	Zografakis et al. (2009)
-	Recreational Fishing (Venice Lagoon)	344,97 €/household/year	228.22€/household/year	Defrancesco E.et al. (2000)
+	Research and Education (Wetland)	10,05 €/household/year	9.47€/household/year	Birol et al (2006)
+	Job Creation (Urban)	1,95 €/job	£1.08/job	Bergmann et al. (2004)

TROPOS LOCATIONS



Choice Experiment: Rank-Ordered Logit

- $\Pr\{y^{1b} > y^{2b} > y^{2w} > y^{1w} > y^{r}\} =$

  $\Pr\{y^{1b} | y^{1w}, y^{2b}, y^{2w}, y^{r}\} \Pr\{y^{2b} | y^{2w}, y^{1w}, y^{r}\}$

  $\times \Pr\{y^{2w} | y^{1w}, y^{r}\} \Pr\{y^{1w} | y^{r}\}$

- Under typical assumptions of a sequence of independent logit choice probabilities each full ranking gives the following product of logits:

$$\Pr(y^{1b} \succ y^{2b} \succ y^{2w} \succ y^{1w} \succ y^{r}) = \frac{\exp(v^{1b})}{\sum_{j \in 1b,2b,2w,1w,r} \exp(v^{j})} \times \frac{\exp(v^{2b})}{\sum_{j \in 2b,2w,1w,r} \exp(v^{j})} \times \frac{\exp(v^{r})}{\sum_{j \in 2w,1w,r} \exp(v^{j})} \times \frac{\exp(v^{2w})}{\sum_{j \in 2w,1w} \exp(v^{j})}$$

- *v:* indirect utilities of alternatives

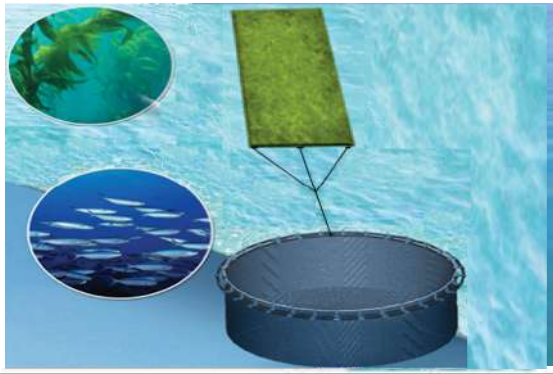
- Estimation:

$$L_i = \prod_{j=1}^{J} \left[\frac{\exp\{\mu_{ij}\}}{\sum_{k=1}^{J} \delta_{ijk} \exp\{\mu_{ik}\}} \right]$$

Choice Experiment: Liuqiu Island, Taiwan

- To elicit stakeholder preferences for alternative MUOPs designs:
  - Design 1. Aquaculture facilities (fish + algae)
  - Design 2. Aquaculture facilities + Renewable energy + Leisure facilities
- Two levels of mitigation impacts:
  - Optimal
  - Acceptable

Design 1. Aquaculture Facilities



Attributes	Description and economic impacts	Environmental Impacts	Levels	
Design 1: Aquaculture Facilities (Fish+Algae): Satellite Unit (not inside the platform)	Fish and Algae Aquaculture: 1,333 FTE positions and GDP impact of NT$ 1,660 million (€43.35 million)	**Solid and liquid wastes:** Major effect on water and sediment quality, benthos, fish and turtles, marine mammals and humans **Noise and vibrations:** fish and turtles and marine mammals, the mooring will significantly affect sediment dynamics. **Artificial lighting of the fish farm units:** pose a major impact on marine mammals, birds and bats, and fish and turtles. **Escape of fish from the fish cages and the introduction of alien species:** major impact for plankton, benthos, and fish and turtles	1	Acceptable reduction on environmental impacts
			2	Optimal levels of conservation and high visitor satisfaction

Design 2. Aquaculture Facilities + Renewable Energy: OTEC plant + Leisure Facilities

Attributes	Description and economic impacts	Environmental impacts	Mitigation levels
Design 2: Aquaculture Facilities (Fish+Algae): Satellite Unit (not inside the platform)+ +Renewable Energy: OTEC plant not inside the platform +Leisure Facilities (Accommodation +Food and Beverage)	Fish and Algae Aquaculture: 1,333 FTE positions and GDP impact of NT$ 1,660 million (€43.35 million)	**Solid and liquid wastes:** Major effect on water and sediment quality, benthos, fish and turtles, marine mammals and humans **Noise and vibrations:** fish and turtles and marine mammals, the mooring will significantly affect sediment dynamics. **Artificial lighting of the fish farm units:** pose a major impact on marine mammals, birds and bats, and fish and turtles. **Escape of fish from the fish cages and the introduction of alien species:** major impact for plankton, benthos, and fish and turtles	1 Acceptable reduction on environmental impacts 2 Optimal levels of conservation and high visitor satisfaction
	Renewable Energy + Accomodation, restaurant, sky lounge, garden and store	**Heat energy:** major effect on water temperature and the pelagic flora and fauna. **Solid and liquid wastes:** Major effect on water and sediment quality, benthos, fish and turtles, marine mammals and humans	

Table 3-3: Sample size for Choice Modelling

Choice Cards	Pilot Survey	Final Survey
Residents	9	61
Tourists	11	169
Total	20	230

Table 3-4: Sample distribution among villages

Village	Population	Proportion	Choice Cards	
			Optimal number	Actual number
Shangfu	1926	16%	9	5
Dafu	1902	16%	9	14
Chungfu	1364	11%	8	8
Tienfu	1213	10%	6	7
Benfu	2402	20%	12	12
Sanfu	897	7%	5	2
Nanfu	1333	11%	7	6
Yufu	1114	9%	5	6
Total	12151	100%	61	61

Eliciting Stakeholders Preferences for Alternative MUOPs Designs:

Design 1: Aquaculture facilities (fish + algae)
Design 2: Aquaculture facilities+ Renewable energy+ Leisure facilities

Two levels of mitigation impacts:
– Optimal
– Acceptable

Full Rank Preference Method with Visual Aids

PAYMENT VEHICLE FOR RESIDENTS:

- Local Tax increase (per year).
  - Respondents' contribution for sustainable pollution mitigation.
  - WTP to avoid environmental damage.
  - This attribute has five levels:
    a) 0 euro per year (status quo)
    b) 10 euros per year
    c) 20 euros per year
    d) 30 euros per year
    e) 40 euro per year.

PAYMENT VEHICLE FOR TOURISTS

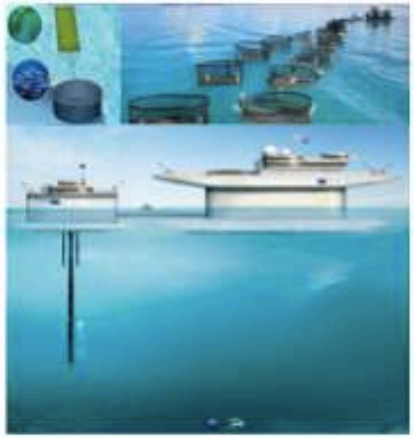
- Daily Tourist tax: an increase on holiday cost in Liuqiu Island per day.

- The levels for this attribute:
  a) 0 euro per day (status quo)
  b) 2 euros per day
  c) 4 euros per day
  d) 6 euros per day
  e) 8 euro per day

Choice card example Tourists (12 in total)

	Option A	Option B	Option C
Choice card 9	**Design 1** 	**Design 2** 	**I prefer the current status (no platform is installed)**
Environmental effects			
Extent of mitigation in aquaculture	Optimal mitigation of environmental impacts	Acceptable mitigation of environmental impacts	
Renewable energy and leisure facilities	Does not exist	Optimal mitigation of environmental impacts	
Daily tax	**NT$ 80 (€2.09)**	**NT$ 160 (€4.18)**	**0**
Which option do you prefer most?			
Which option do you prefer least?			

Choice card example Residents (12 in total)

	Option A	Option B	Option C
Choice card 9	**Design 2** 	**Design 2** 	I prefer the current status (no platform is installed)
Environmental effects			
Aquaculture	Optimal mitigation of environmental impacts	Acceptable mitigation of environmental impacts	
Renewable energy and leisure facilities	Acceptable mitigation of environmental impacts	Optimal mitigation of environmental impacts	
Annual tax increase	**NT$ 800 (€20.89)**	**NT$ 1,600 (€41.78)**	**0**
Which option do you prefer most?			
Which option do you prefer least?			

Variables explanation and values used in NPV estimation.

Variable			Unit	Value for each variable
B_t	Market benefit	GDP impact (OPEX aquaculture)	Million $NT	672
		GDP impact (OPEX aquaculture +leisure +energy)	Million $NT	1403
	Non-market benefit	Aquaculture	Million $NT	-996.62
		Aquaculture +leisure +energy	Million $NT	618.25
C_t		OPEX (aquaculture)	Million $NT	1565
		OPEX (aquaculture + leisure+ energy)	Million $NT	3192
R	Interest rate			0.04
T	Project life span		Year	20
I	CAPEX	Aquaculture	Million $NT	2759
		Aquaculture +leisure+energy	Million $NT	7724
	GDP impact of CAPEX	Aquaculture	Million $NT	955
		Aquaculture + leisure+ energy	Million $NT	2743

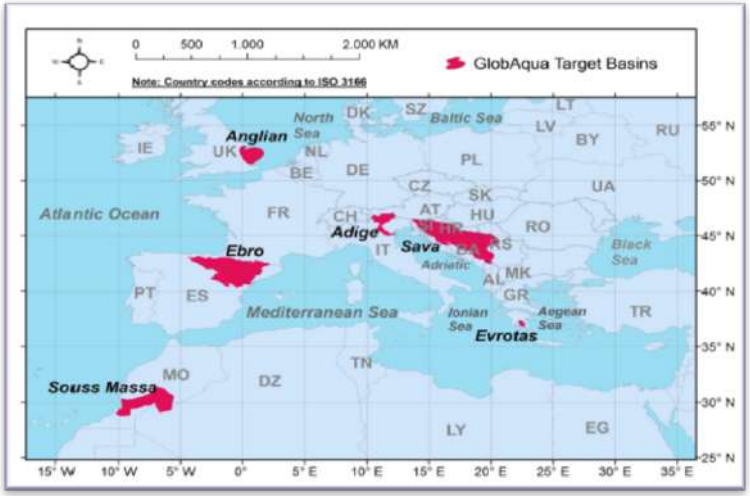
NPV for the platform with aquaculture only and for the platform with aquaculture, OTEC and leisure: with and without WTP for sustainable development r=4% and t=20 (unit: million $NT)

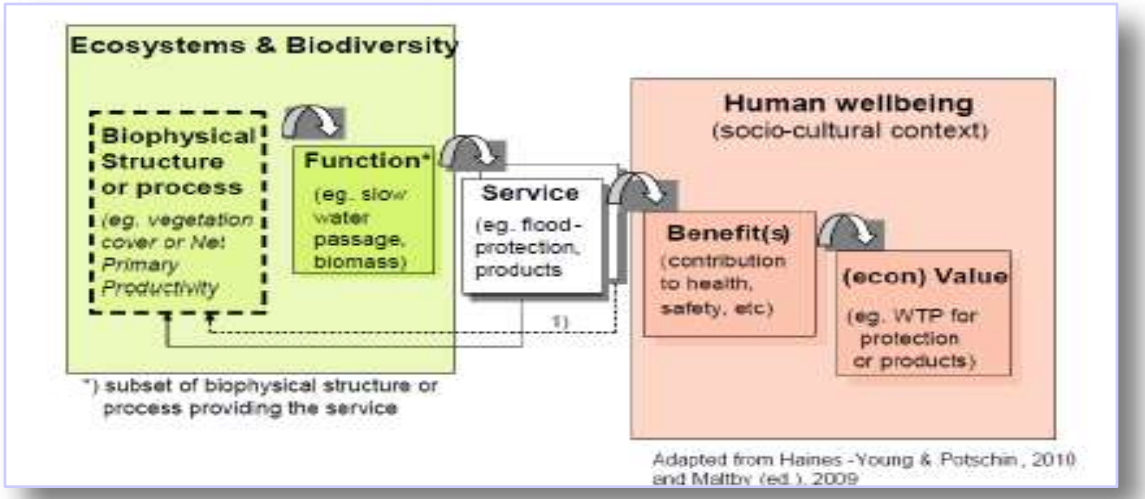
	Aquaculture		**Aquaculture+OTEC+leisure**	
	Without WTP for aquaculture	With WTP for aquaculture	Without WTP for sustainable development	With WTP for sustainable development
NPV	-13,940.47	-27,484.83	-29,294.41	-20,892.21

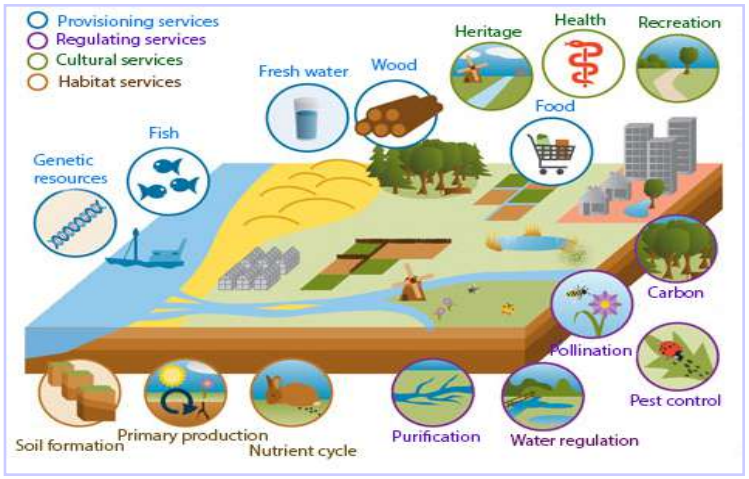
GLOBAQUA

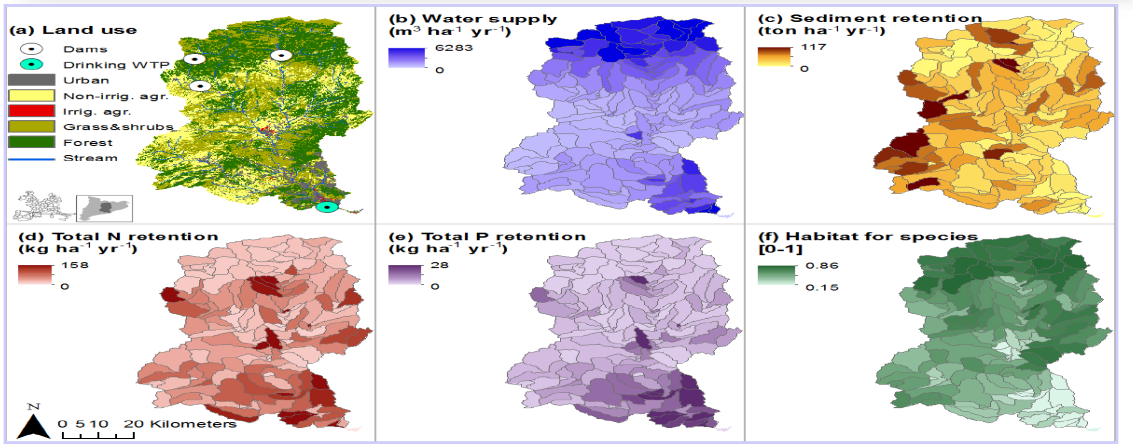
Managing the effects of multiple stressors on biodiversity and functioning of aquatic ecosystems

http://www.globaqua-project.eu, Budget: 10,000,000 euro







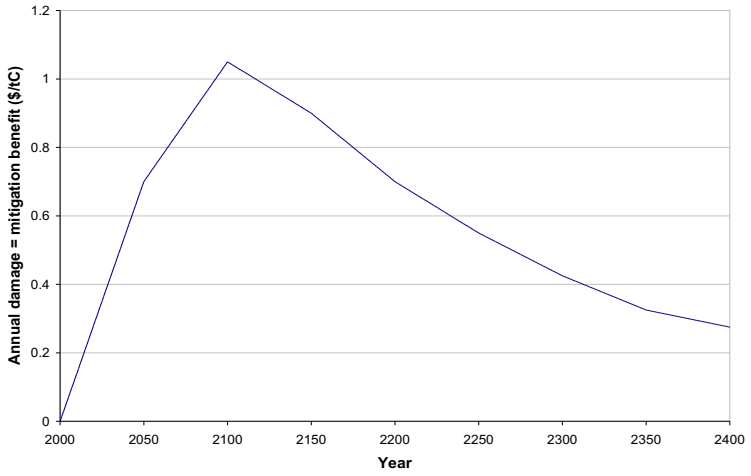


The Value of Distant Benefits: The socially efficient discount rate
Various Sources of Funding: National Governments, OECD, WB

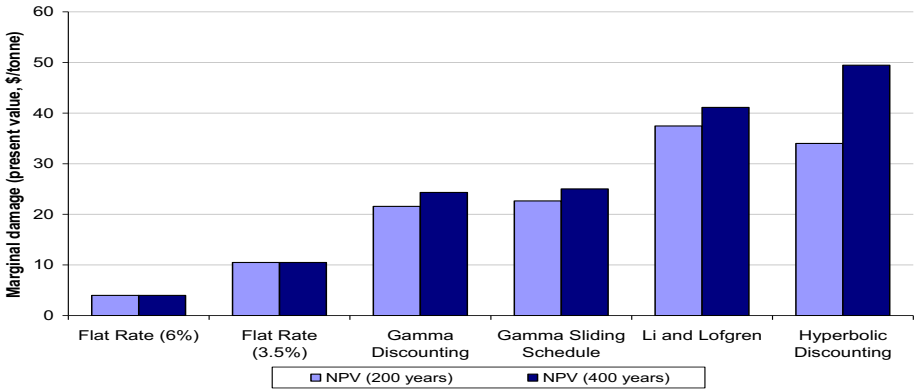
Sustainability, WCED, 1987.

There is something awkward about discounting benefits that arise a century hence. For even at a modest discount rate, no investment will look worthwhile. The Economist, 1991.

Damage from 1 tone of CO2 emission



Discounted Marginal Damage of CO2 emission



Series of Koundouri et. al papers:

Period of Years	Discount Rate (%)
0 – 30	3.5
31 – 75	3.0
76-125	2.5
126-200	2.0
201-300	1.5
301 +	1.0

The Value of Distant Benefits
Discount Rate for CBA, Ramsey Formula extended for Risk & Uncertainty
[series of papers by Koundouri et al.)

In an Uncertain Environment:

- Persistent shocks on the growth rate of consumption
- Persistent shocks on short-term interest rates
- Persistent shocks on growth expectations, translate into persistent shocks on interest rates

→ Determine the shape of the term structure of the socially efficient discount rate & imply DDR.

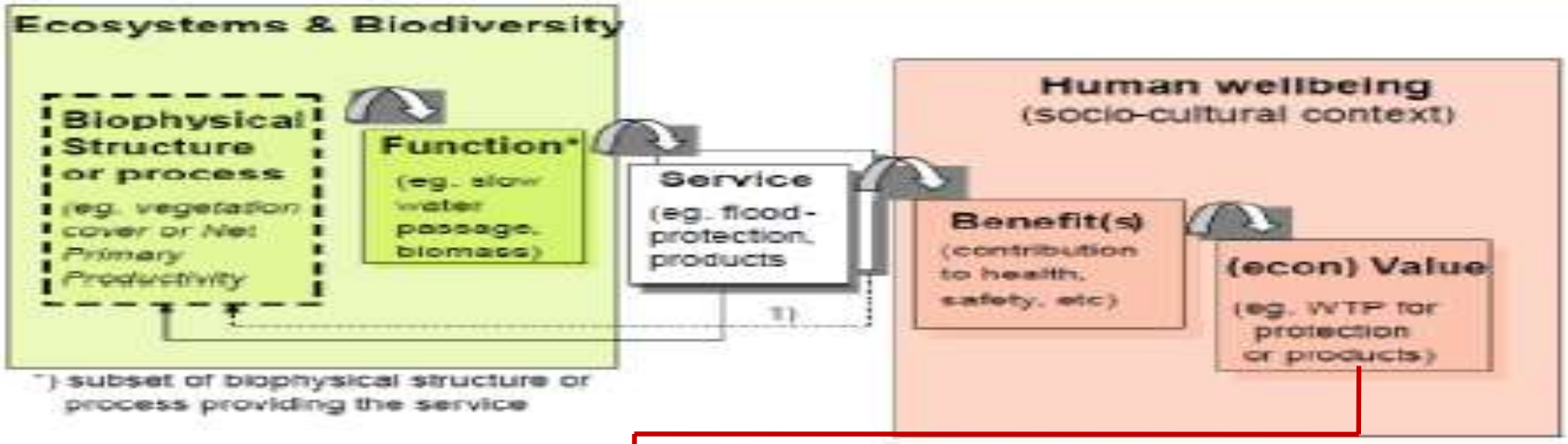
Estimate Theory Consistent DDR trajectory

- *Using Historical Data*
- *Without Structural Model*
- *Using univariate time series regime switching models:*
  - *describe stochastic dynamics of the real IR*
  - *future properties of the IR are determined by its own past behaviour*

Information accumulation may transmit patterns of preferences towards Risk & Uncertainty: Influence time preferences & attitudes towards the environment.

As environment becomes more important and current generations care more about the future: DDR for PV of LR effects!

VALUATION OF GREEK BIODIVERSITY



TEV
ES-related Goods & Services

USE & OPTION

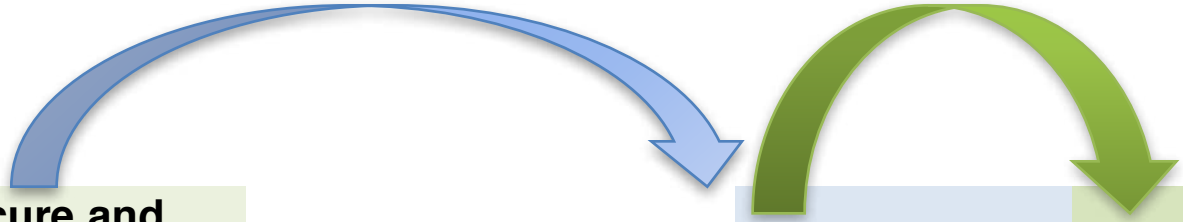
- Agriculture — Production Analysis
- Residential — Demand Analysis
- Industrial — Value Transfer
- Health — Lab experiment
- Recreation — Choice Experiment

PASSIVE

- Existence Value — Choice Experiment
- Bequest Value — Choice Experiment
- Warm Glow — Lab Experiment
- Altruistic — Lap Experiment

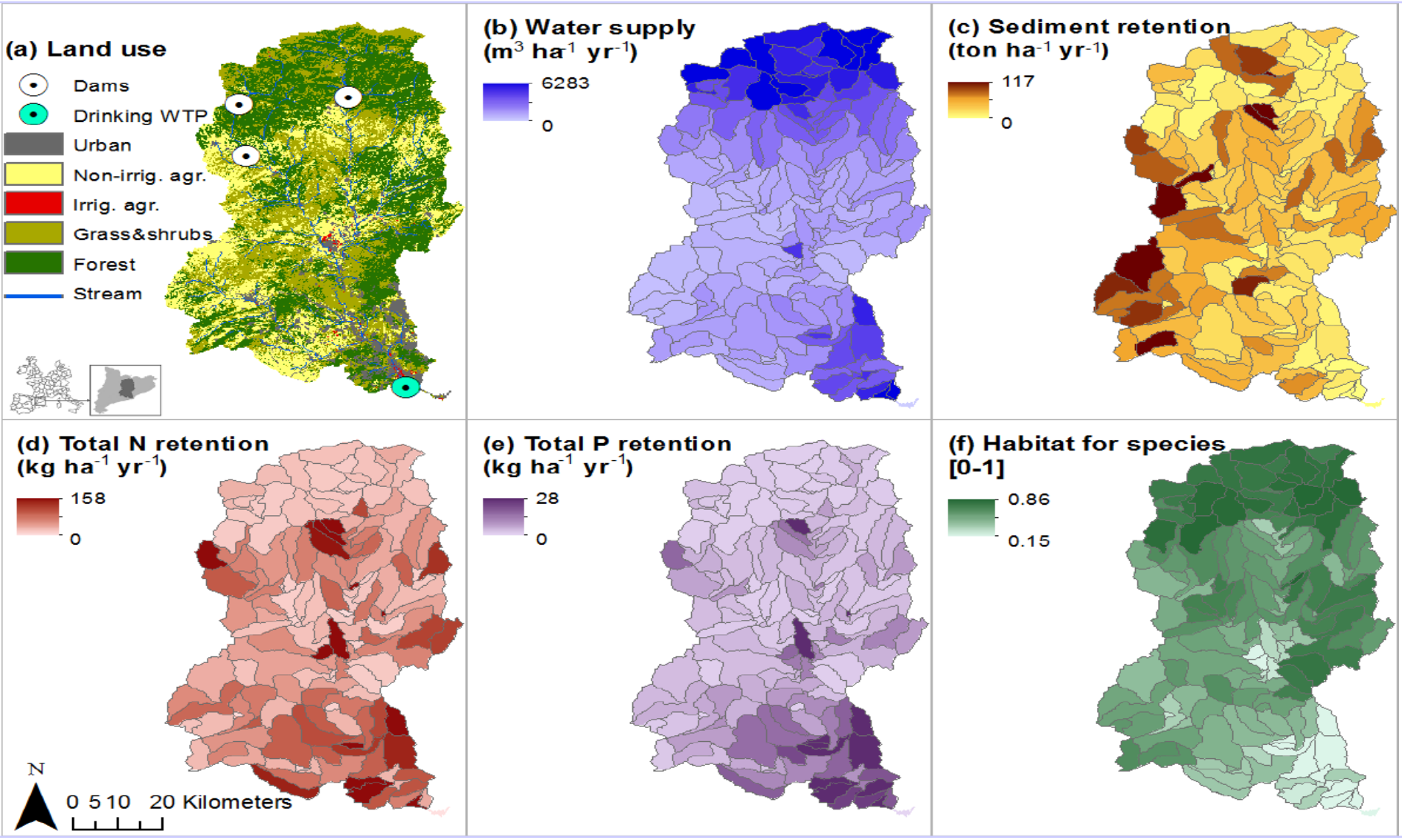
DSS: CBA (GIS + Over time: CC scenarios)

Institutions + Policy Recommendations

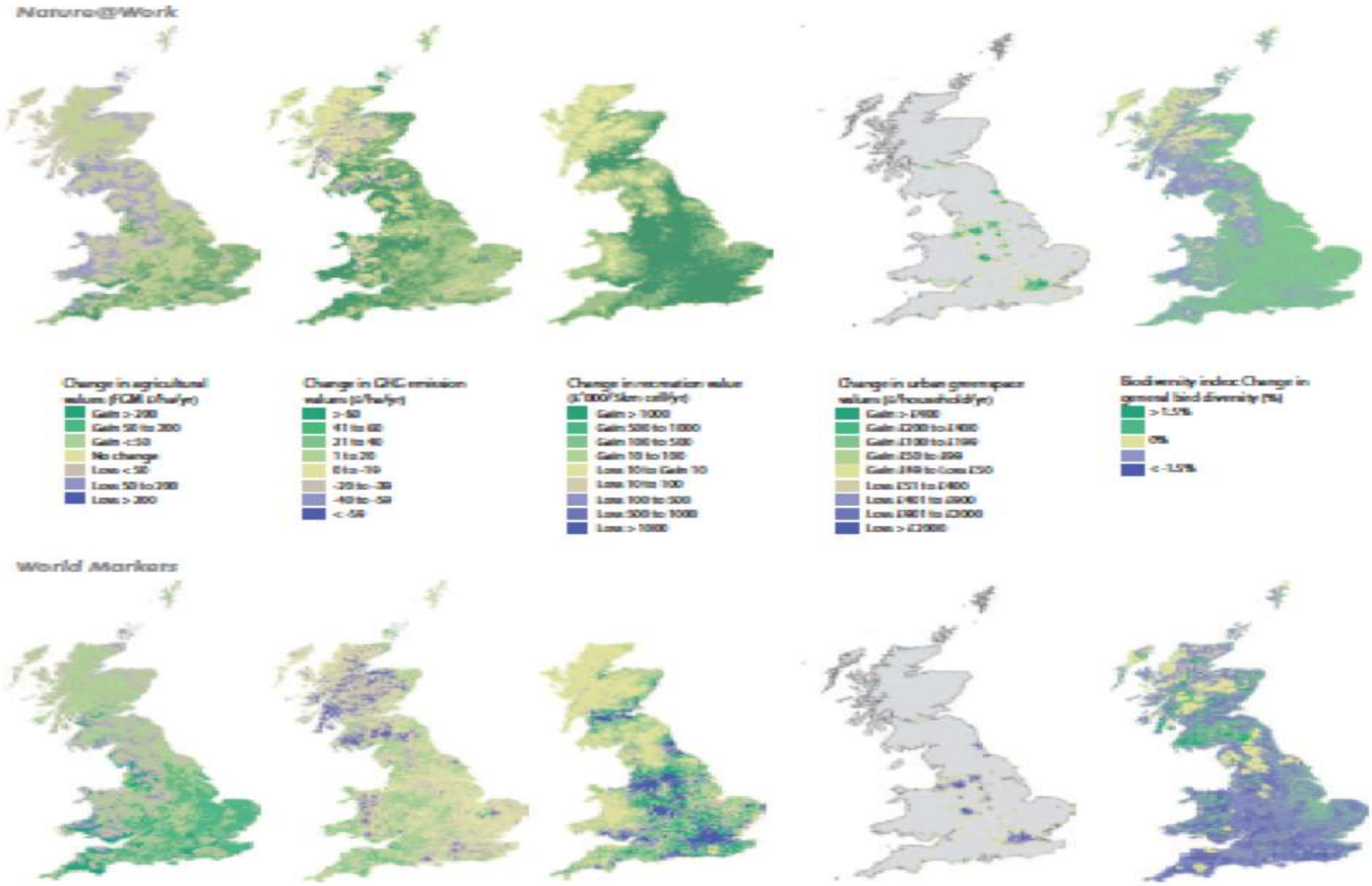


Biophysical strucure and process	Functions	Services	Benefits
Rainfall-vegetation interaction	Water provisioning	Water provisioning	Water for drinking purposes Water for irrigation purpose Hydropower production
Biotic and abiotic processes	Removal or breakdown of Oxenic nutrients and compounds	Waste treatment	Better surface water and groundwater quality Enjoyment of recreational areas Higher surface water quality
Vegetation and geomorphology	Sediment retention	Erosion protection	avoided soil losses Extension of water management infrastructures lifetime soil carbon storage Enjoyment of recreational areas
Habitat availability	Refugium for species and maintance of genetic diversity	Habitat for species	Existence/ conversation of genetic and species diversity

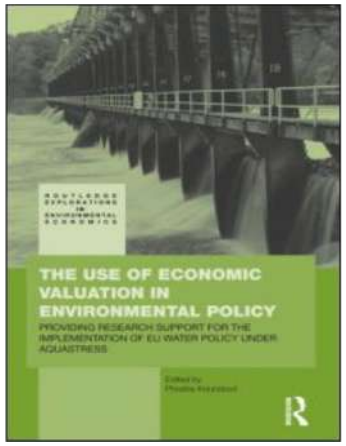
Ecosystem services in space

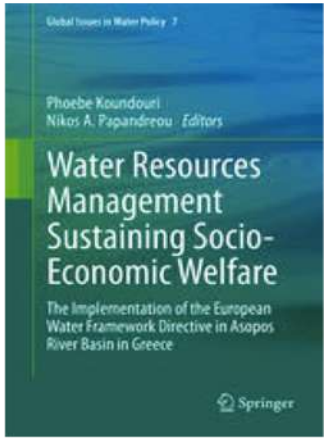


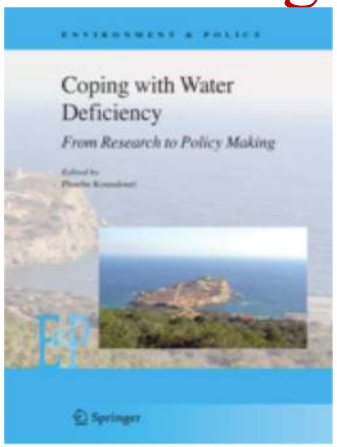
Ecosystem services and Values changes in time

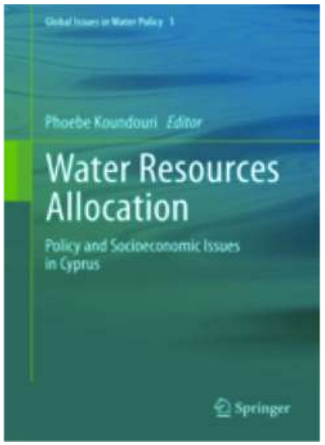


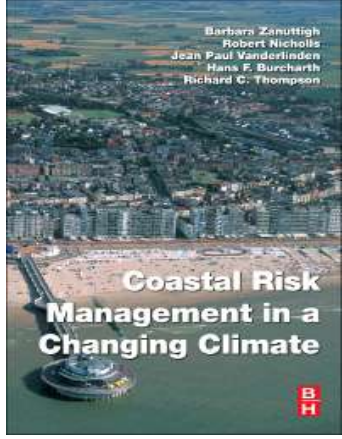
Published and Forthcoming Books

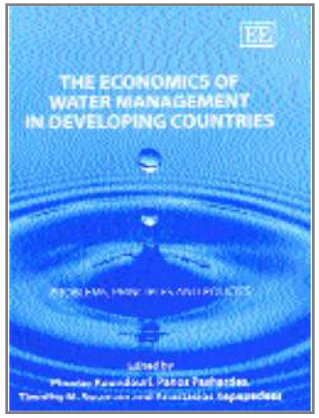


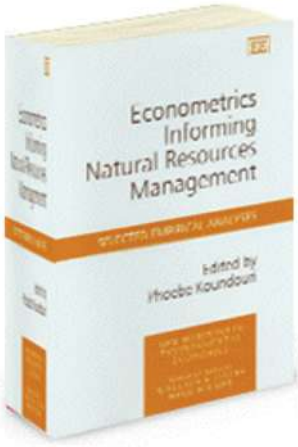


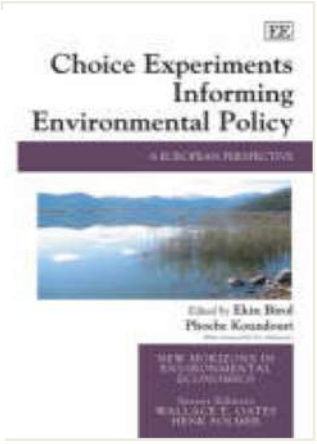


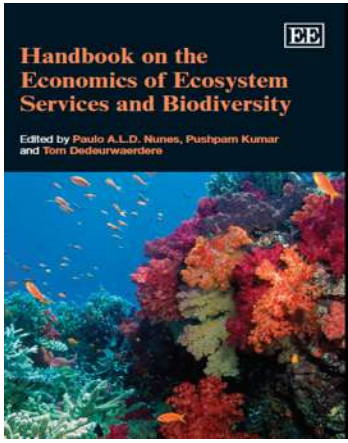


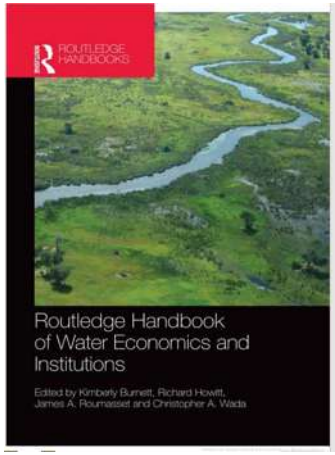












Forthcoming:

- Koundouri, P. (editor) Innovative Multi-Purpose Offshore Platforms: Economic Engineering and Ecological Perspectives. Springer Publishing, 2015.
- Koundouri, P. (editor) The Economics of Marine Energy Production: A framework of analysis and its application in European oceans. Springer Publishing, 2015.
- Markandya, A., and Koundouri, P. (editors) Fisheries Policy and Management. World Scientific Publishing, 2016.
- Koundouri, P. (editor) Handbook on Ecosystem Services and Water Resources Management. Cambridge Uni Press.