European Sediment Research Network
Acronym: SedNet
EC contract No.: EVK1-CT-2001-20002
Key action: 1.4.1 Abatement of water pollution from contaminated land, landfills and sediments

Annexes to the MINUTES OF THE WORKSHOP ON

Societal Cost Benefit Analysis and Sediments

18th-19th March 2004 in Warsaw, Poland

Hosted by:
The Warsaw Agricultural University
Faculty of Engineering and Environmental Science
Department of Hydraulic Engineering and Environmental Recultivation (WAU)

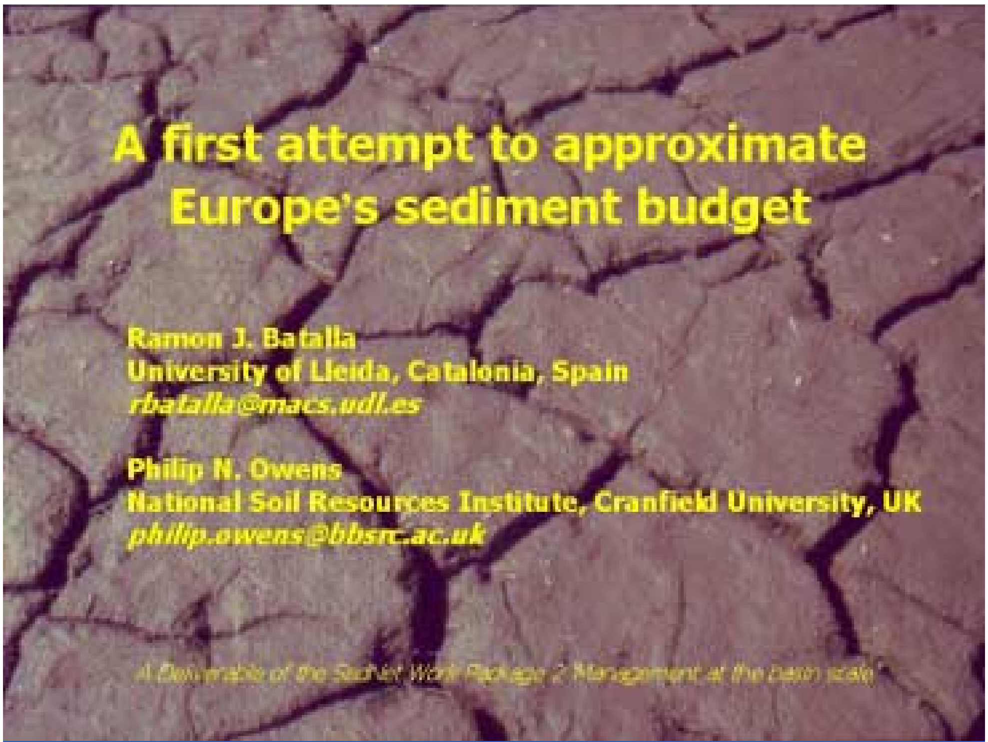
Organized by:
Sediment management at the river basin scale (WP2)
And
Coordination, synthesis, dissemination and stakeholders panel (WP1)

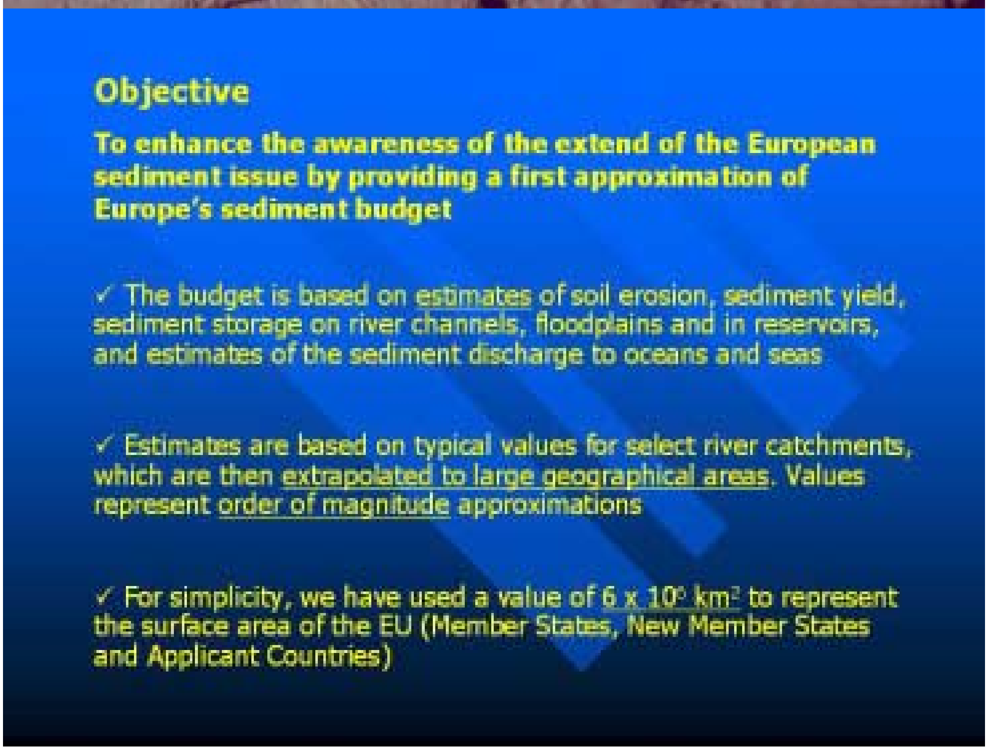
AUTHORS: Philip N. Owens, Adriaan Slob, Gerald Jan Ellen.

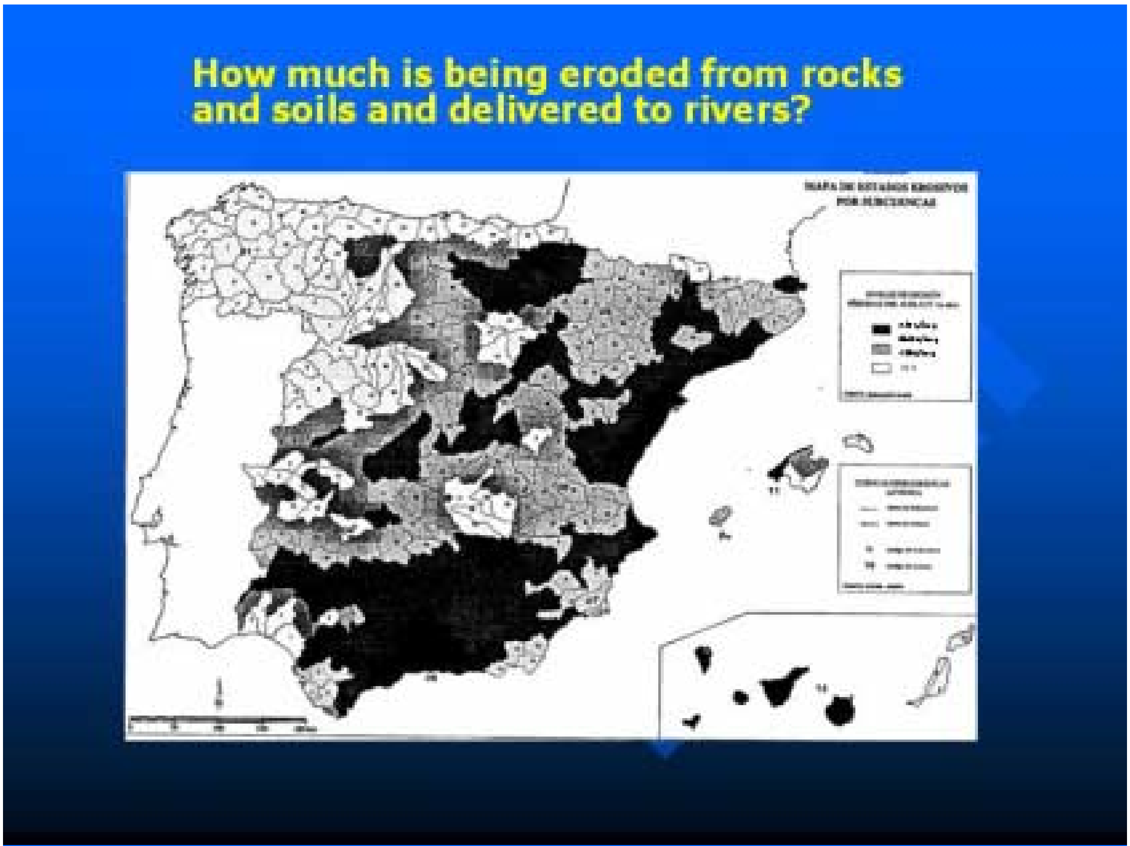
Agreed by the workshop attendees and the WP2 Core Group

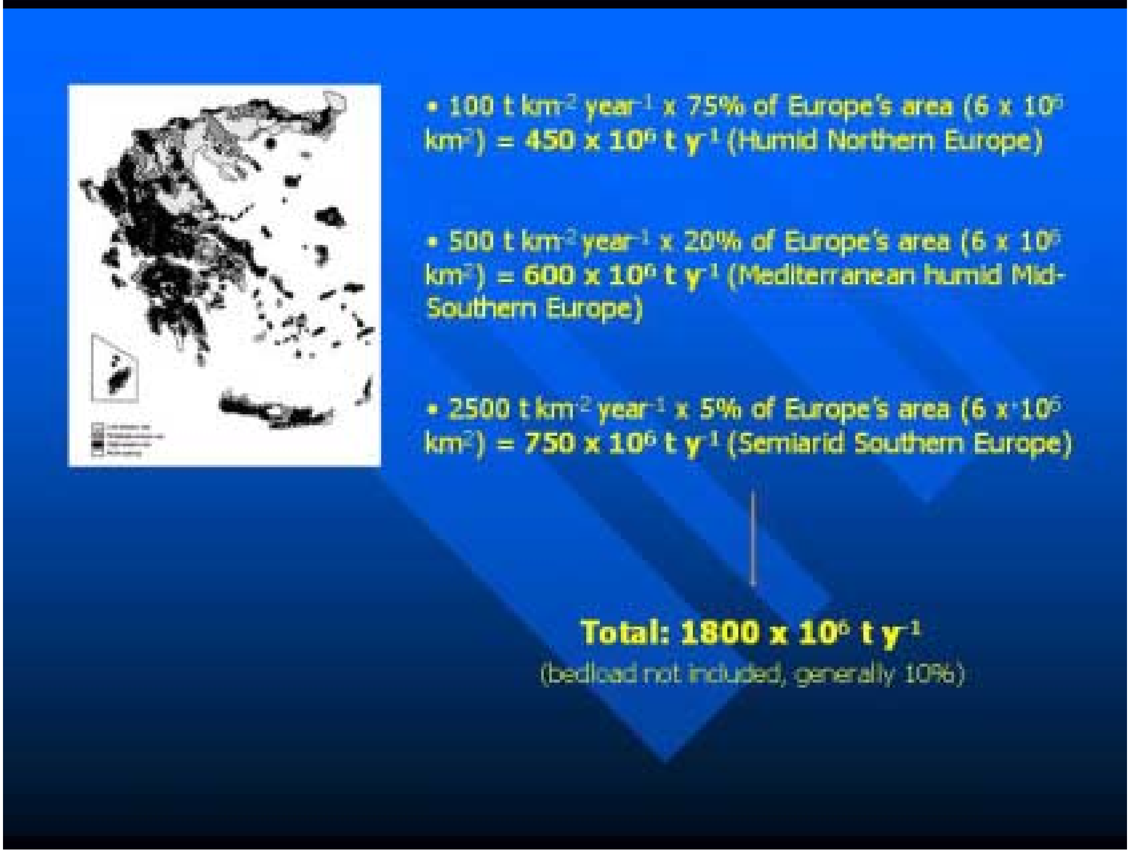
DATE: May 2004			Pages: 31

Annex I: Presentation on *A first attempt to approximate Europe's sediment budget* by Ramon J. Batalla, University of Lleida, Catalonia, Spain and Philip N. Owens, National Soil Resources Institute, Cranfield University, UK

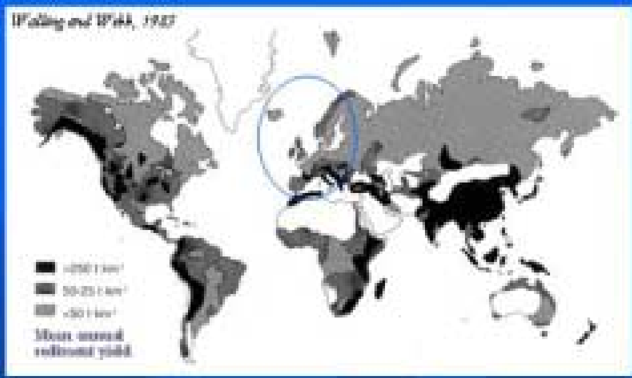





How much is being eroded from rocks and soils and delivered to rivers?


• 100 t km^{-2} year^{-1} x 75% of Europe's area (6 x 10^6 km^2) = 450 x 10^6 t y^{-1} (Humid Northern Europe)
• 500 t km^{-2} year^{-1} x 20% of Europe's area (6 x 10^6 km^2) = 600 x 10^6 t y^{-1} (Mediterranean humid Mid-Southern Europe)
• 2500 t km^{-2} year^{-1} x 5% of Europe's area (6 x 10^6 km^2) = 750 x 10^6 t y^{-1} (Semiarid Southern Europe)
Total: 1800 x 10^6 t y^{-1}
(bedload not included, generally 10%)

How much is being delivered from rivers to the seas?

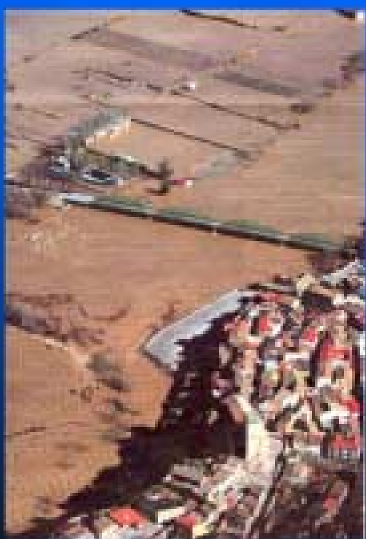


- 40 t km^{-2} y^{-1} x 60% of Europe's area (6 x 10^6 km^2) = **144 x 10^6 t y^{-1}**
- 150 t km^{-2} y^{-1} x 30% of Europe's area (6 x 10^6 km^2) = **270 x 10^6 t y^{-1}**
- 500 t km^{-2} y^{-1} x 10% of Europe's area (6 x 10^6 km^2) = **300 x 10^6 t y^{-1}**

Total: 714 x 10^6 t y^{-1}

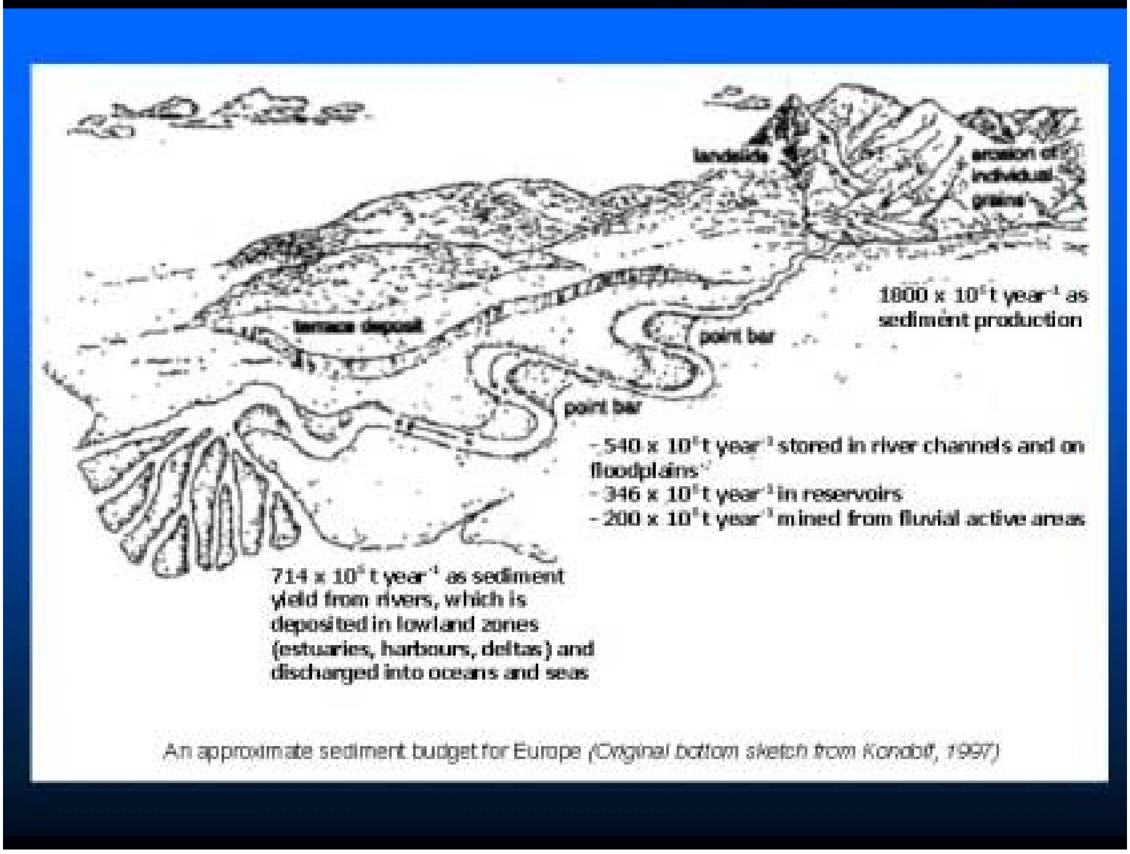
(bedload not included, generally 10%)

How much is stored/extracted in between production and deposition areas?

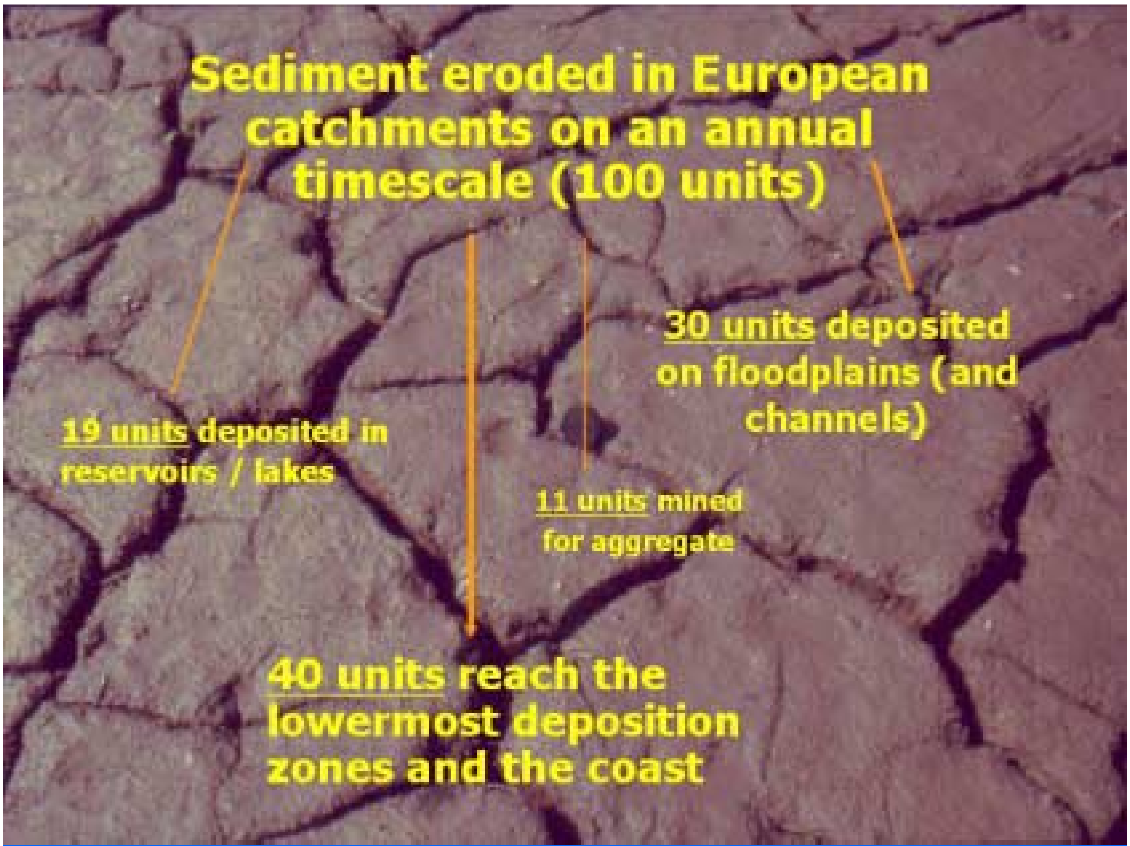


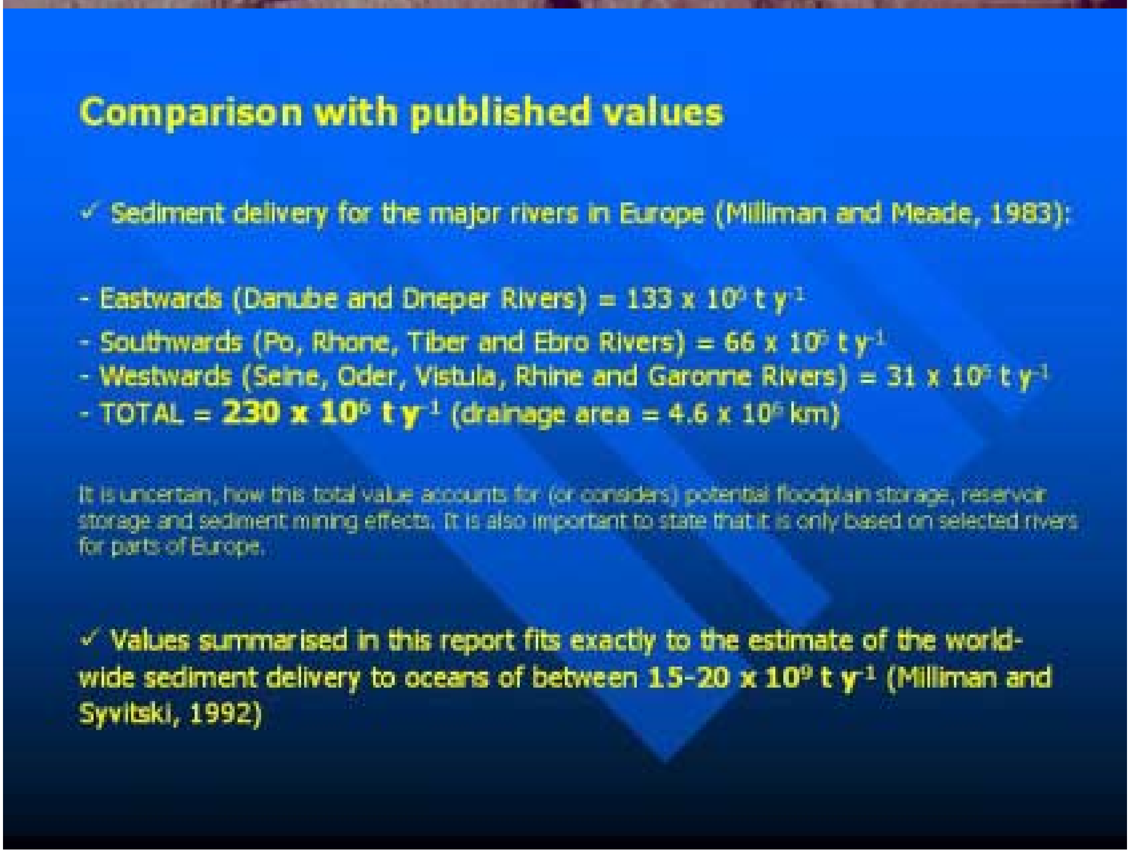
- In-channel storage of fine-grained sediment = 5% to 10% of the sediment delivered to rivers = **90 to 180 x 10^6 t y^{-1}**
- Floodplain sedimentation of fine sediment = 10% to 50% of the sediment delivered to rivers = **180 and 900 x 10^6 t y^{-1}** (Owens et al., 1999)
- Average estimate of floodplain and channel storage = **540 x 10^6 t y^{-1}**

(assuming that within-channel sediment storage does not represent a net loss to the system at the annual timescale)

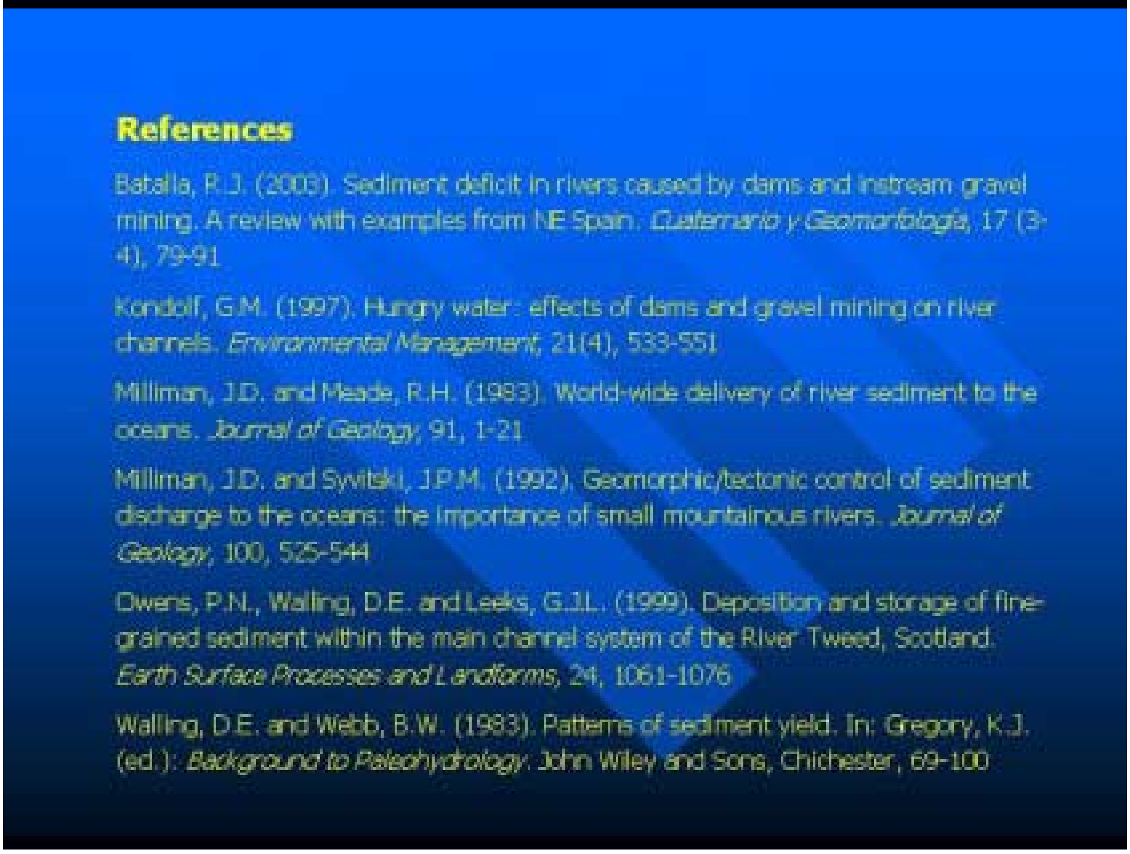


An approximate sediment budget for Europe *(Original bottom sketch from Kondolf, 1997)*

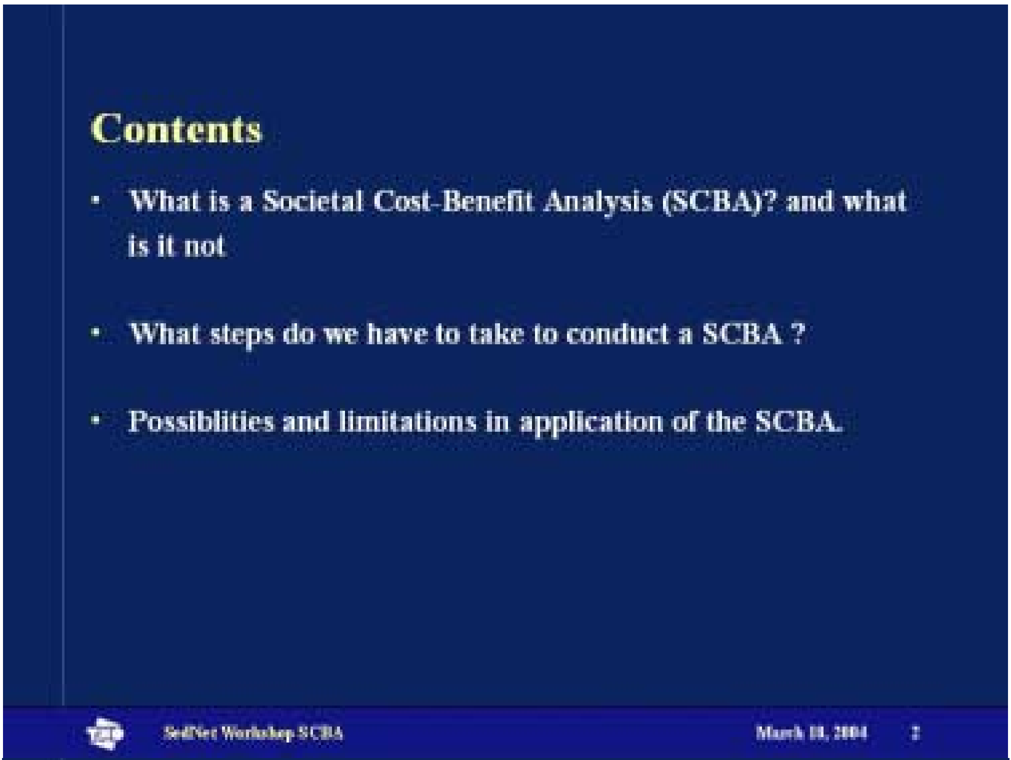

Sediment eroded in European catchments on an annual timescale (100 units)
30 units deposited on floodplains (and channels)
19 units deposited in reservoirs / lakes
11 units mined for aggregate
40 units reach the lowermost deposition zones and the coast

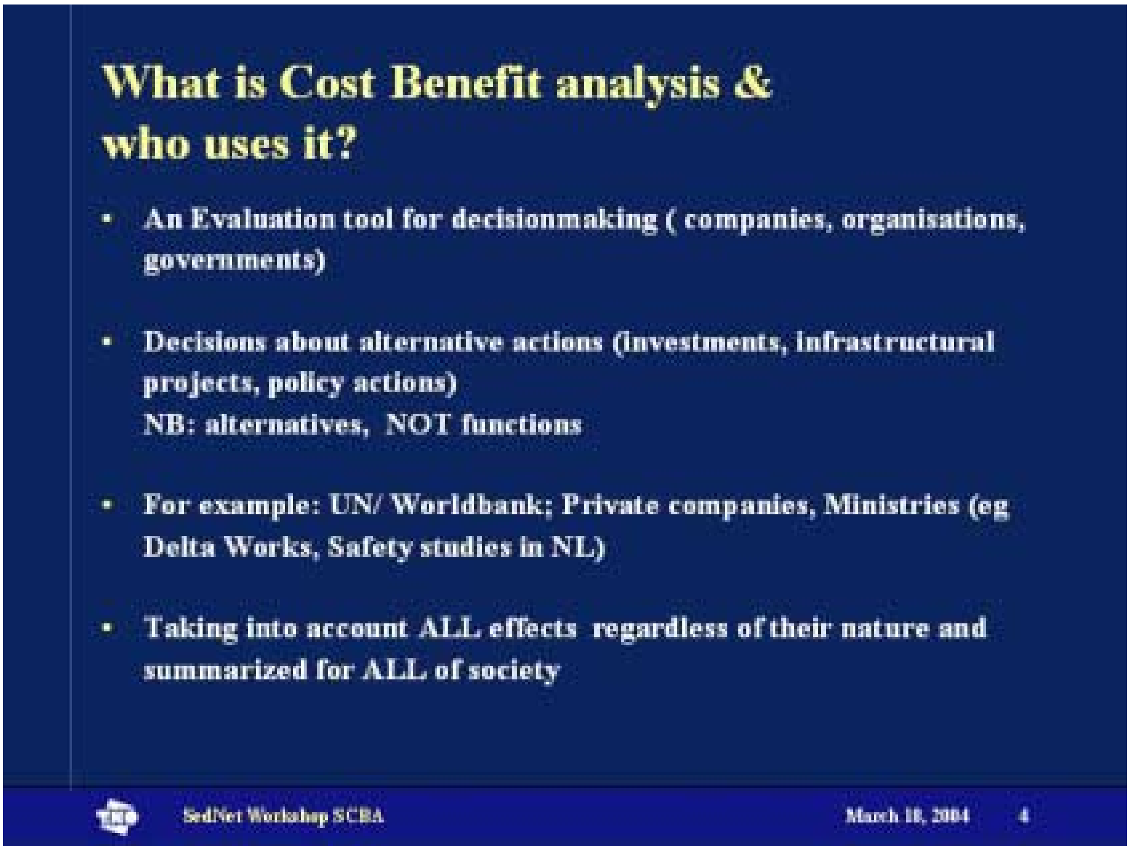

Comparison with published values
✓ Sediment delivery for the major rivers in Europe (Milliman and Meade, 1983):
- Eastwards (Danube and Dneper Rivers) = 133 x 10^6 t y^{-1}
- Southwards (Po, Rhone, Tiber and Ebro Rivers) = 66 x 10^6 t y^{-1}
- Westwards (Seine, Oder, Vistula, Rhine and Garonne Rivers) = 31 x 10^6 t y^{-1}
- TOTAL = 230 x 10^6 t y^{-1} (drainage area = 4.6 x 10^6 km)
It is uncertain, how this total value accounts for (or considers) potential floodplain storage, reservoir storage and sediment mining effects. It is also important to state that it is only based on selected rivers for parts of Europe.
✓ Values summarised in this report fits exactly to the estimate of the world-wide sediment delivery to oceans of between 15-20 x 10^9 t y^{-1} (Milliman and Syvitski, 1992)


Final remarks
✓ Estimations indicate orders of magnitude of each of the main sediment-related processes in rivers of Europe, and so considerable caution should be used with these values
✓ Uncertainty is high due to the lack of extensive, reliable and homogeneous data on sediment production, transport and deposition for all European river catchments
✓ Because of the limitations associated with the values presented, there exists a need for a comprehensive Europe-wide assessment of sediment fluxes and transfers within European rivers, and the delivery of sediment to the coastal zone


References
Batalla, R.J. (2003). Sediment deficit in rivers caused by dams and instream gravel mining. A review with examples from NE Spain. Cuaternario y Geomorfología, 17 (3-4), 79-91
Kondolf, G.M. (1997). Hungry water: effects of dams and gravel mining on river channels. Environmental Management, 21(4), 533-551
Milliman, J.D. and Meade, R.H. (1983). World-wide delivery of river sediment to the oceans. Journal of Geology, 91, 1-21
Milliman, J.D. and Syvitski, J.P.M. (1992). Geomorphic/tectonic control of sediment discharge to the oceans: the importance of small mountainous rivers. Journal of Geology, 100, 525-544
Owens, P.N., Walling, D.E. and Leeks, G.J.L. (1999). Deposition and storage of fine-grained sediment within the main channel system of the River Tweed, Scotland. Earth Surface Processes and Landforms, 24, 1061-1076
Walling, D.E. and Webb, B.W. (1983). Patterns of sediment yield. In: Gregory, K.J. (ed.): Background to Paleohydrology. John Wiley and Sons, Chichester, 69-100

Annex II: Presentation on *Societal Cost Benefit Analysis (SBCA) and Sediment Management* by Jaap van der Vlies TNO Strategy Technology and Policy, The Netherlands




What is Cost Benefit analysis & who uses it?
• An Evaluation tool for decisionmaking (companies, organisations, governments)
• Decisions about alternative actions (investments, infrastructural projects, policy actions)
NB: alternatives, NOT functions
• For example: UN/ Worldbank; Private companies, Ministries (eg Delta Works, Safety studies in NL)
• Taking into account ALL effects regardless of their nature and summarized for ALL of society
SedNet Workshop SCBA
March 18, 2004
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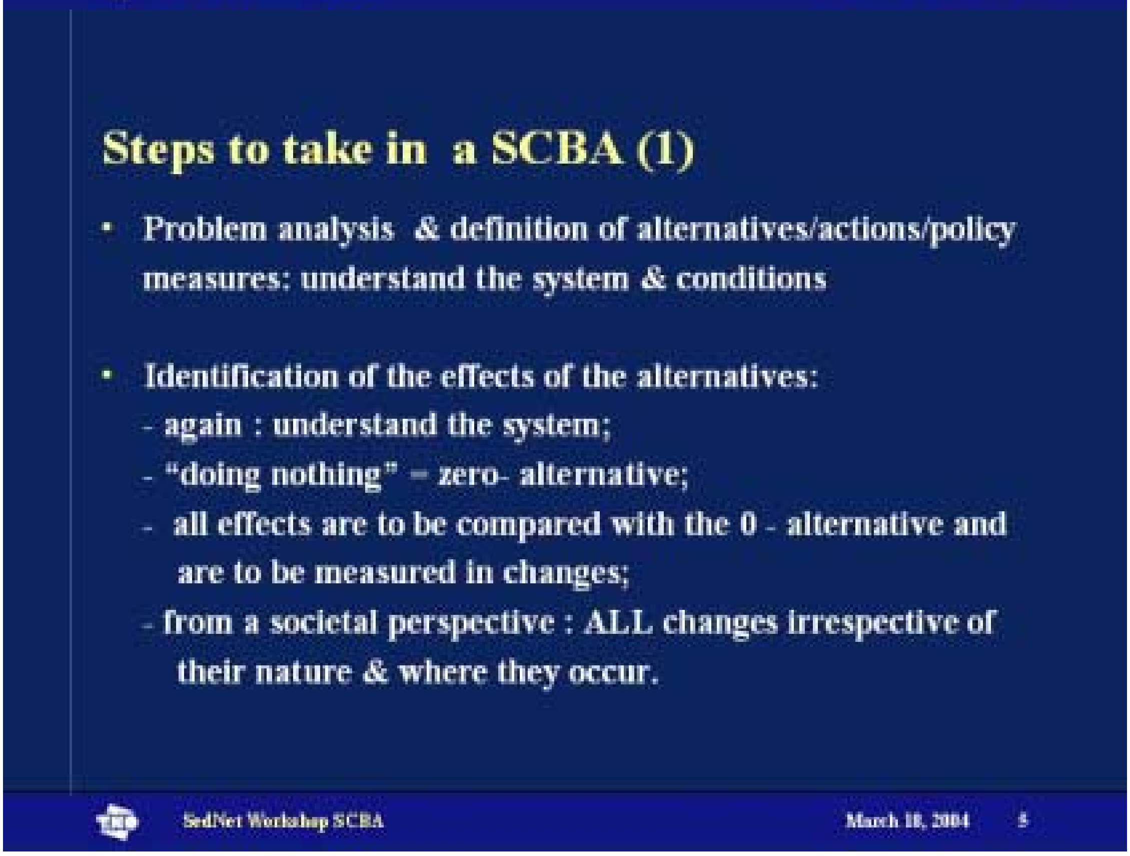
Steps to take in a SCBA (1)
• Problem analysis & definition of alternatives/actions/policy measures: understand the system & conditions
• Identification of the effects of the alternatives:
- again : understand the system;
- "doing nothing" = zero- alternative;
- all effects are to be compared with the 0 - alternative and are to be measured in changes;
- from a societal perspective : ALL changes irrespective of their nature & where they occur.
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Steps to be taken in a SCBA (2)

- Analysis of relevant exogenous developments
  (for the 0-alternative & sensitivity analysis)

- Quantification/valuation of the effects (costs & benefits) of the different alternatives; where possible in monetary terms
  - special attention for discounting
  - watch out for double counting & imponderables

- Ranking of alternatives according to Cost benefit ratio

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Possibilities & limitations

Possibilities

- In principle many possibilities to make choices transparant
- Stake holder involvement (to get information about the system & generating alternatives)
- To help comparisons of alternatives;
- Combines Disciplines

Limitations

- Profound understanding of the system one tries to influence (takes time)
- Stakeholders (& political agenda's) also need time, timing & their specific setting
- A SCBA makes no choices: only a ranking
- Communication of results is important

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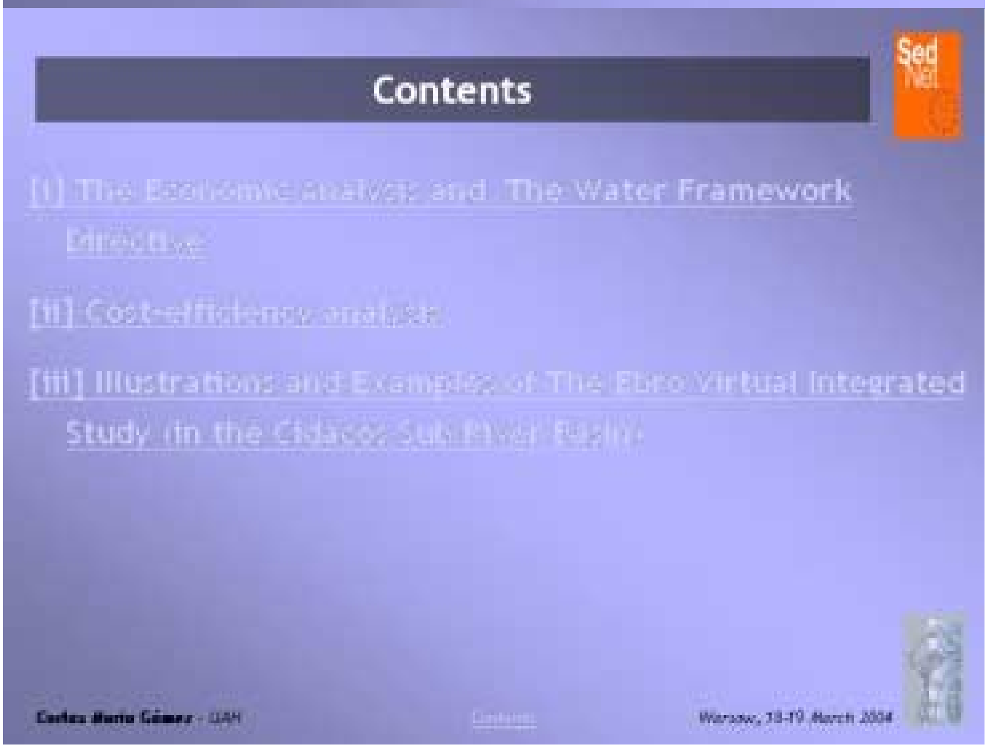
Annex III: Presentation on *Economic Analysis and River Basin Management* by Carlos Mario Gómez, Department of Economics, University of Alcalá Madrid, Spain



Economic Analysis in the WFD

For achieving its environmental objectives, i.e. good water status for all waters, in the most effective manner. The Water Framework Directive clearly integrates economic analysis into water management and policy making.

The Directive calls for:

- The identification of the economic significance of water uses.
- The application of economic principles (e.g. the polluter pays principle),
- The use of economic approaches and tools (e.g. cost-effectiveness analysis)
- The consideration of economic instruments (e.g. water pricing)
- The analysis of the recovery of the economic costs of providing water for different economic activities (Cost recovery analysis).

To be useful for decision-making, the different elements of the economic analysis should be well integrated in the policy decision and management cycle.

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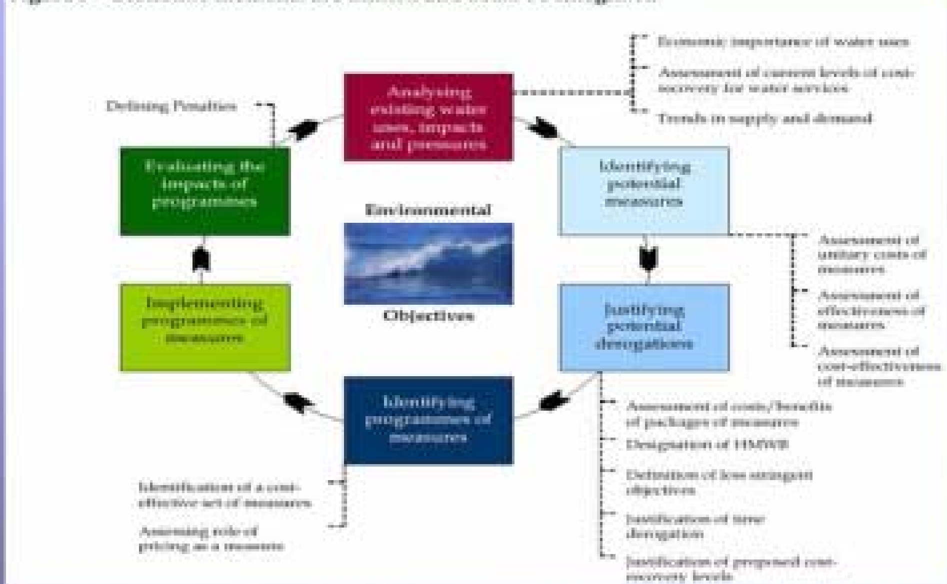
[i] Economic Analysys in the WFD implementation Process

Figure 3 – Economic Elements are Linked and Must be Integrated



Source: WATECO [2002] *The implementation challenge of the waterframework directive*

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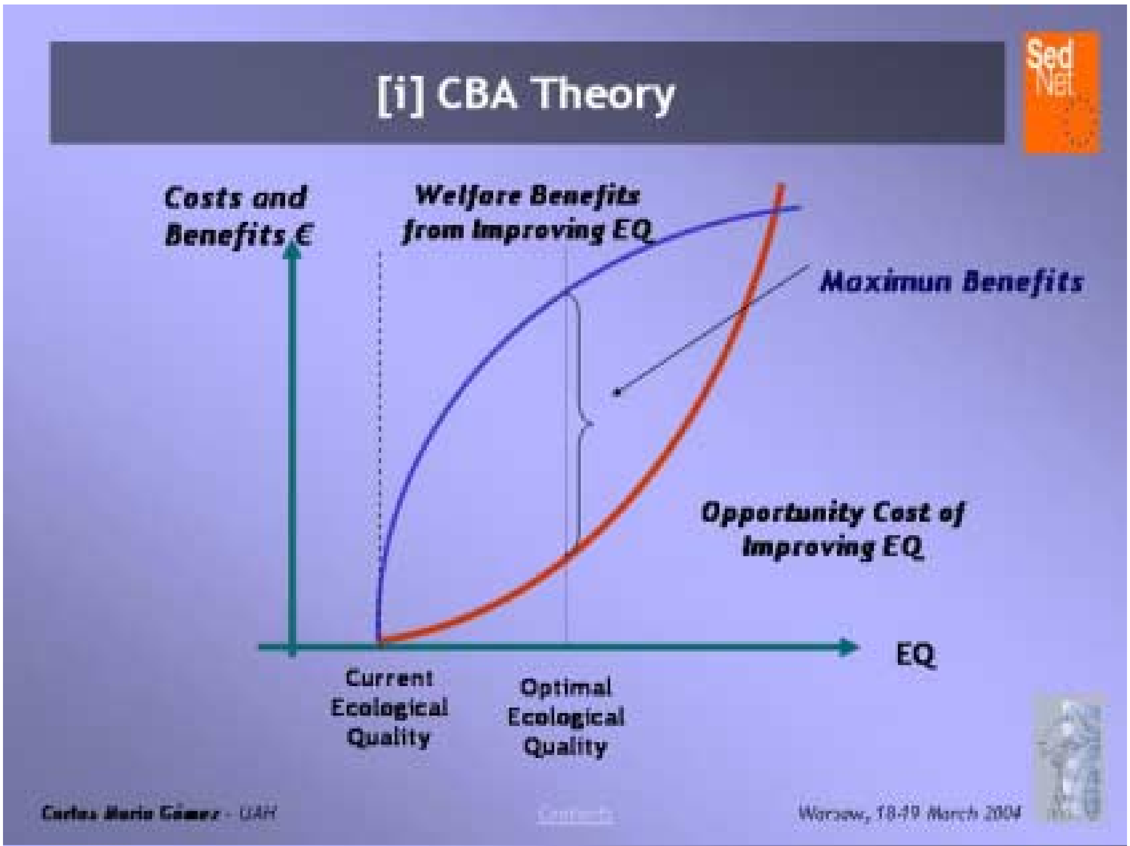
[i] CBA Theory
Costs and Benefits €
Welfare Benefits from Improving EQ
Maximun Benefits
Opportunity Cost of Improving EQ
EQ
Current Ecological Quality
Optimal Ecological Quality
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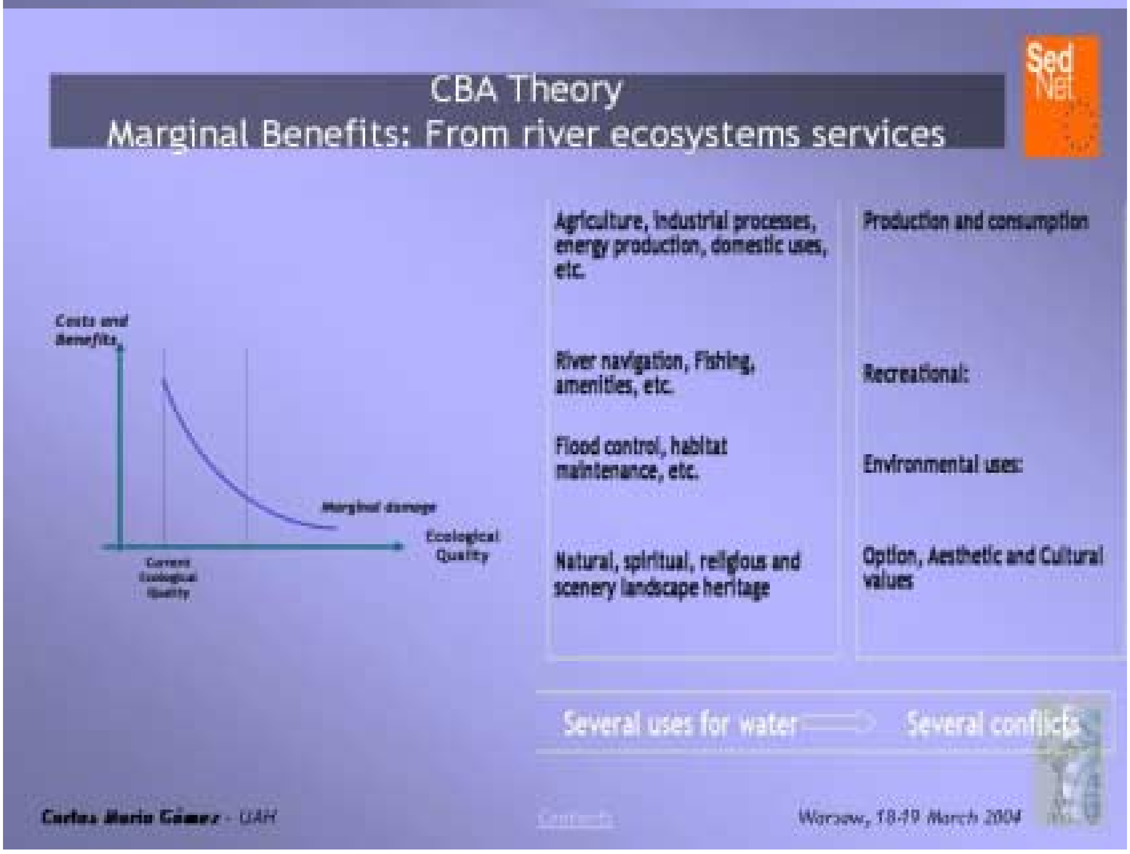
CBA Theory
Marginal Benefits: From river ecosystems services
Costs and Benefits
Marginal damage
Ecological Quality
Current Ecological Quality
Agriculture, industrial processes, energy production, domestic uses, etc.
Production and consumption
River navigation, Fishing, amenities, etc.
Recreational:
Flood control, habitat maintenance, etc.
Environmental uses:
Natural, spiritual, religious and scenery landscape heritage
Option, Aesthetic and Cultural values
Several uses for water
Several conflicts
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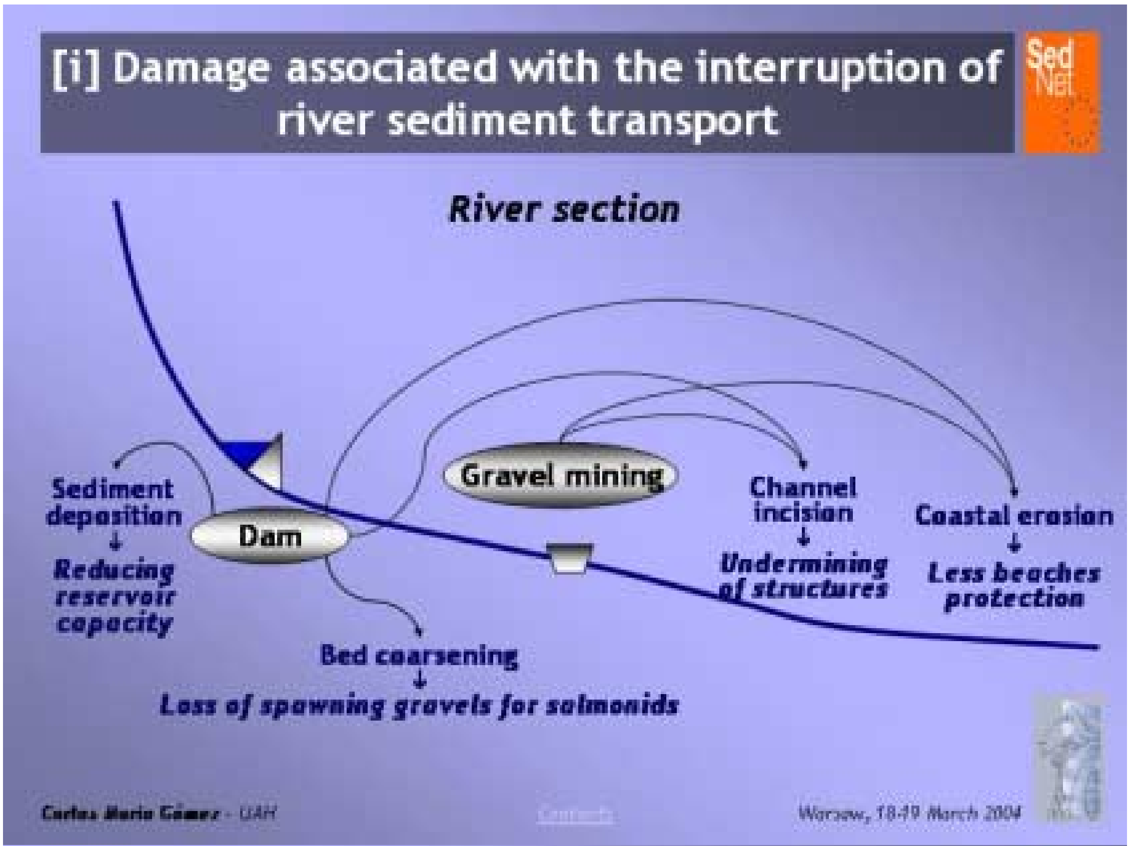
[i] Damage associated with the interruption of river sediment transport
River section
Sediment deposition
↓
Reducing reservoir capacity
Dam
Gravel mining
Channel incision
↓
Undermining of structures
Coastal erosion
↓
Less beaches protection
Bed coarsening
↓
Loss of spawning gravels for salmonids
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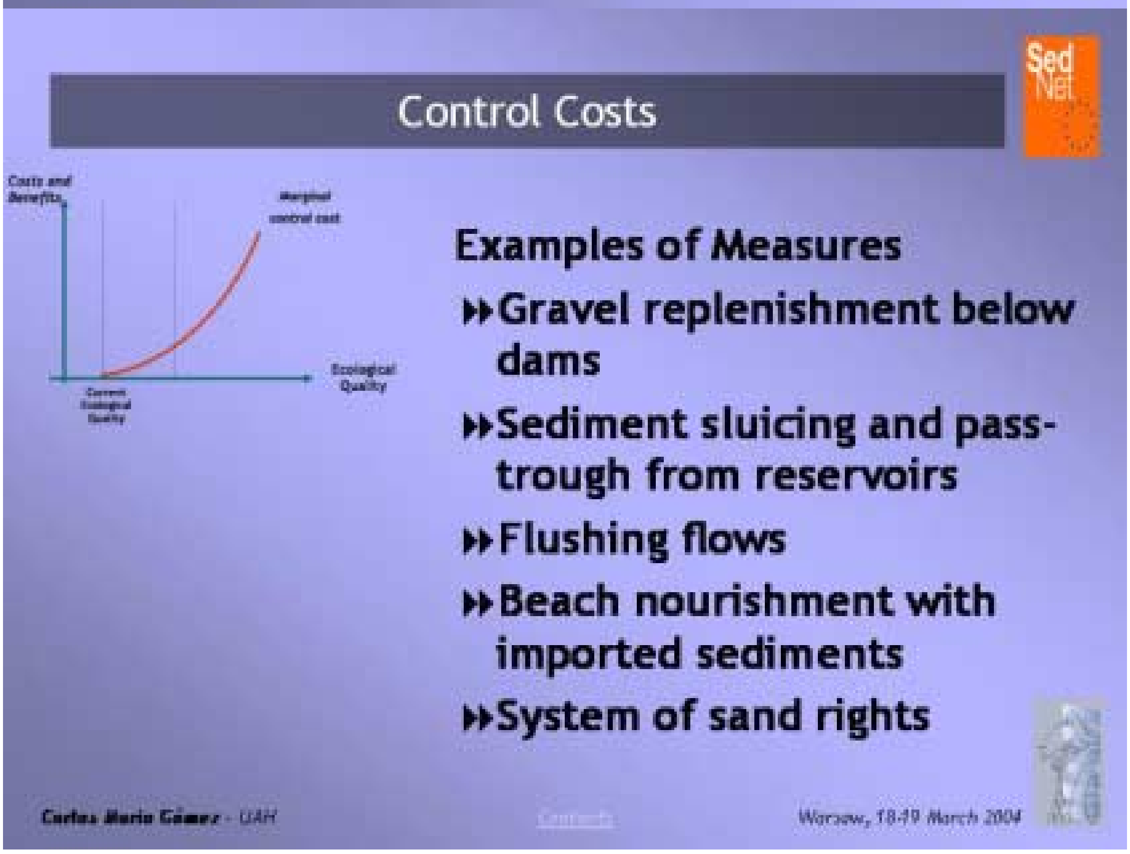
Control Costs
Costs and Benefits
Marginal control cost
Ecological Quality
Current Ecological Quality
Examples of Measures
Gravel replenishment below dams
Sediment sluicing and pass-trough from reservoirs
Flushing flows
Beach nourishment with imported sediments
System of sand rights
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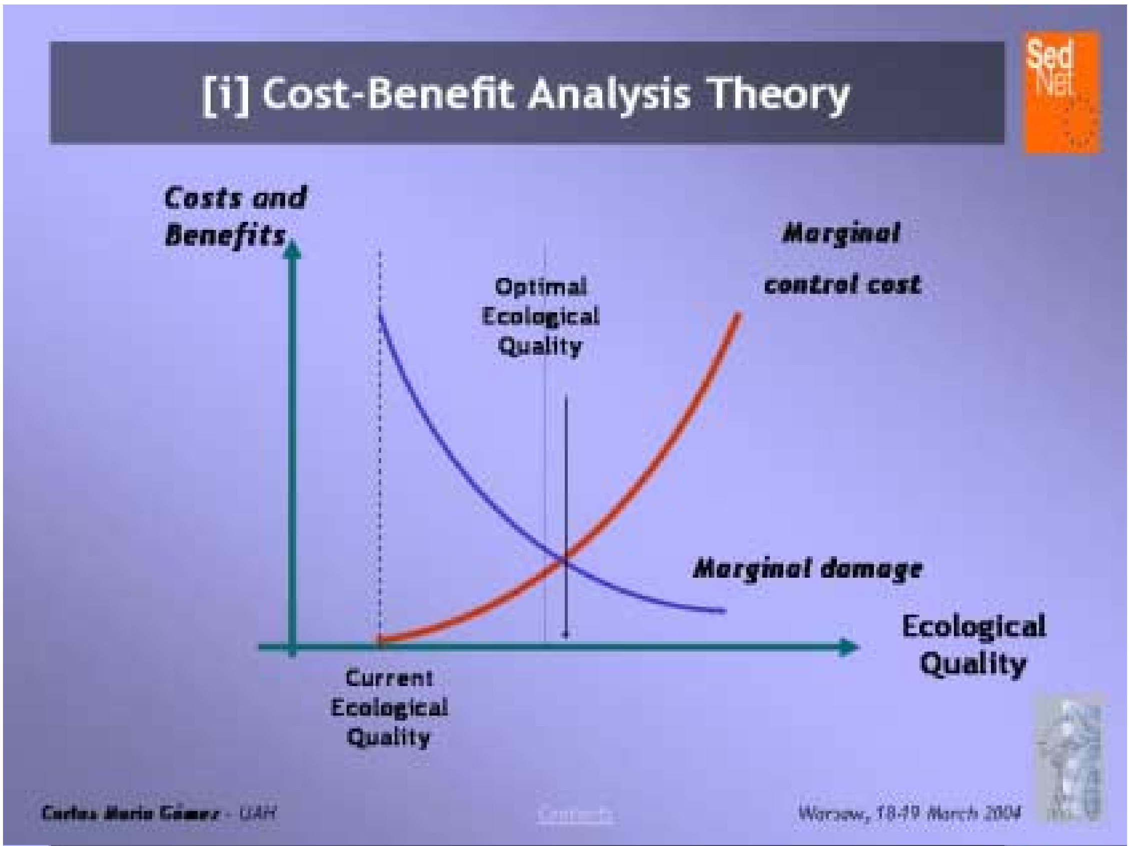
[i] Cost-Benefit Analysis Theory
Costs and Benefits
Marginal control cost
Optimal Ecological Quality
Marginal damage
Ecological Quality
Current Ecological Quality
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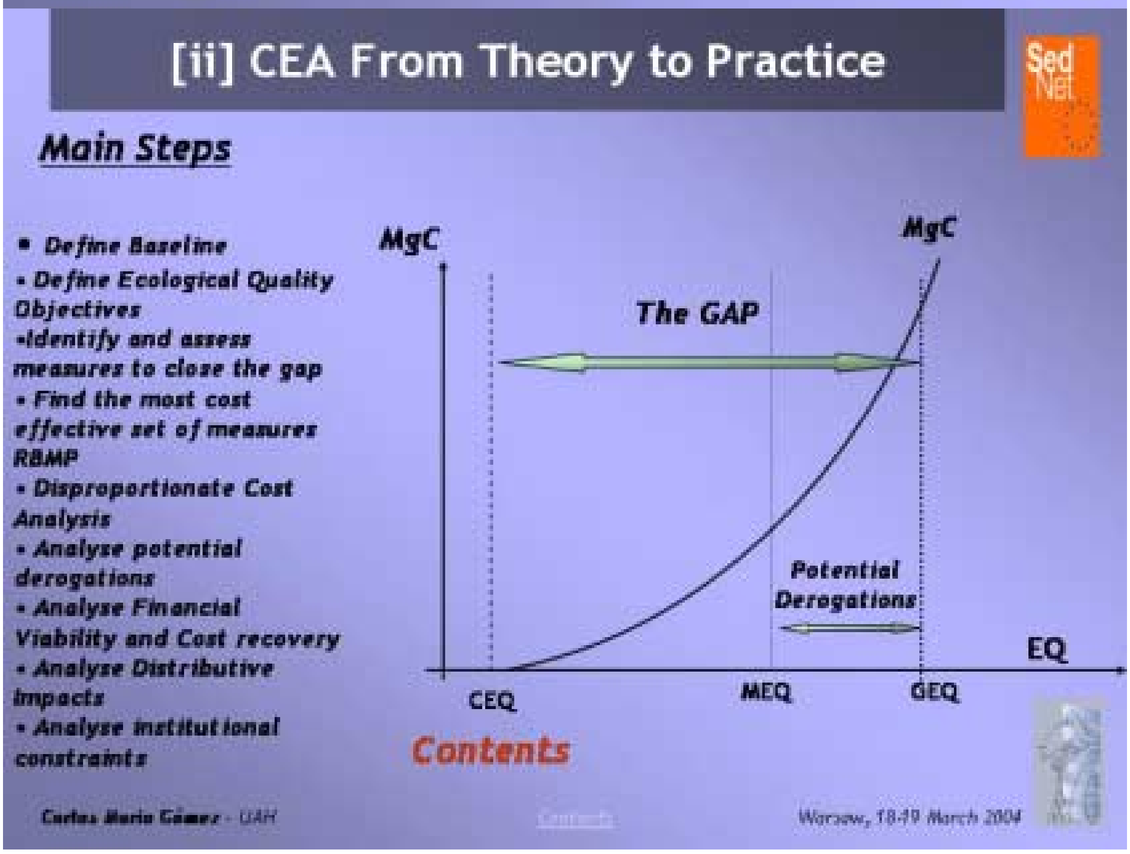
[ii] CEA From Theory to Practice
Main Steps
• Define Baseline
• Define Ecological Quality Objectives
•Identify and assess measures to close the gap
• Find the most cost effective set of measures RBMP
• Disproportionate Cost Analysis
• Analyse potential derogations
• Analyse Financial Viability and Cost recovery
• Analyse Distributive impacts
• Analyse institutional constraints
MgC
MgC
The GAP
Potential Derogations
EQ
CEQ
MEQ
GEQ
Contents
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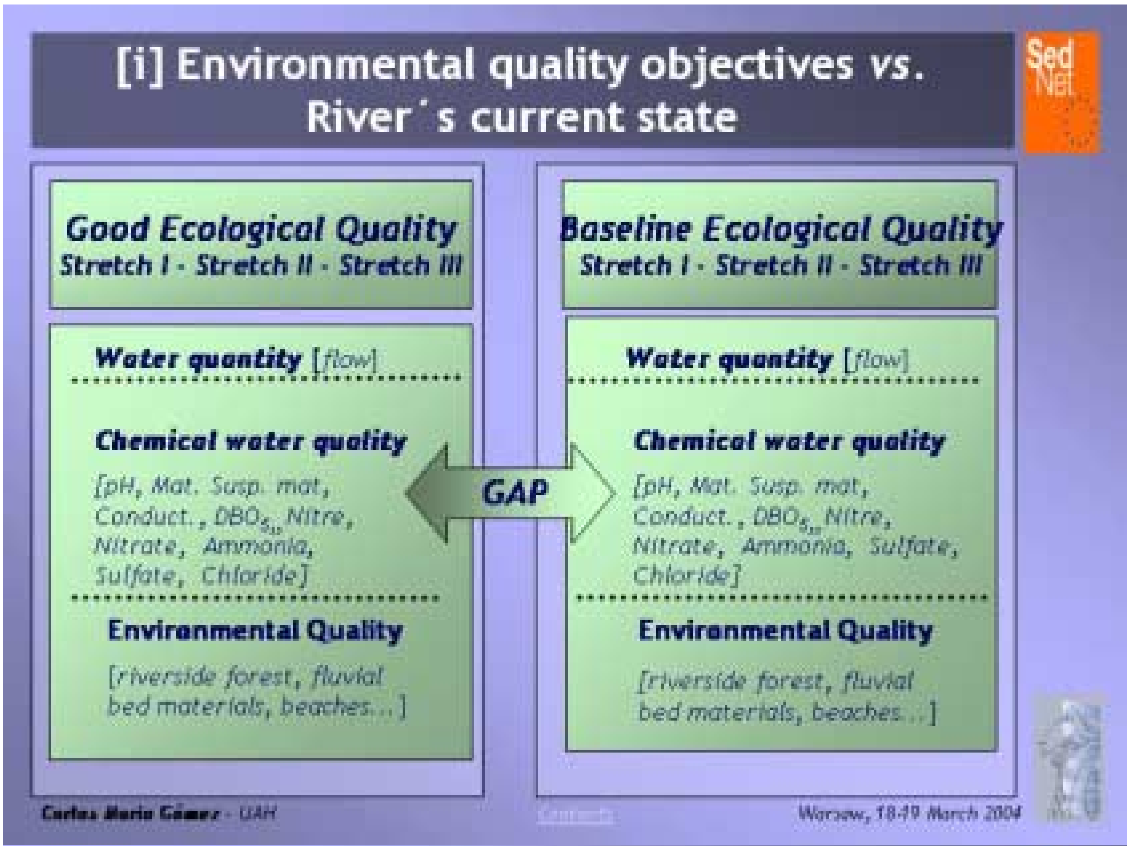
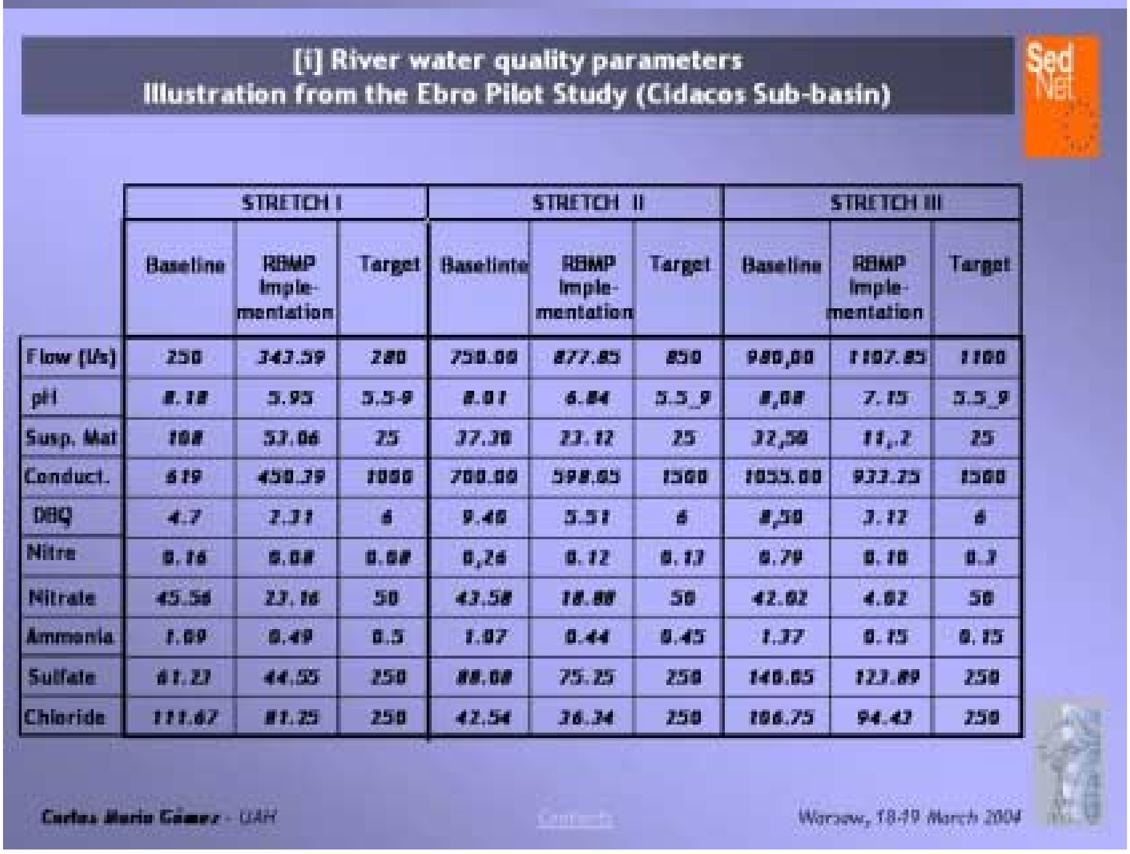
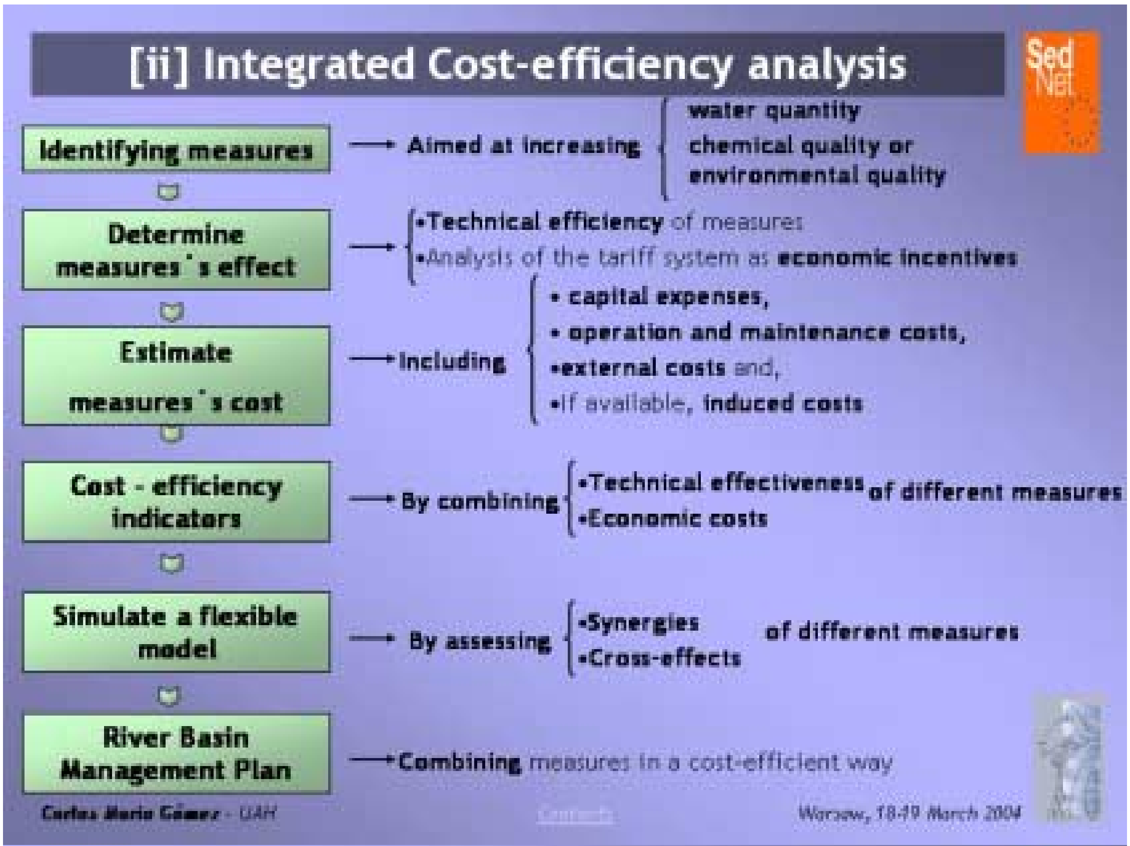



[i] River water quality parameters
Illustration from the Ebro Pilot Study (Cidacos Sub-basin)

	STRETCH I			STRETCH II			STRETCH III		
	Baseline	RBMP Imple-mentation	Target	Baselinte	RBMP Imple-mentation	Target	Baseline	RBMP Imple-mentation	Target
Flow (l/s)	250	343.59	280	750.00	877.85	850	980,00	1107.85	1100
pH	8.18	5.95	5.5-9	8.01	6.84	5.5_9	8,08	7.15	5.5_9
Susp. Mat	108	53.06	25	37.30	23.12	25	32,50	11,.2	25
Conduct.	619	450.39	1000	700.00	598.05	1500	1055.00	933.25	1500
DBQ	4.7	2.31	6	9.40	5.51	6	8,50	3.12	6
Nitre	0.16	0.08	0.08	0,26	0.12	0.13	0.79	0.10	0.3
Nitrate	45.58	23.16	50	43.58	18.88	50	42.02	4.02	50
Ammonia	1.09	0.49	0.5	1.07	0.44	0.45	1.37	0.15	0.15
Sulfate	61.23	44.55	250	88.08	75.25	250	140.65	123.89	250
Chloride	111.67	81.25	250	42.54	36.34	250	106.75	94.43	250


[ii] Integrated Cost-efficiency analysis
Identifying measures
Aimed at increasing
water quantity
chemical quality or
environmental quality
Determine measures´s effect
•Technical efficiency of measures
•Analysis of the tariff system as economic incentives
Estimate measures´s cost
Including
• capital expenses,
• operation and maintenance costs,
•external costs and,
•if available, induced costs
Cost - efficiency indicators
By combining
•Technical effectiveness
•Economic costs
of different measures
Simulate a flexible model
By assessing
•Synergies
•Cross-effects
of different measures
River Basin Management Plan
Combining measures in a cost-efficient way
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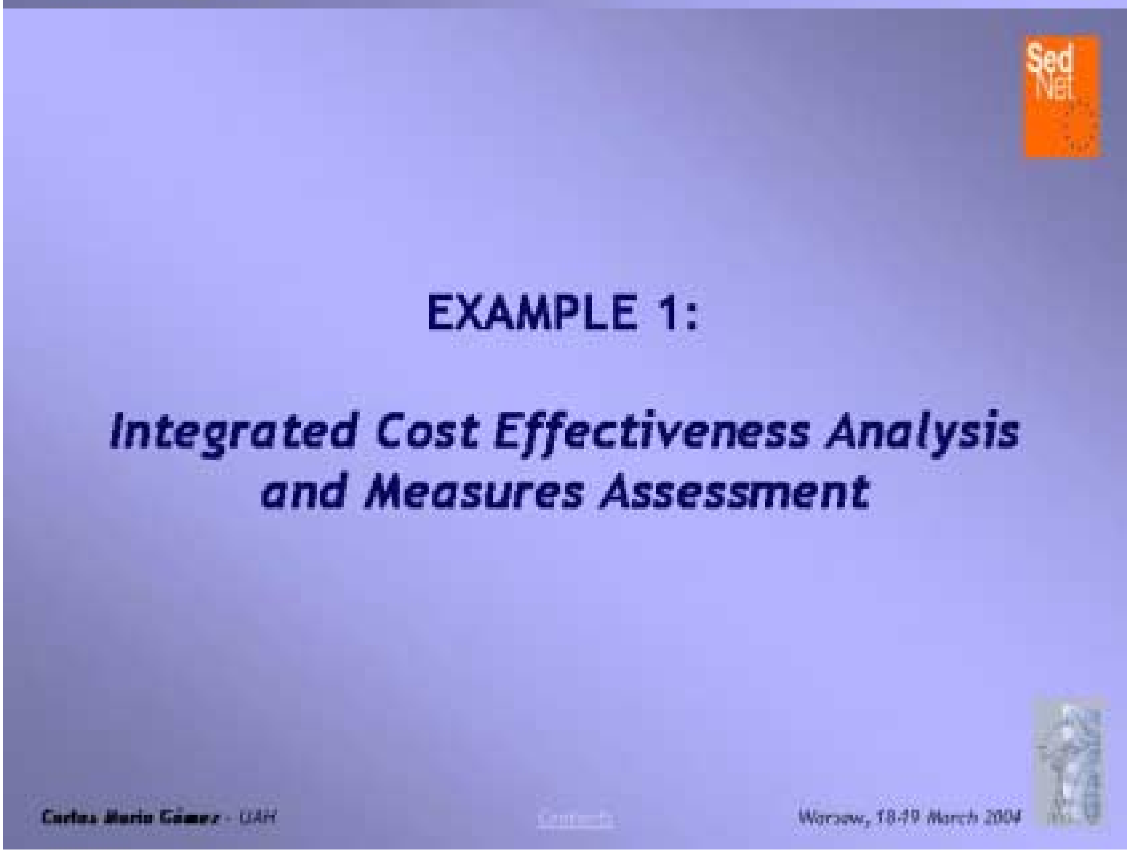
EXAMPLE 1:
Integrated Cost Effectiveness Analysis and Measures Assessment
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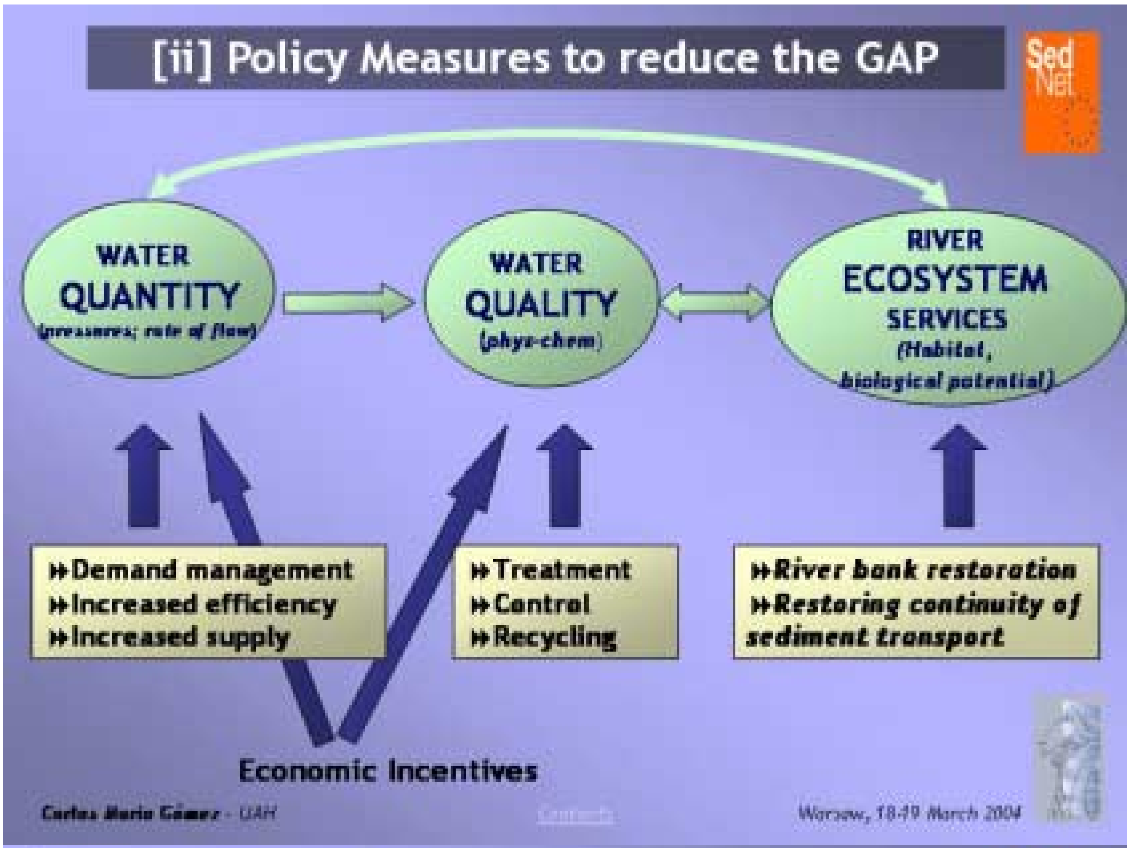
[ii] Policy Measures to reduce the GAP
WATER QUANTITY
(pressures; rate of flow)
WATER QUALITY
(phys-chem)
RIVER ECOSYSTEM SERVICES
(Habitat, biological potential)
Demand management
Increased efficiency
Increased supply
Treatment
Control
Recycling
River bank restoration
Restoring continuity of sediment transport
Economic Incentives
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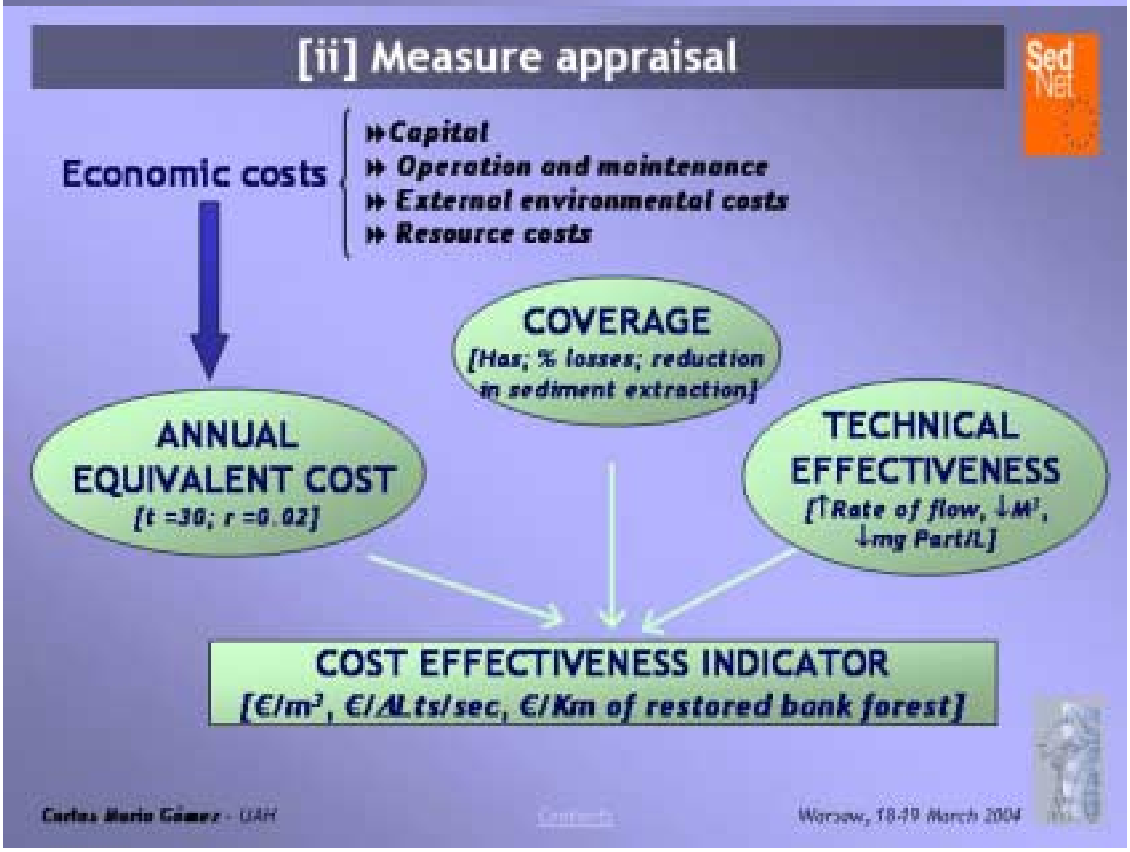
[ii] Measure appraisal
Economic costs
Capital
Operation and maintenance
External environmental costs
Resource costs
COVERAGE
[Has; % losses; reduction in sediment extraction]
ANNUAL EQUIVALENT COST
[t =30; r =0.02]
TECHNICAL EFFECTIVENESS
[↑Rate of flow, ↓M³, ↓mg Part/L]
COST EFFECTIVENESS INDICATOR
[€/m³, €/ALts/sec, €/Km of restored bank forest]
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[ii] Example of measure appraisal

Water Body:	*Stretch I*
Measure:	*Efficiency in Urban Distribution Networks*
Actual Efficiency:	*70%*
Maximum Attainable Efficiency	*85%*
Maximum Water Saved [m^3]	*695,258*
Cost Effectiveness Indicator 1 [€/m^3]	*0.26*
Maximum Flow Increase [l/s]	*11.1*
Cost Effectiveness Indicator 2 [€/l.p.s.]	*5,232*

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[ii] Cost-effectiveness indicators of water saving measures in rural areas

MEASURE	MAX. COVERAGE (Has)	AEC (€)	MAX. WATER SAVINGS (m3)	MAX. WATER FLOW INCREASE (lit/sec)	COST-EFFECTIVENESS INDICATORS €/m^3	€/lts/sec
IRRIGATION ASSISTANCE						
	21	411	16,938	0.54	0.02	766
7,000-10,000 m3/Ha	1	70	586	0.07	0.03	1,077
5,000-7,000 m3/Ha	3	60	1,561	0.05	0.04	1,212
	19	384	1,620	0.05	0.24	7,475
Less than 1,000 m3/Ha	1	20	81.	0.003	0.25	7,755
WSP (WATER SAVINGS PROGRAM)						
	21	1,234	16,938	0.54	0.07	2,297
7,000-10,000 m3/Ha	1	60	586	0.07	0.10	3,231
	3	180	1,561	0.05	0.12	3,635
	19	1,152	1,620	0.05	0.71	23,766
Less than 1,000 m3/Ha	1	60	81	0.003	0.74	22,425
EFFICIENCY IN CHANNELS	45	7,704	53,189	1.69	0.14	4,568
CHANGE OF DISTRIBUTION	45	10,859	66,062	2.09	0.16	5,184
CHANGE IN IRRIGATION TECHNOLOGY	26	5,141	66,062	2.09	0.08	2,454
CHANGE OF DISTRIBUTION + IRRIGATION TECHNOLOGY	26	11,342	110,720	3.51	0.1	3,230

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[ii] Cost-effectiveness indicators of water saving measures in urban areas

Measure	Maximum Water Saving	AEC €	AEC/M³	Maximum Flow Increase lt/sec	AEC/Lt/s
1. New abstractions	1,000,000	100,000	0.100	31.7	6,307
2. Water imports	Unlimited		0.224	Unlimited	7,560
3. Efficiency in distrib. network	695,258	58,072	0.260	11.1	5,232
4. Instalation of meters	88,989	25,376	0.280	2.8	8,993
5. Saving campaign consumers	103,820	17,744	0.170	3.3	5,390
7. Saving program households	136,330	20,805	0.150	4.3	4,813
8. Saving program firms	48,589	5,201	0.110	1.5	3,376
9. Saving program institutions	27,822	5,300	0.190	0.9	5 ,896
10. Water recycling	350,000	92,855	0.260	11.1	8,367

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Cost-Eft. Ind. / Quality measures (NO_3) - Stretch I

Stretch I		NO_3 Initial Concentration (mg/l):35.61	Individual Efficiency ($mgNO_3$ / l)	AEC (€)	AEC/ Saved unit (€/mg/ l)
Relative contribution		Measures			
0.25	cattle raising	Quality control on cattle wastewater points	0.88	6,010	6,836
0.25	agric.	Quality control on drainage net	0.88	6,010	6,836
0.25	agric.	Contamination reduction Programme	1.76	15,020	8,543
0.25	gan.	Cattle wastewater control	2.2	24,040	10,938
0.25	agric.	Good Practices Campaign	1.32	18,030	13,673
1		River bank restoration	4.07	138,868	34,109
0.25	cattle raising	Cattle wastewater treatment	8.7	345,247	39,690
0.5	urb.	New wastewater treatment plant	0.35	20,807	59.170

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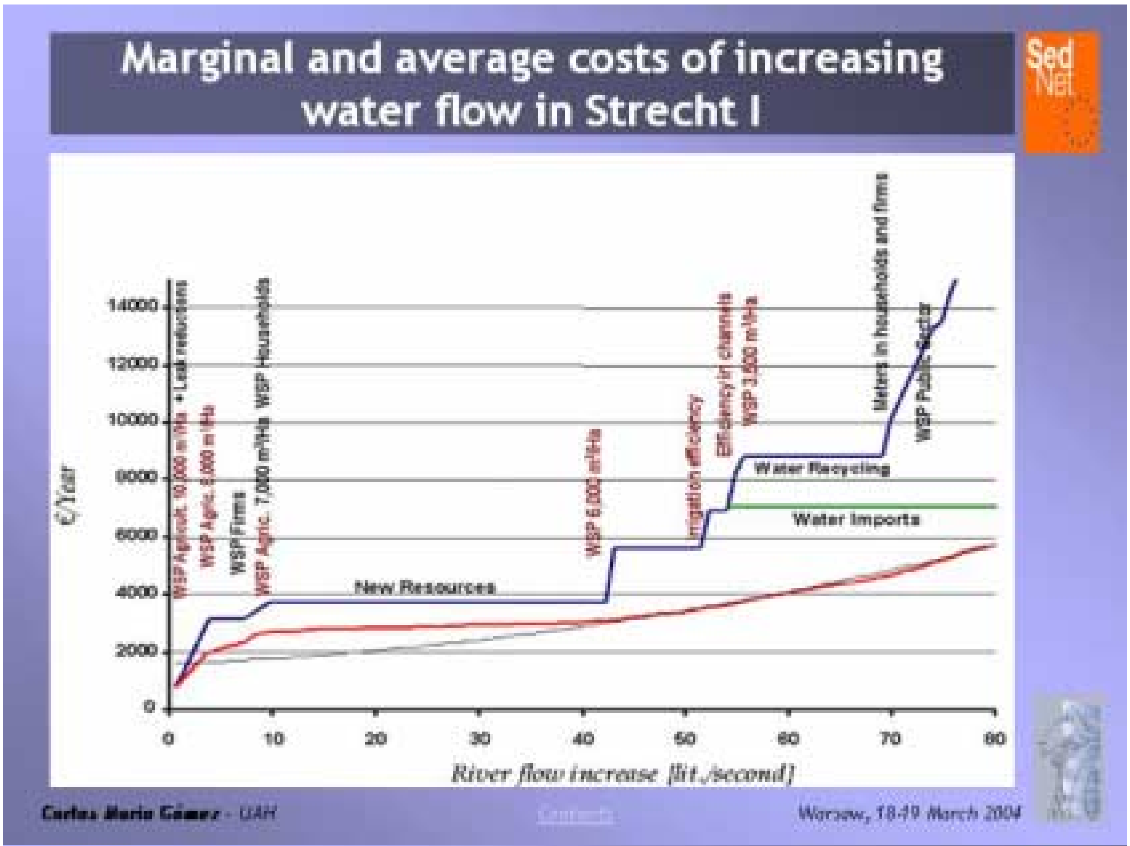
Marginal and average costs of increasing water flow in Strecht I
SedNet
€/Year
14000
12000
10000
8000
6000
4000
2000
0
WSP Households
WSP Firms
WSP 6,000 m³/Ha
Irrigation efficiency
Efficiency in channels
WSP 3,500 m³/Ha
Meters in households and firms
WSP Public Sector
New Resources
Water Recycling
Water Imports
0
10
20
30
40
50
60
70
80
River flow increase [lit./second]
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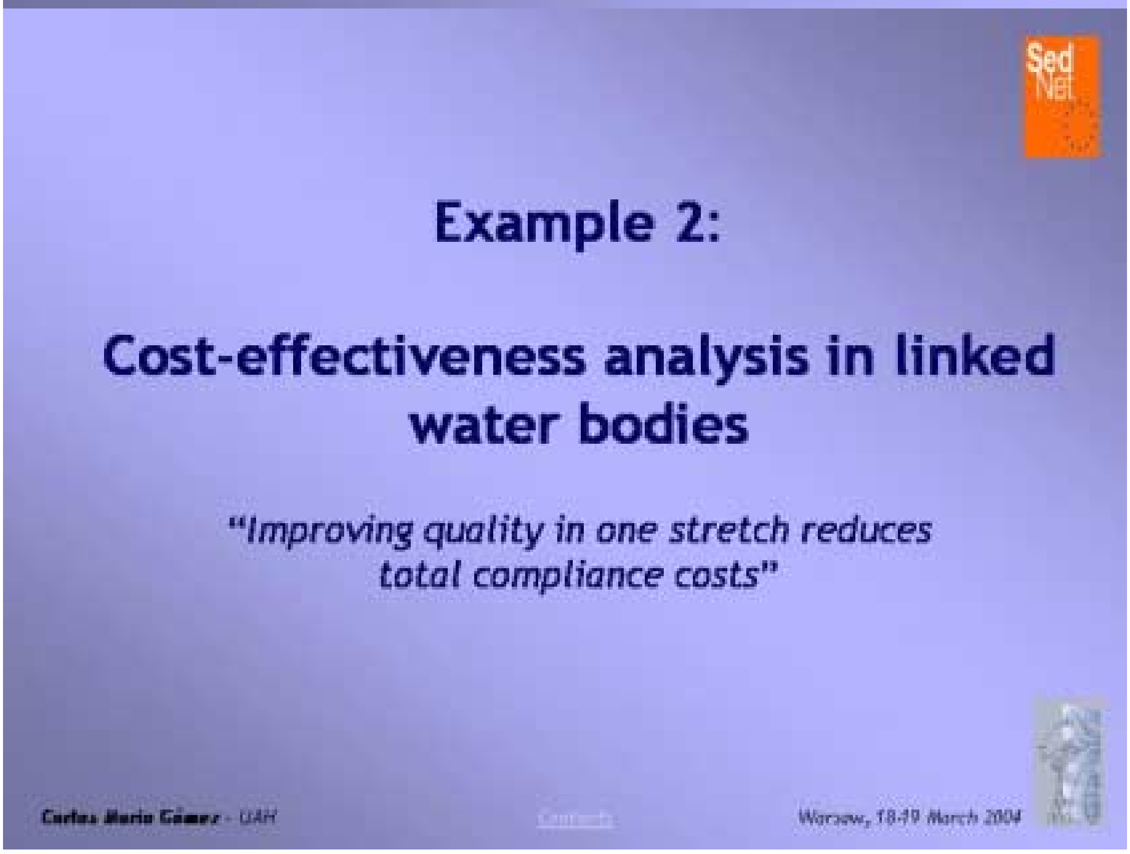
SedNet
Example 2:
Cost-effectiveness analysis in linked water bodies
"Improving quality in one stretch reduces total compliance costs"
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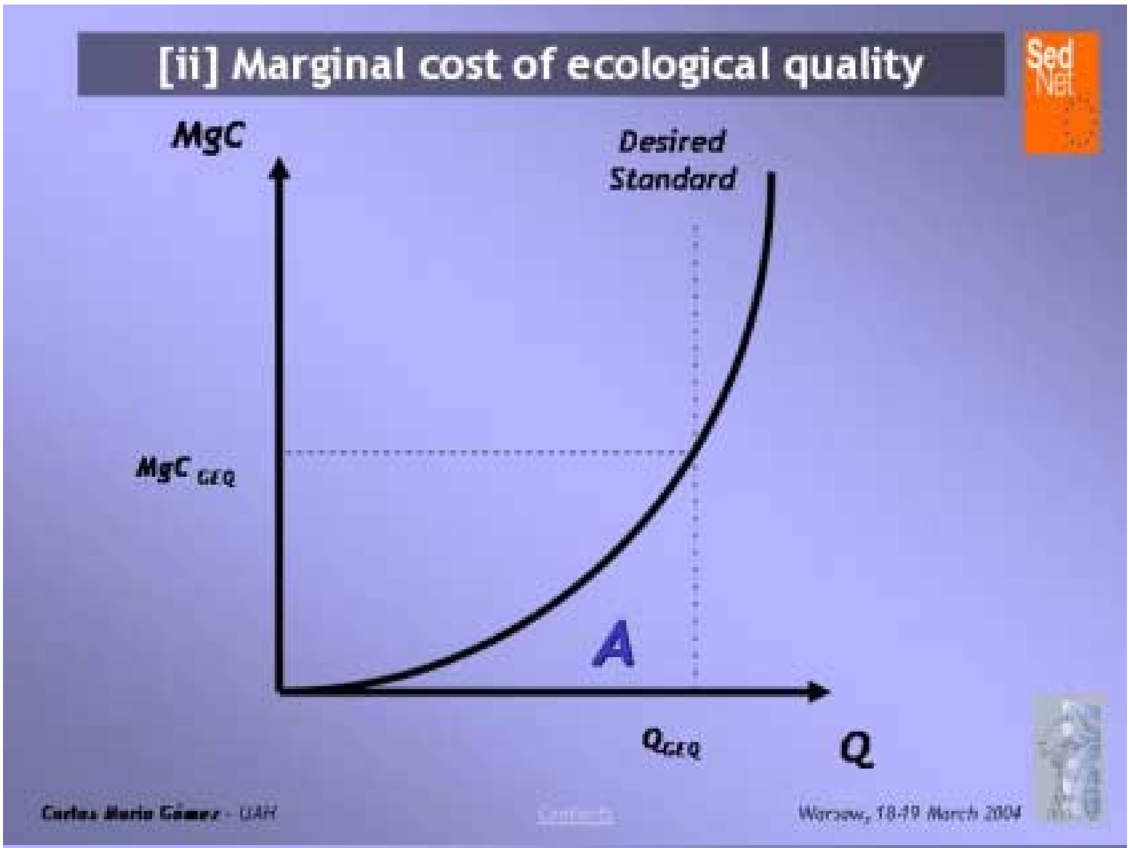
[ii] Marginal cost of ecological quality
MgC
Desired
Standard
MgC GEQ
A
QGEQ
Q
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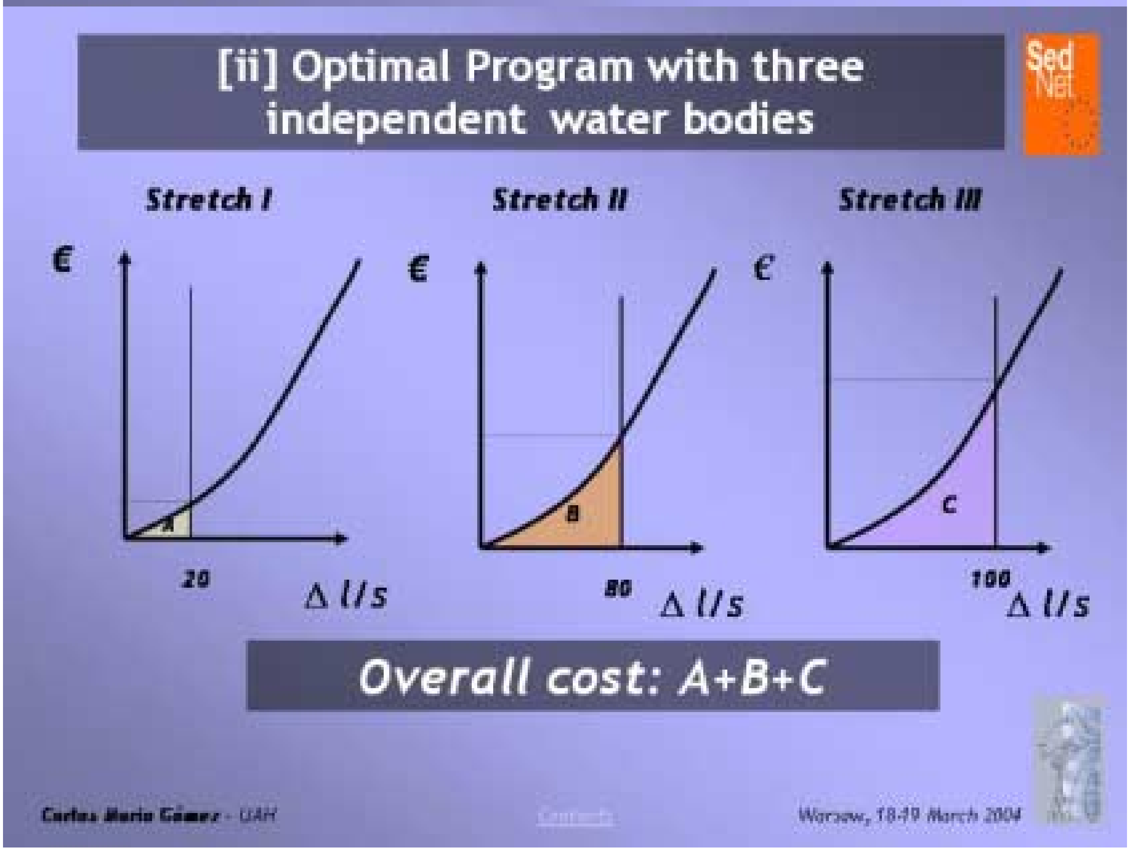
[ii] Optimal Program with three independent water bodies
Stretch I
Stretch II
Stretch III
€
€
€
A
B
C
20
Δ l/s
80
Δ l/s
100
Δ l/s
Overall cost: A+B+C
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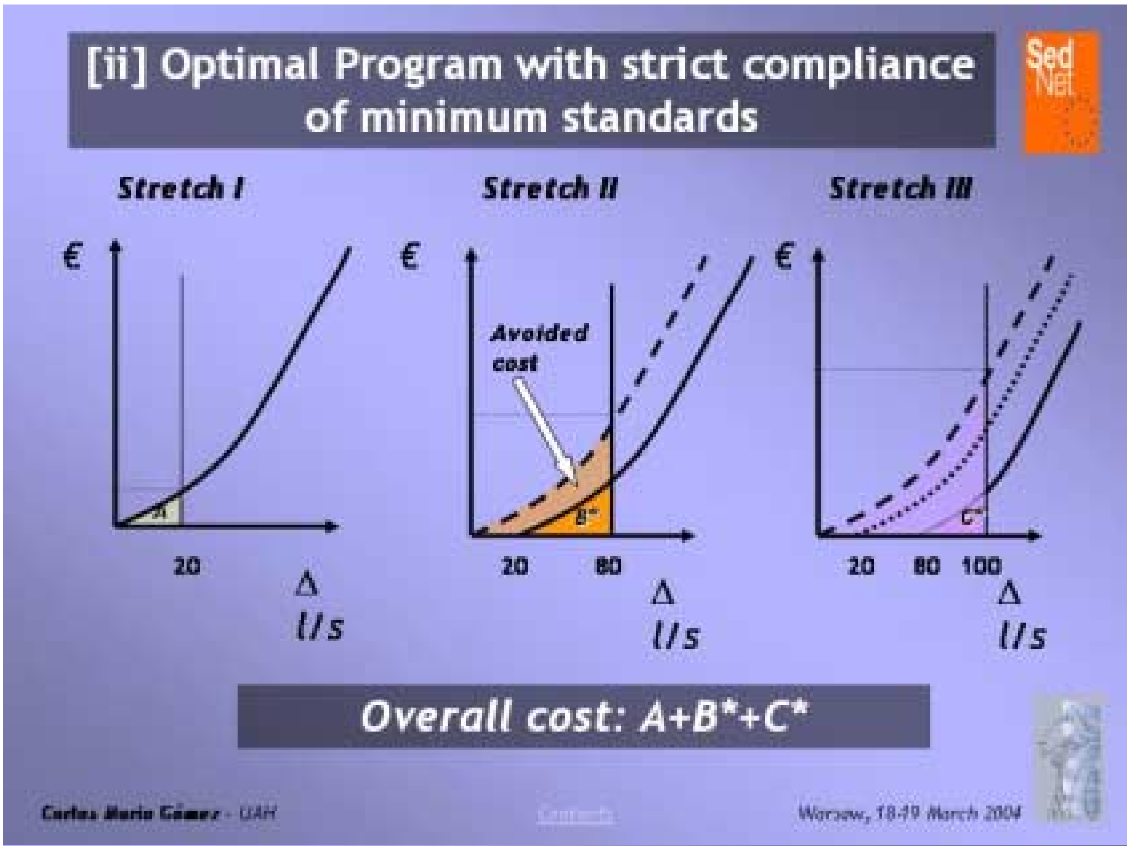
[ii] Optimal Program with strict compliance of minimum standards
Stretch I
Stretch II
Stretch III
€
20
Δ l/s
Avoided cost
B*
80
C*
100
Overall cost: A+B*+C*
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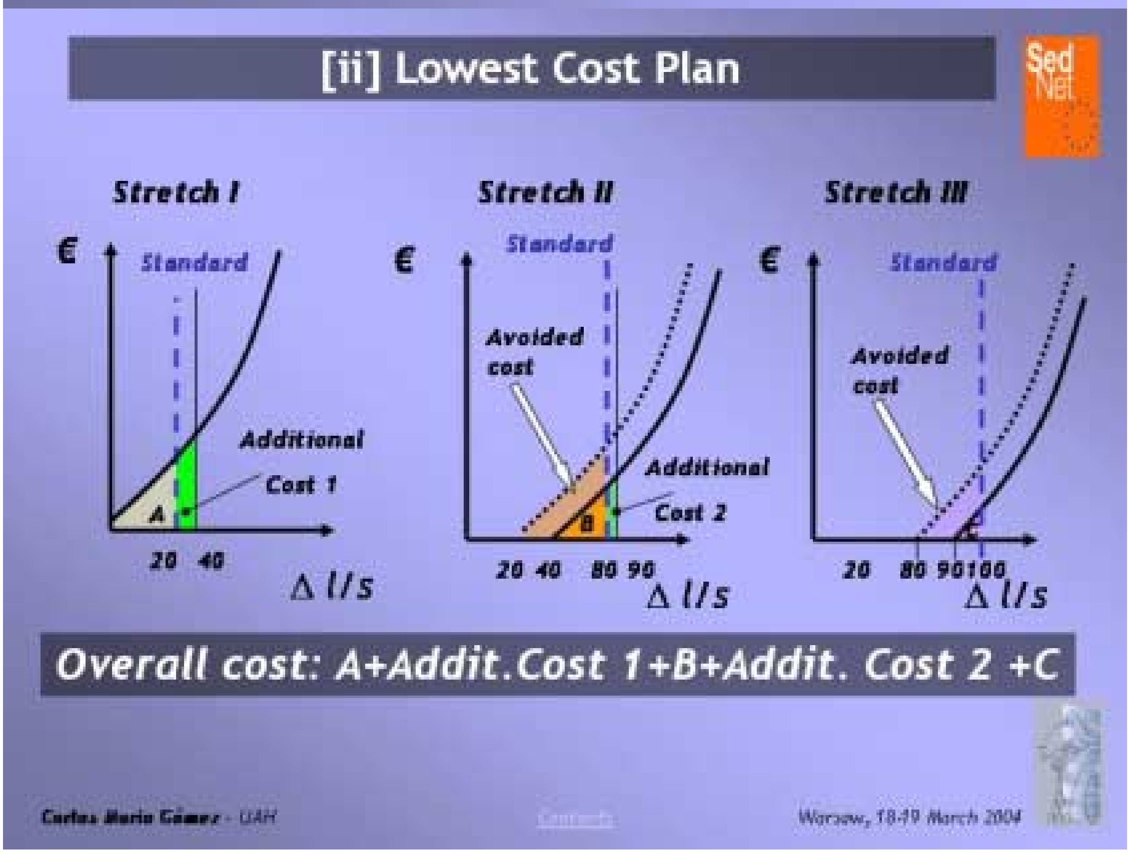
[ii] Lowest Cost Plan
Stretch I
Stretch II
Stretch III
€
Standard
Additional
Cost 1
A
20 40
Δ l/s
Avoided cost
Additional
Cost 2
B
20 40 80 90
C
20 80 90100
Overall cost: A+Addit.Cost 1+B+Addit. Cost 2 +C
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EXAMPLE 3:
Interactions between quality and quantity
"Quantity measures reduce the quality target reaching cost"
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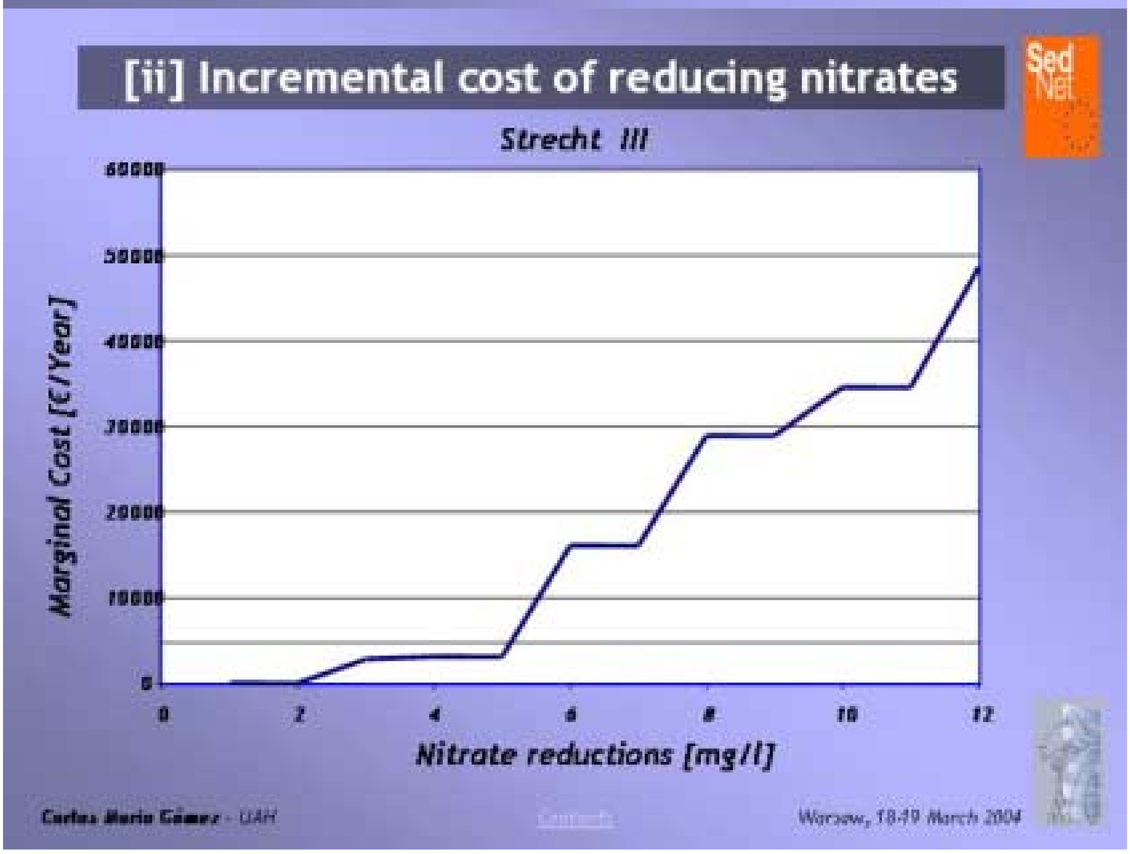
[ii] Incremental cost of reducing nitrates
Strecht III
Marginal Cost [€/Year]
60000
50000
40000
30000
20000
10000
0
0
2
4
6
8
10
12
Nitrate reductions [mg/l]
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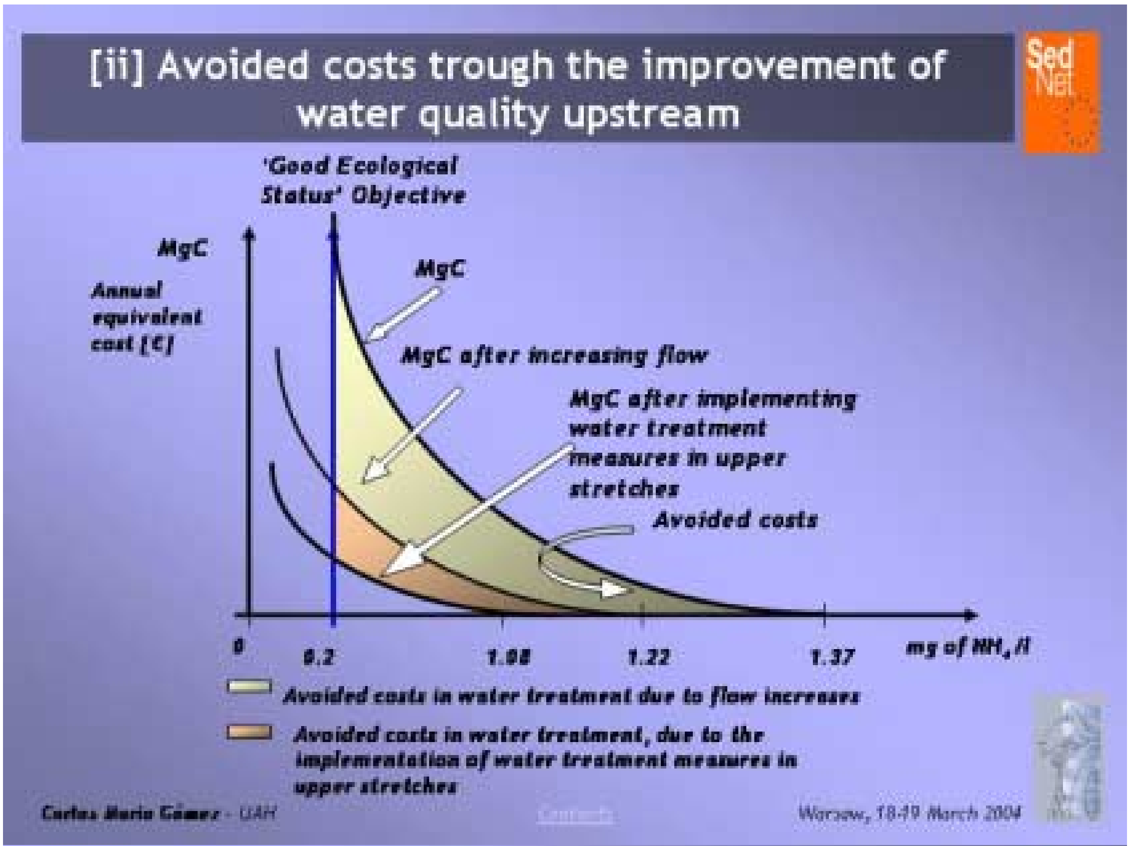
[ii] Avoided costs trough the improvement of water quality upstream
'Good Ecological Status' Objective
MgC
Annual equivalent cost [€]
MgC
MgC after increasing flow
MgC after implementing water treatment measures in upper stretches
Avoided costs
0
0.2
1.08
1.22
1.37
mg of NH_4/l
Avoided costs in water treatment due to flow increases
Avoided costs in water treatment, due to the implementation of water treatment measures in upper stretches
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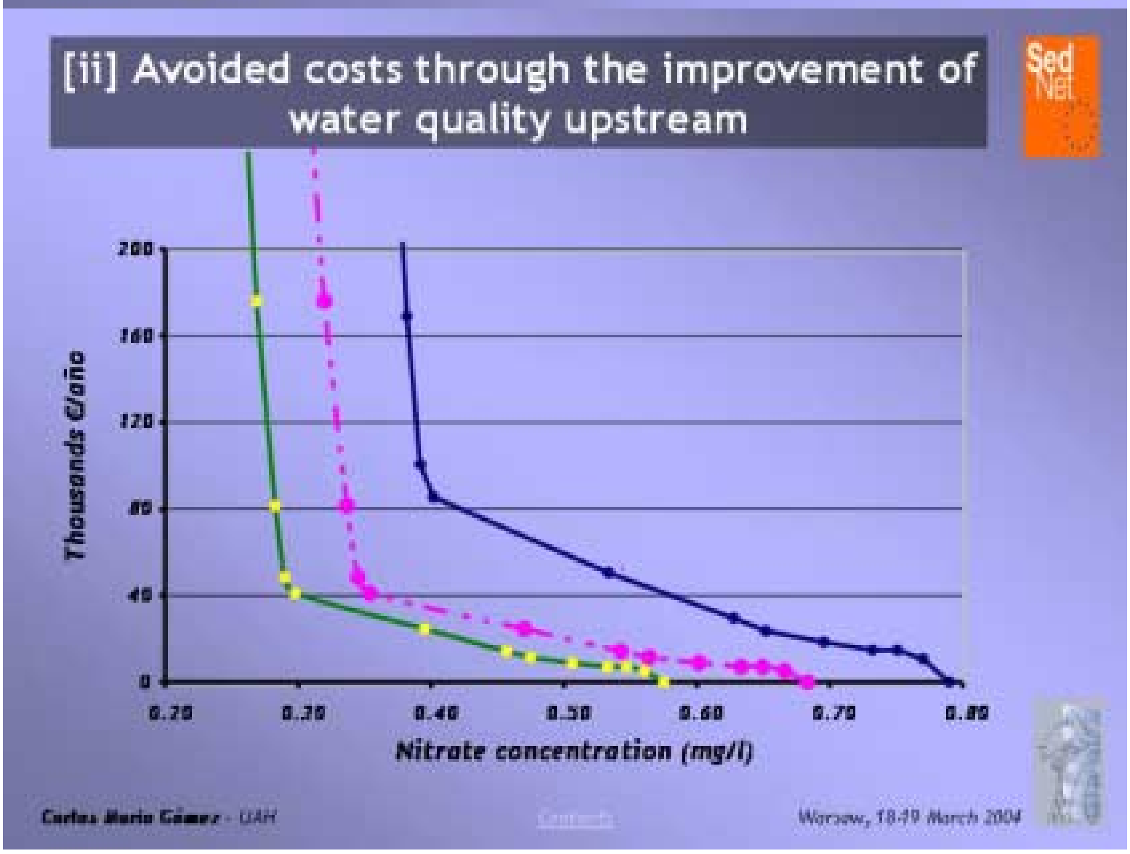
[ii] Avoided costs through the improvement of water quality upstream
200
160
120
80
40
0
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Thousands €/año
Nitrate concentration (mg/l)
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[ii] River Basin Management Plan - Quantity and ecological measures

Strecht I	
Measures	**Cost**
Irrigation Assistance	
5.000-7.000 m3/Ha	60
7.000-10.000 m3/Ha	70
>10.000 m3/Ha	411
< 1.000 m3/Ha	70
1.000 -5.000 m3/Ha	384
Water Saving Program	
5.000-7.000 m3/Ha	180
7.000-10.000 m3/Ha	60
>10.000 m3/Ha	1.238
Channel Substitut. +Irrigation Techn.	11.347
New abstractions	100.000
Water imports	22.400
Efficiency distribution networks	158.370
Meters instalation	25.376
Consumers saving campaign	17.744
Households Saving Program	70.806
Firms Saving Program	5.201
Institution Saving Program	5.201
River bank restoration	64.805

Strecht II	
Measures	**Cost**
Irrigation Assistance	
5.000-10.000 m3/Ha	740
1.600-5.000 m3/Ha	420
>10.000 m3/Ha	1.660
1.000-1.200 m3/Ha	7.370
1.200-1.600 m3/Ha	24.340
Water Saving Program	
5.000-10.000 m3/Ha	2.720
>10.000 m3/Ha	4.980
River bank restoration	111.094

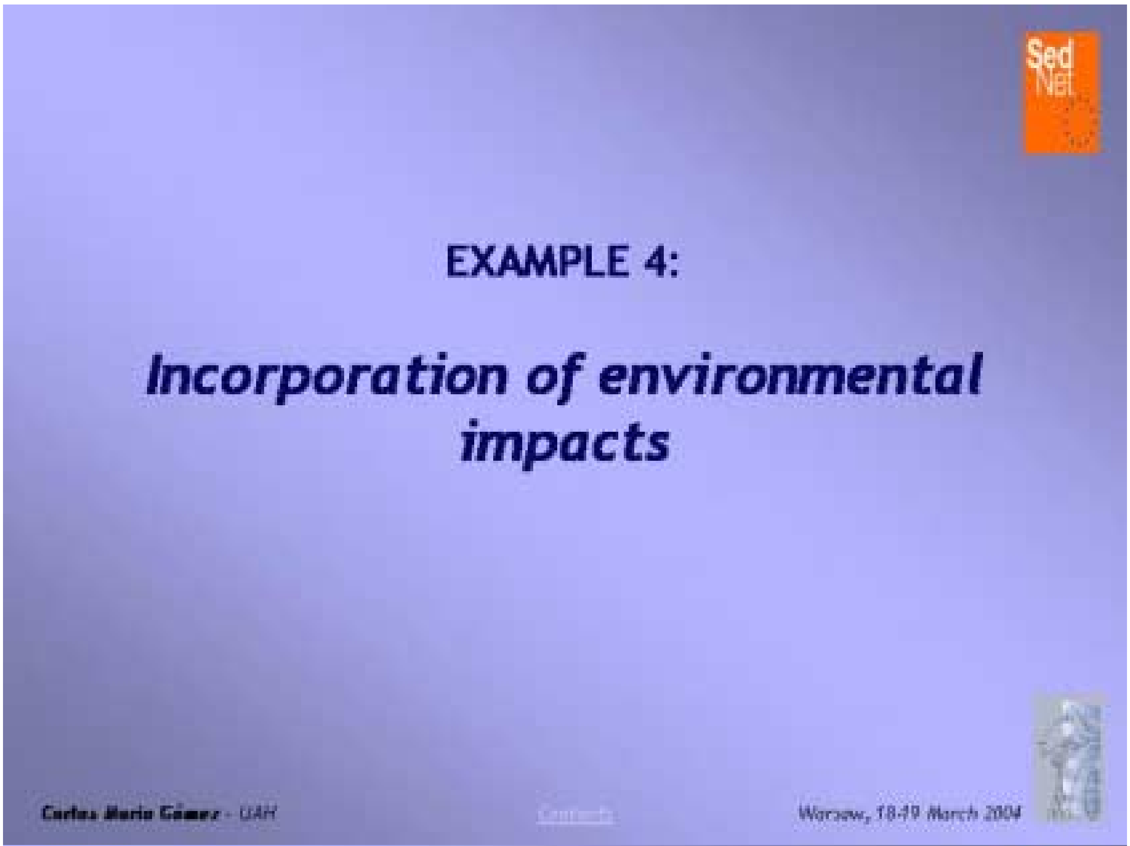
Strecht III	
Measures	**Cost**
River bank rest.	138.868

River Basin Management Plan - Quality measures

Sector	Measures	Cost (€)
Urban	Control	4.388
Urban	New wastewater treatment plant	28.552
Urban	Advanced technologhies for waste water treatment	205.167
Urban	Cattle wastewater control	24.040
Urban	Quality control on cattle wastewater points	6.010
Cattle raising	Cattle wastewater treatment	340.000

River Basin Management Plan - Financial instruments

% Cost recovery		
100%	Agricultural tariffs increase (€/m³)	0,05
100%	Water supply tariff increase (€/m³)	0,27
100%	Cattle wastewater treatment tariff (€/m³)	5,2
100%	Households wastewater treatment tariff (€/m³)	0,17
100%	Industrial wastewater treatment tariff(€/m³)	0,18


Sed Net
EXAMPLE 4:
Incorporation of environmental impacts
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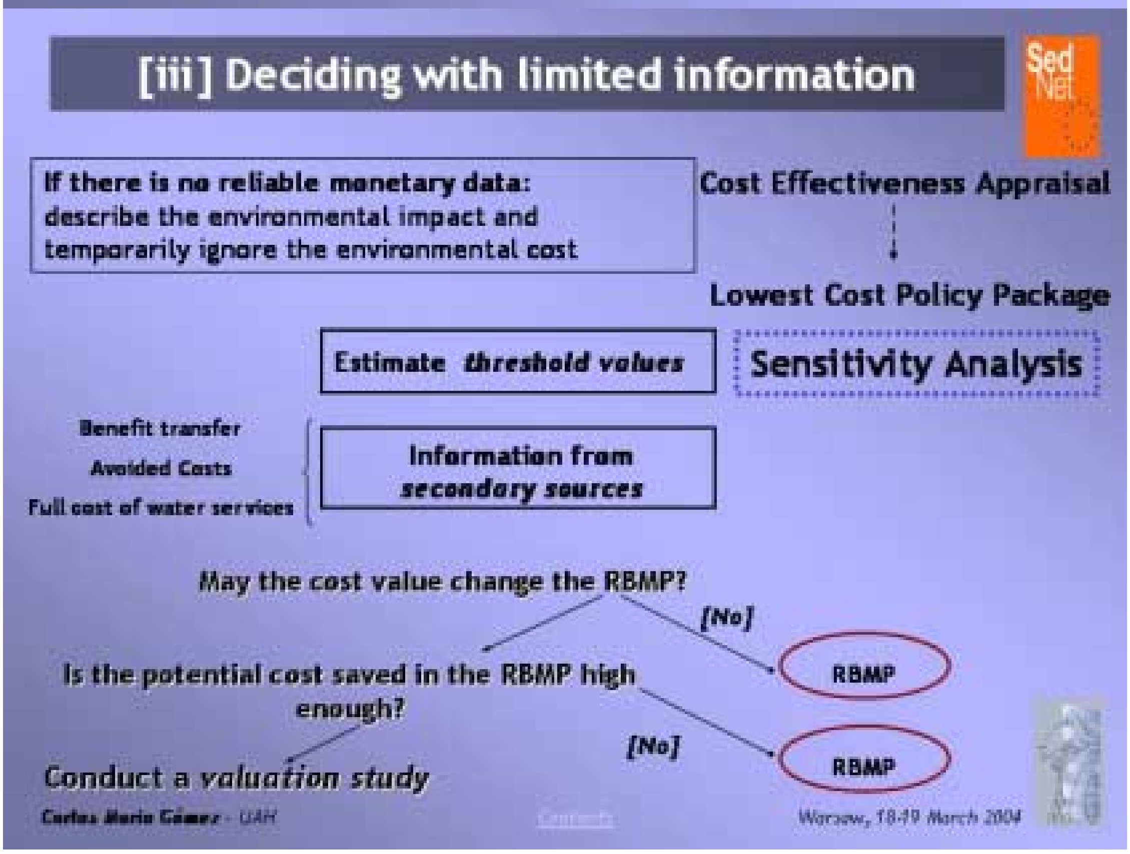
[iii] Deciding with limited information
Sed Net
If there is no reliable monetary data: describe the environmental impact and temporarily ignore the environmental cost
Cost Effectiveness Appraisal
Lowest Cost Policy Package
Estimate threshold values
Sensitivity Analysis
Benefit transfer
Avoided Costs
Full cost of water services
Information from secondary sources
May the cost value change the RBMP?
[No]
RBMP
Is the potential cost saved in the RBMP high enough?
[No]
RBMP
Conduct a valuation study
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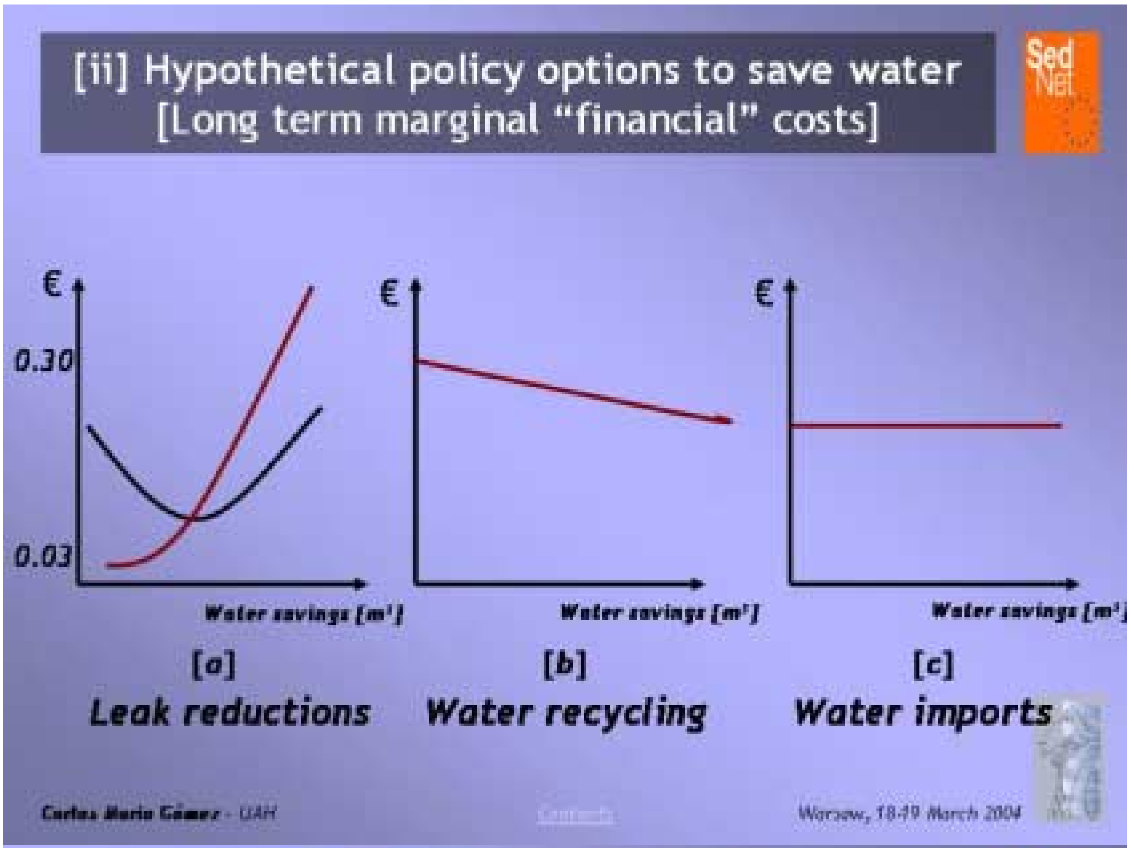
[ii] Hypothetical policy options to save water
[Long term marginal "financial" costs]
€
0.30
0.03
Water savings [m³]
[a]
Leak reductions
€
Water savings [m³]
[b]
Water recycling
€
Water savings [m³]
[c]
Water imports
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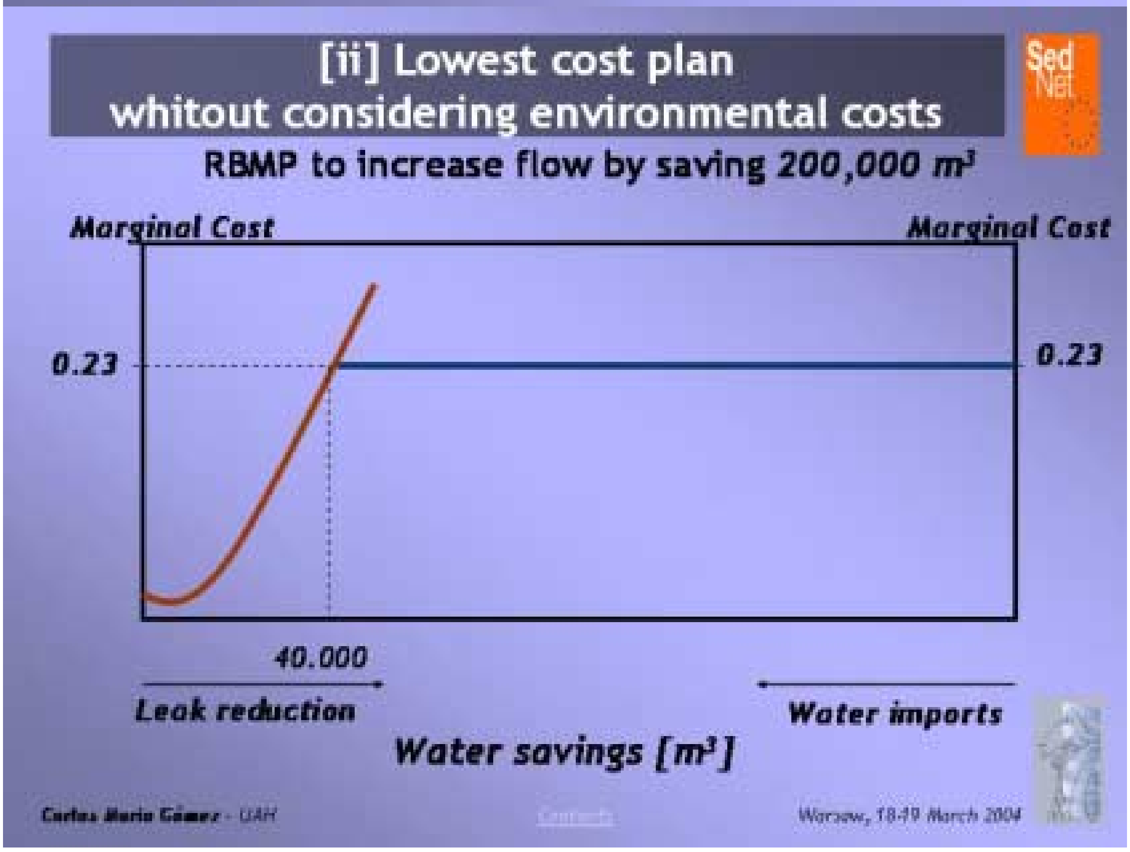
[ii] Lowest cost plan
whitout considering environmental costs
RBMP to increase flow by saving 200,000 m³
Marginal Cost
Marginal Cost
0.23
0.23
40.000
Leak reduction
Water imports
Water savings [m³]
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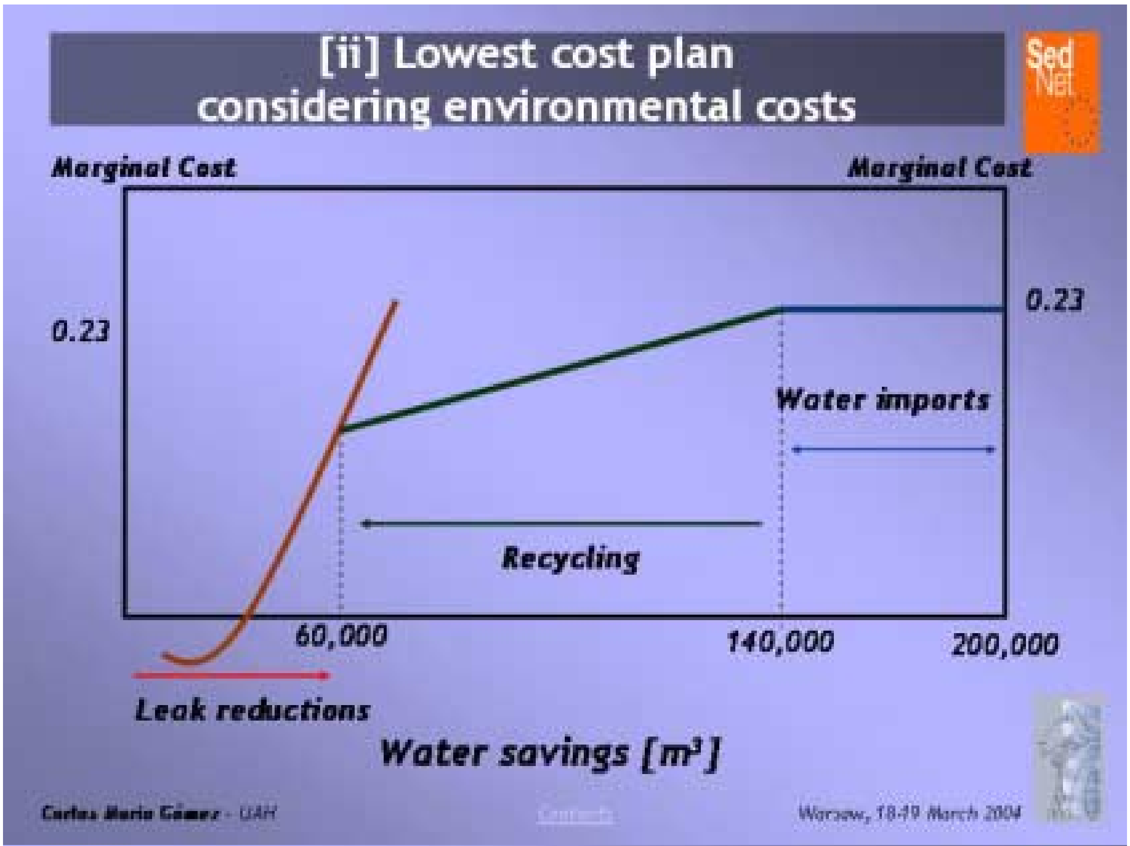

EXAMPLE 5:

Incentives Water Prices and the Least cost RBMP

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The Water Prices Needed for Full Recovery of the RBMP

ECONOMIC INCENTIVES [€/m³]	Current level	New tariff	% Increase
Price of irrigation Water	0.016	0.06	275
Drinking water price	0.6	0.87	45
Cattle wastewater treatment tariff	0	0.8	
Households wastewater treatment tariff	0	0.17	
Industrial wastewater treatment tariff	0	0.006	
Agricultural wastewater treatment tariff	0	0.006	

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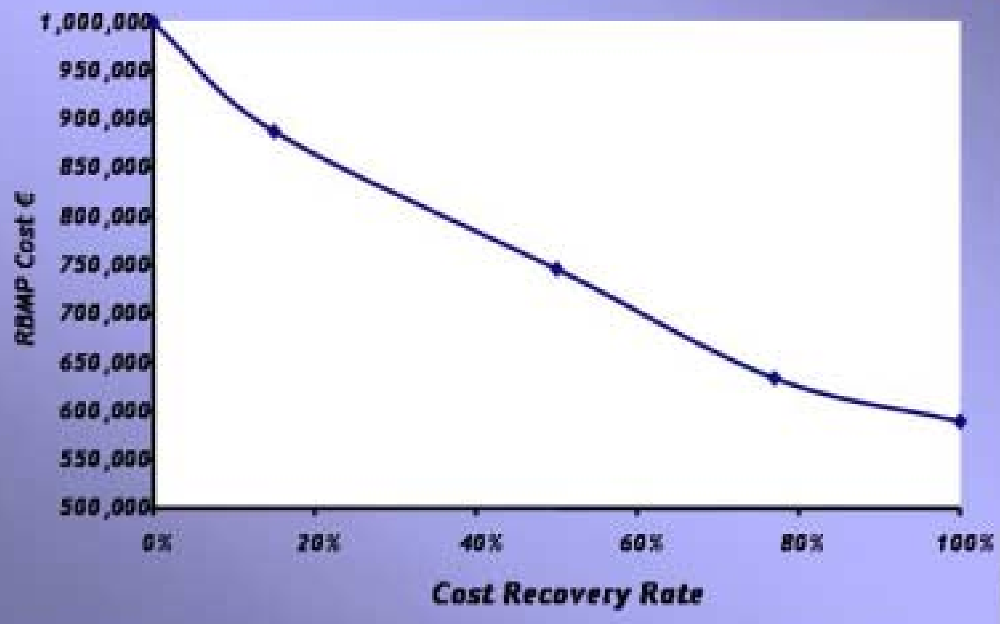
[iii] Sensitivity Analysis: The Overall RBMP Cost and the Cost Recovery Rate



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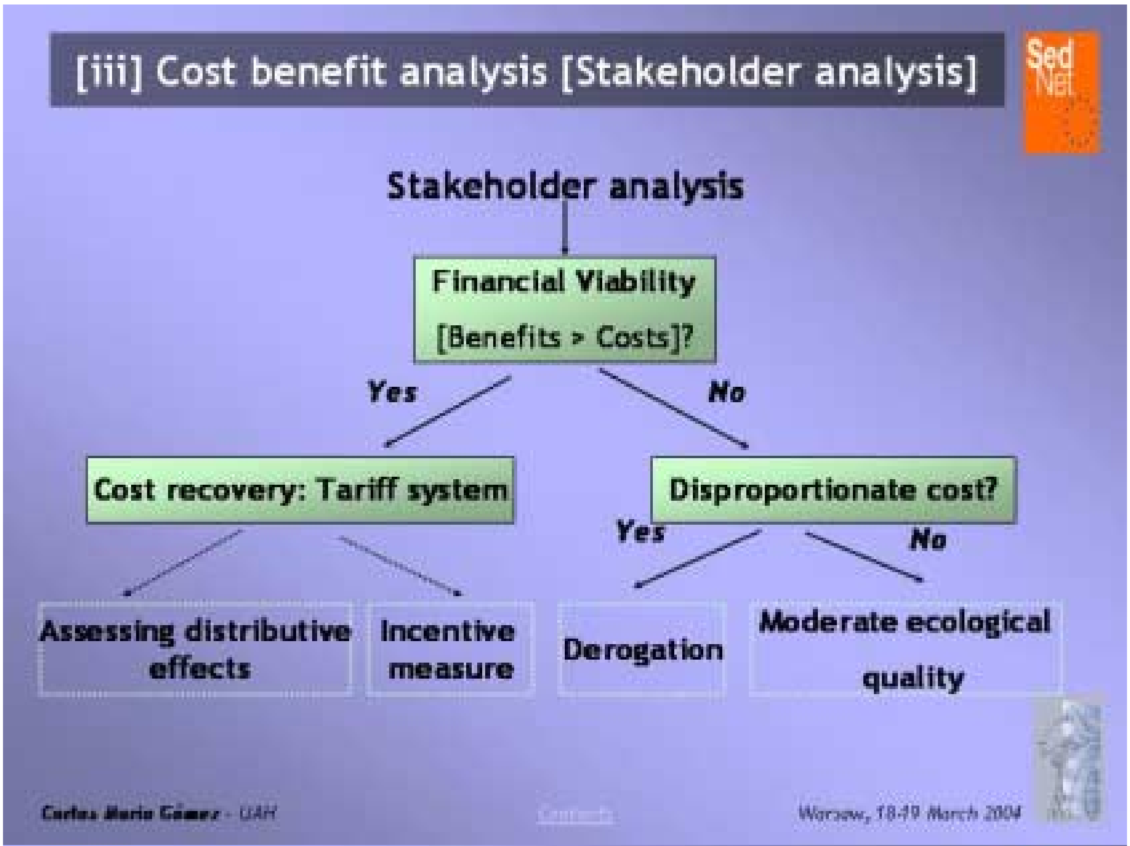

[i] Environmental impacts and their relevance to the overall decision-making process

	Type	*Relevant for*	*Valuation best at*
A	External costs or benefits associated with the ecological status of the river basin	Consultation and agreement on RBMP	- CBA - Derogation analysis - Stakeholder analysis
B	External costs or benefits associated to implemented measures to achieve the ecological status of the river basin.	Measure appraisal	- Estimation of *cost effectiveness indicators* [CEI]; - Order different measures according to CEI.
C	Environmental costs and benefits internalised within the river management plan.	Evaluating costs of alternative RBMP.	- CEA decisions at the basin level

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