BASQUE CENTRE
FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

"Economic Valuation of Ecosystem Services"

Aline Chiabai

EUSKO JAURLARITZA GOBIERNO VASCO
INGURUMEN ETA LURRALDE ANTOLAMENTU SAILA
DEPARTAMENTO DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO

EUSKO JAURLARITZA GOBIERNO VASCO
HEZKUNTZA, UNIBERTSITATE ETA IKERKETA SAILA
DEPARTAMENTO DE EDUCACIÓN, UNIVERSIDADES E INVESTIGACIÓN

Universidad del País Vasco
Euskal Herriko Unibertsitatea

ikerbasque
Basque Foundation for Science

ihobe

Outline

- Millennium Ecosystem Assessment MEA
- Ecosystem services and biodiversity
- Why economic indicators are needed?
- Framework for economic valuation
- Total economic values and valuation techniques
- Applications:
  - COPI: worldwide study for forest biomes
  - K-Egokitzen: impacts of sea level rise in the Basque country
  - CLIMBE: hydropower

The Millennium Ecosystem Assessment (1)

- **Millennium Ecosystem Assessment** carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for policy actions needed for conservation
- MEA responds to government requests through 4 international conventions—the Convention on Biological Diversity, the United Nations Convention to Combat Desertification, the Ramsar Convention on Wetlands, and the Convention on Migratory Species
- Designed to also meet needs of other stakeholders, including the business community, the health sector, nongovernmental organizations, and indigenous peoples.

The Millennium Ecosystem Assessment (2)

- The assessment focuses on the relationship between ecosystems and human well-being and, in particular, on "ecosystem services."
- An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit.
- MEA deals with the full range of ecosystems—from relatively undisturbed (primary forests, landscapes with mixed patterns of human use) to ecosystems intensively managed and modified by humans (agricultural land and urban areas).

The Millennium Ecosystem Assessment

Ecosystem goods definitions

… the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life
(Daily 1997).

...the benefits human populations derive, directly or indirectly, from ecosystem functions
(Costanza et al 1997).

<u>...the benefits people obtain from ecosystems</u>
(MEA 2005).

…ecological components directly consumed or enjoyed to produce human well-being
(Boyd and Banzhaf 2007)

The MEA: Ecosystem Goods and Services

PROVISIONING SERVICES

(products obtained from ecosystem)

- Food
- Timber
- Woodfuel
- Fiber
- Fresh water

CULTURAL SERVICES

(Non-material benefits obtained from ecosystems)

- Spiritual and religious
- Recreation and tourism
- Aesthetic
- Educational

…

REGULATING SERVICES

(Benefits obtained from regulation of ecosystem processes)

- Climate regulation
- Water purification
- Soil quality maintenance
- Water regulation (flood prevention, runoff magnitude…)
- Pollination

…

SUPPORTING SERVICES

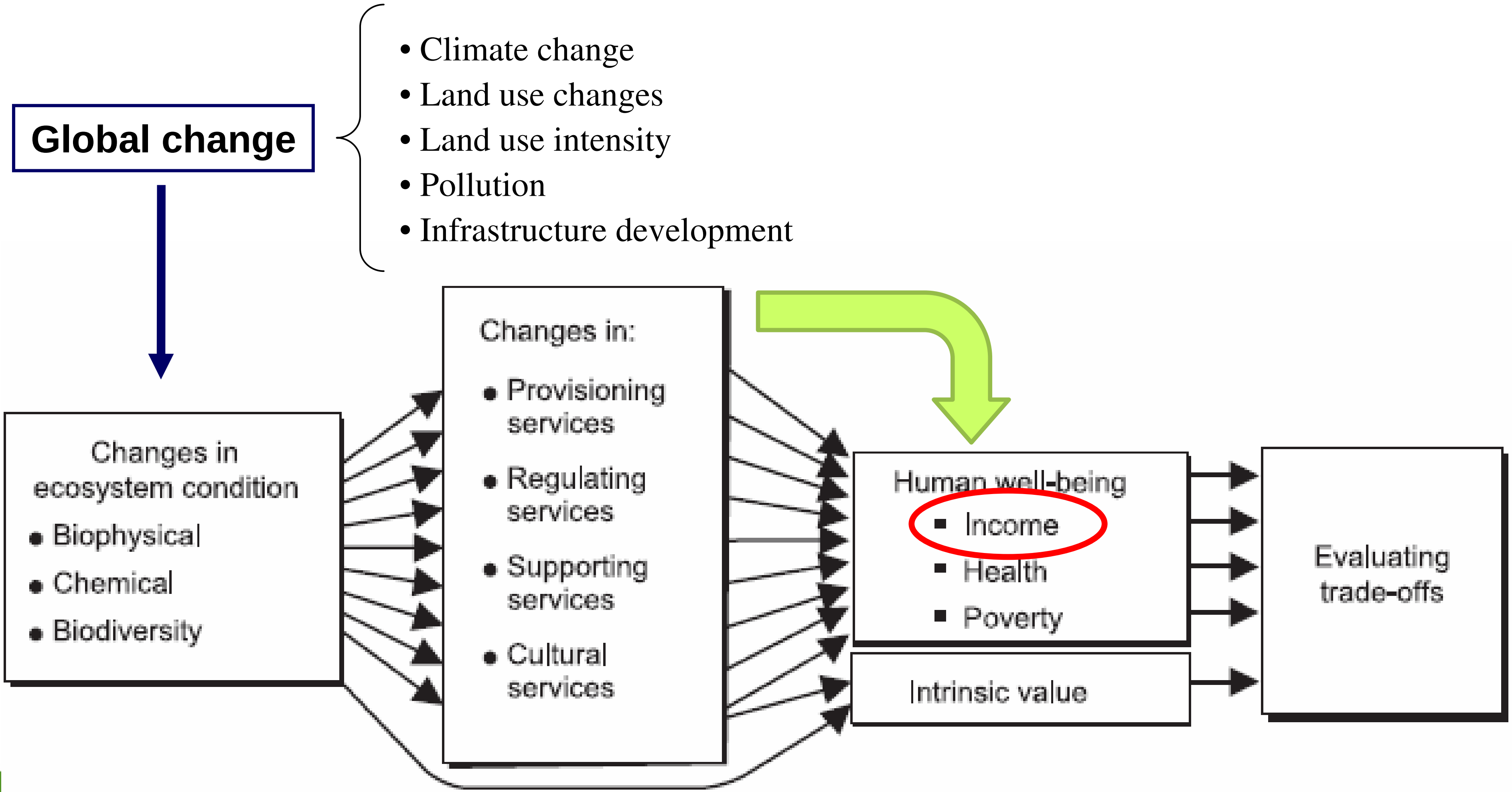
(Services necessary for the production of all other ecosystem services)

- Soil formation
- Nutrient cycling
- Primary production

The Millennium Ecosystem Assessment

Conceptual framework

Source: MEA (2005), adapted



Relationship biodiversity indicators and EGSs

CHANGES IN ECOSYSTEM CONDITIONS

- Biodiversity loss
- Degradation and loss of land

EGSs

- Change in the quality of the services
- Change in land productivity

WELFARE LOSS

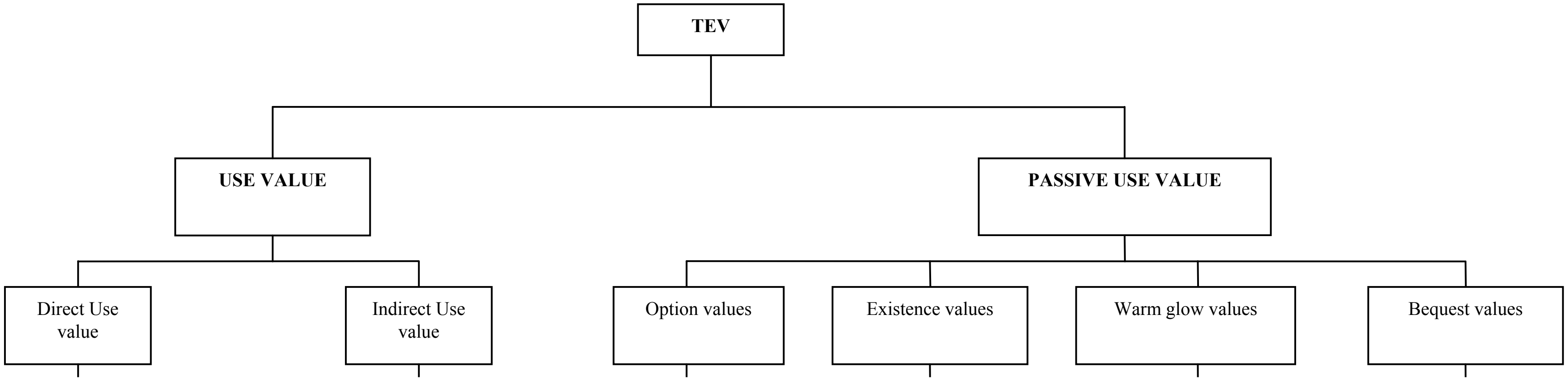
- Market impacts (on economic sectors)
- Non-market impacts

Why we need economic indicators?

- For informed decision-making on environmental protection, adaptation to climate change, etc, governments need to know:
  - Impacts on natural resources and ES: cost of inaction
  - Economic damages that could be avoided through adaptation or protection measures
  - Financial resources required to put in place appropriate measures
  - Cost-benefit analysis of alternative measures

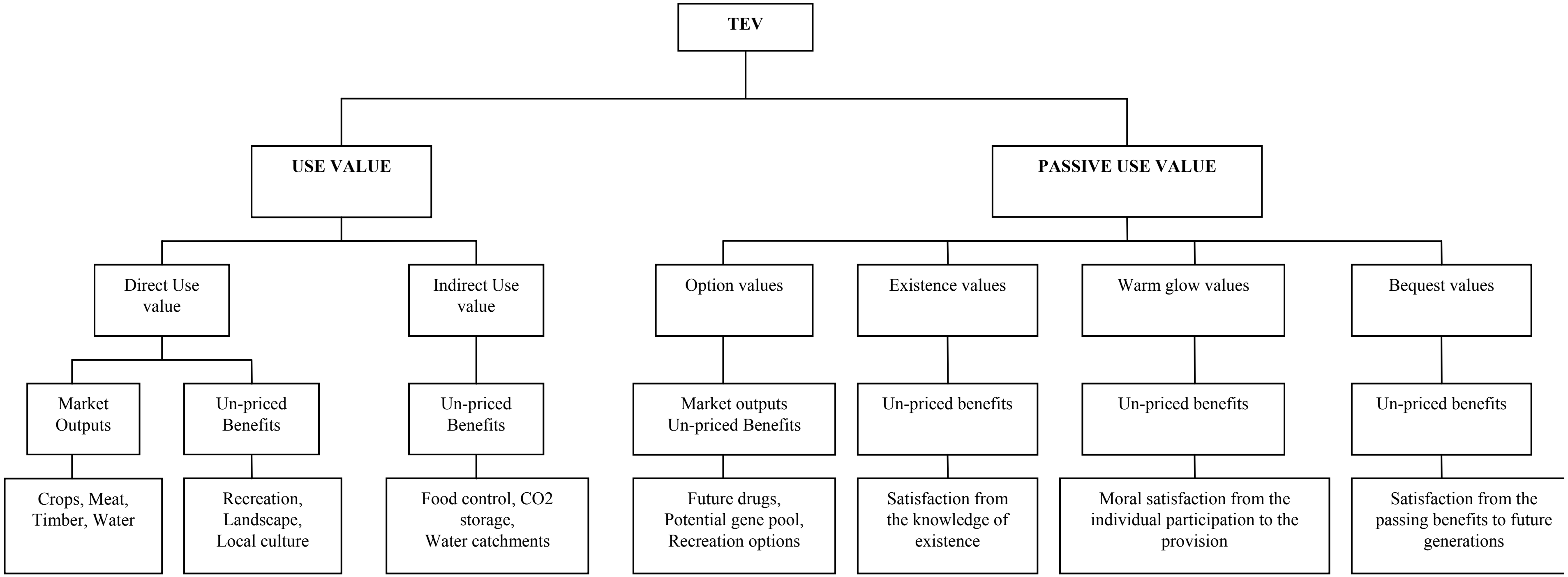
Economic valuation framework

Total economic value of EGS



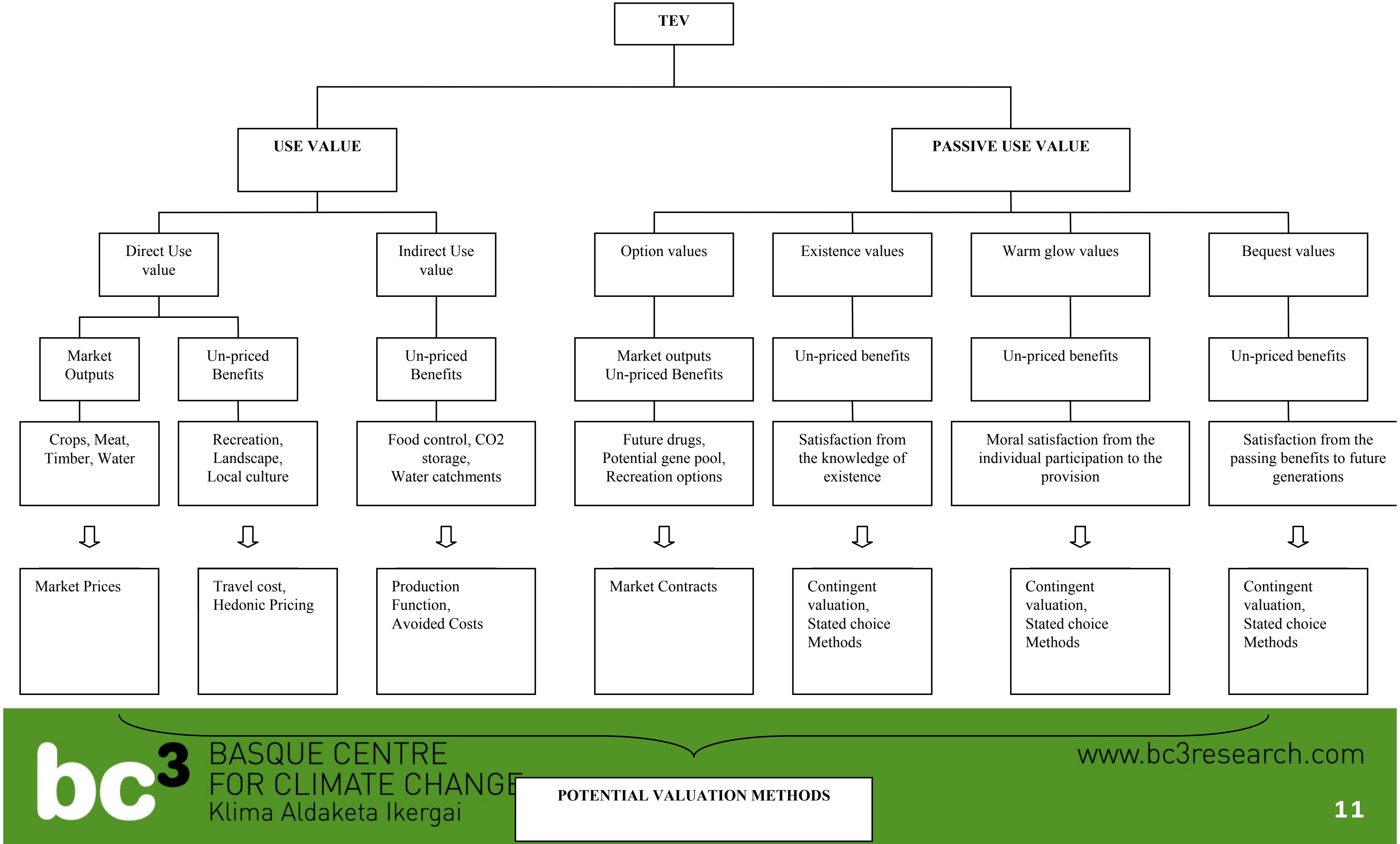
Economic valuation framework

Total economic value of EGS



Economic valuation framework

Total economic value of EGS



ES valuation methods

Ecosystem services:

- Wood and non-wood forest products
- Carbon in forests
- Cultural services
  - Recreational use
  - Passive use

ESTIMATION PROCESS:

WOOD FOREST PRODUCTS:

Classification of forest products

The Provisioning Services Provided by Forest Ecosystem

Wood forest products (WFPs)	Non-wood forest products (NWFPs)	
	Plant products	Animal products
•Industrial Roundwood •Wood pulp •Recovered paper •Sawnwood •Wood-based panels •Paper and paper board •Wood fuel	•Food •Fodder •Raw material for medicine and aromatic products •Raw material for colorants and dyes •Raw material for utensils, crafts & construction •Ornamental plants •Exudates •Other plant products	•Living animals •Hides, skins and trophies •Wild honey and beeswax •Bush meat •Other edible animal products

Sources: FAOSTAT and FAO/FRA 2005.

Methodological approach for valuing WFPs

- Computation of annual net value (NV) (flow)
- Computation of the net present value (NPV) (stock)
- NPV per hectare

(1) Annual net value (NV) (FLOW) yearly basis

$$NV_{i,j} = \left[VIE_{i,j} \times \frac{QP_{i,j}}{QIE_{i,j}} \right] \times r_i$$

$NV_{i,j}$ = net annual value of WFPs by country i and product j,
$VIE_{i,j}$ = average of annual import and export values,
$QP_{i,j}$ = annual domestic production quantity,
$QIE_{i,j}$ = average of annual import and export quantities,
r = rent rate – i.e. percentage of value that is net income.

(2) Net present value (NPV)(stock)

$$NPV_{i,j} = \sum_{t=0}^{T} \frac{(NV_{i,j})_t}{(1+d)^t} = NV_0 + \frac{NV_1}{(1+d)^1} + \frac{NV_2}{(1+d)^2} + \ldots + \frac{NV_T}{(1+d)^T}$$

Constant flows → $$NPV_{i,j} = \frac{NV_{i,j}}{d}$$

$$NPV_{i,j} = \sum_{t=1}^{T} \frac{NV_{i,j}^{1}(1+g)^t}{(1+d)^t} = \sum_{t=1}^{T} \frac{NV_{i,j}}{(1+d-g)^t}$$

Constant flows → $$NPV_{i,j} = \frac{NV_{i,j}}{(d-g)}$$

$NPV_{i,j}$ = net present value
$NV_{i,j}$ = annual value
d = discount rate
g = growth rate or appreciation of the benefits over time

(3) Net present value per hectare

$$AV_{wr,f} = \frac{\sum_{i \in wr} \sum_{j} NPV_{i.j}}{\sum_{i} S_{wr,f}}$$

Weighted mean

$AV_{wr,f}$ = NPV of WFPs per hectare by world region wr and forest biome f

$S_{wr,f}$ = forest area designated to plantation

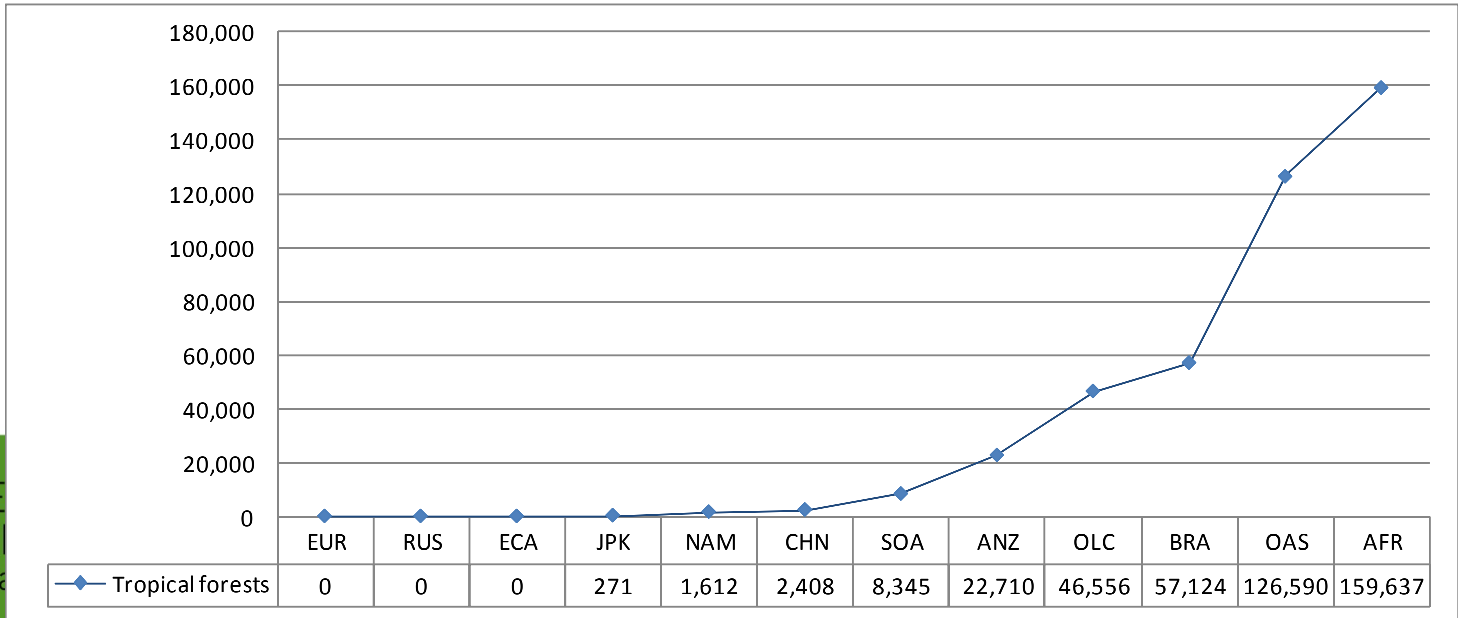
Results: economic value for WFPs and NWFPs (000 US$ 2005)

World region	Ind roundwood	Wood pulp	Recovered paper	Sawnwood	Wood based panels	Paper & paperboard	Wood fuel	Total WFPs	% on TOT	NWFPs	% on TOT	Total
NAM	83,343	42,861	5,631	56,949	27,362	80,416	3,328	299,891	100%	66	0.02%	**299,957**
EUR	2,256	6,164	2,157	11,660	12,024	55,230	374	89,865	98%	1,770	1.93%	**91,635**
JPK	1,779	5,139	3,475	7,379	5,167	31,880	-	54,820	98%	972	1.74%	**55,792**
ANZ	3,579	1,055	306	2,605	1,360	2,239	289	11,433	100%	19	0.16%	**11,452**
BRA	7,720	4,636	891	5,595	2,606	5,741	0	27,189	99%	193	0.71%	**27,382**
RUS	8,226	2,740	237	2,879	2,561	3,508	739	20,890	100%	5	0.02%	**20,895**
SOA	2,765	1,492	115	4,983	993	4,085	30,939	45,372	99%	428	0.93%	**45,800**
CHN	18,608	2,215	5,422	3,487	20,101	37,472	30,638	117,943	100%	-	0.00%	**117,943**
OAS	9,934	2,637	405	3,471	4,985	10,005	53,956	85,392	99%	1,075	1.24%	**86,467**
ECA	656	5	41	710	605	1,082	306	3,405	99%	30	0.86%	**3,434**
OLC	3,285	2,045	305	2,614	1,374	3,615	5,665	18,903	100%	9	0.05%	**18,912**
AFR	10,789	1,353	168	4,697	1,247	2,653	67,937	88,845	99%	897	1.00%	**89,742**
TOT	**152,940**	**72,342**	**19,154**	**107,031**	**80,383**	**237,927**	**194,170**	***863,947***	**99%**	***5,465***	**0.63%**	**869,411**
% on TOT	**18%**	**8%**	**2%**	**12%**	**9%**	**27%**	**22%**	***99%***		***1%***		

Results: NPV per hectare of WFPs by world region and forest biome, stock values (2005US$/ha)

World Region	Boreal	Tropical	Warm-mixed	Temperate mixed	Cool coniferous	Temperate deciduous
NAM	166,987	1,612	39,882	68,561	35,612	35,056
EUR	27,734	-	1,543	11,137	12,100	15,996
JPK	86,895	271	5,721	106,366	168,131	71,228
ANZ	199,179	22,710	93,262	7,519	-	28,407
BRA	-	57,124	15,224	-	-	-
RUS	10,793	-	15	8,270	1,487	555
SOA	98,651	8,345	62,113	6,294	41,918	26,108
CHN	128,005	2,408	52,917	6,261	24,444	48,639
OAS	190,036	126,590	9,948	-	-	263
ECA	15,785	-	-	17,026	9,702	1,321
OLC	69,883	46,556	15,530	720	-	198
AFR	-	159,637	55,522	-	-	2,051

Results for tropical forests



Main findings

- In tropical forests the highest values are registered in AFR
- In Africa the last decades have seen a large expansion of forestry with high yields and large-scale plantations in the private sector
- Between 1980 and 2000, the forest industry in South Africa shows a1,460% increase in the value of sales
- In the boreal and warm-mixed forests, Australia shows the highest values per ha, as the forest industry adds significantly to the national economy with high quality products and competitive supporting infrastructures, attracting investment opportunities

ESTIMATION PROCESS: CARBON

Methodological approach

(1) Assessing the biomass carbon stocks by forest type and geographical region (tC/ha)

(2) Computing economic values of carbon stocks per hectare by forest biome and geographical region

- Price per ton of C can be estimated with Integrated assessment models (WITCH model - World Induced Technical Change Hybrid model or CASES – Cost Assessment for Sustainable Energy Assessment)

$$V_{wr,b} = \left(tC/ha_{wr,b}\right) * \$/tC$$

$V_{wr,b}$ = value per hectare by world region *wr* and fore … ome *b*,
$tC/ha_{wr,b}$ = tons of carbon stocked per hectare,
$\$/tC$ = estimated price per ton of carbon stocked

WITCH MODEL (World Induced Technical Change Hybrid model) (Bosetti et al, 2009)

- Integrated Assessment Model (IAM) built to assess the impacts of climate policies on the global and regional economy
- The model provides, for different future scenarios, the price of carbon permits, the GDP loss, the consumption loss and the total GHG abatement. It gives the marginal cost of reducing 1 ton of CO2 to meet the targets.
- Two settings are used to compute price of carbon for 2050:
  - 640ppm CO_2 equivalent: lower-bound price of permits at 136 US$ per ton of CO2
  - 535ppm CO_2 equivalent, corresponding to an upper-bound price of 417 US$ per ton of CO_2.

Marginal value: carbon storage (Euro)

CASES "Cost Assessment of Sustainable Energy Systems"

Costs [Euro]			
MDC (lower-bound)		MAC (upper-bound)	
Year 2007	Year 2050	Year 2007	Year 2050
6.43	23.11	15.8	179.6

Note: Source http://www.feem-project.net/cases

BIOMASS CARBON STOCK ESTIMATES (tC/ha): biome-average datasets

Forest Biomes	NAM	EUR	JPK	ANZ	BRA	RUS	SOA	CHN	OAS	ECA	OLC	AFR
Boreal	37.37*	37.37*	37.37**	37.37**	-	37.37*	59.4**	25.77*	59.4**	37.98*	34**	-
Tropical	92**	-	149**	149**	186*	-	225*	96**	92*	-	149*	200*
Warm mixed	92**	92**	100**	134**	168*	92**	180*	78**	78**	-	134*	168**
Temperate mixed	51*	59.4*	47.35*	51**	-	37.98*	168**	25.77*	0	59.4*	59.4**	-
Cool coniferous	37.37**	37.37**	37.37**	-	-	37.37**	59.4**	25.77**	0	37.98**	-	-
Temp. deciduous	51*	59.4*	47.35*	51**	-	37.98*	168**	25.77*	59.4*	59.4*	34.88*	59.4**

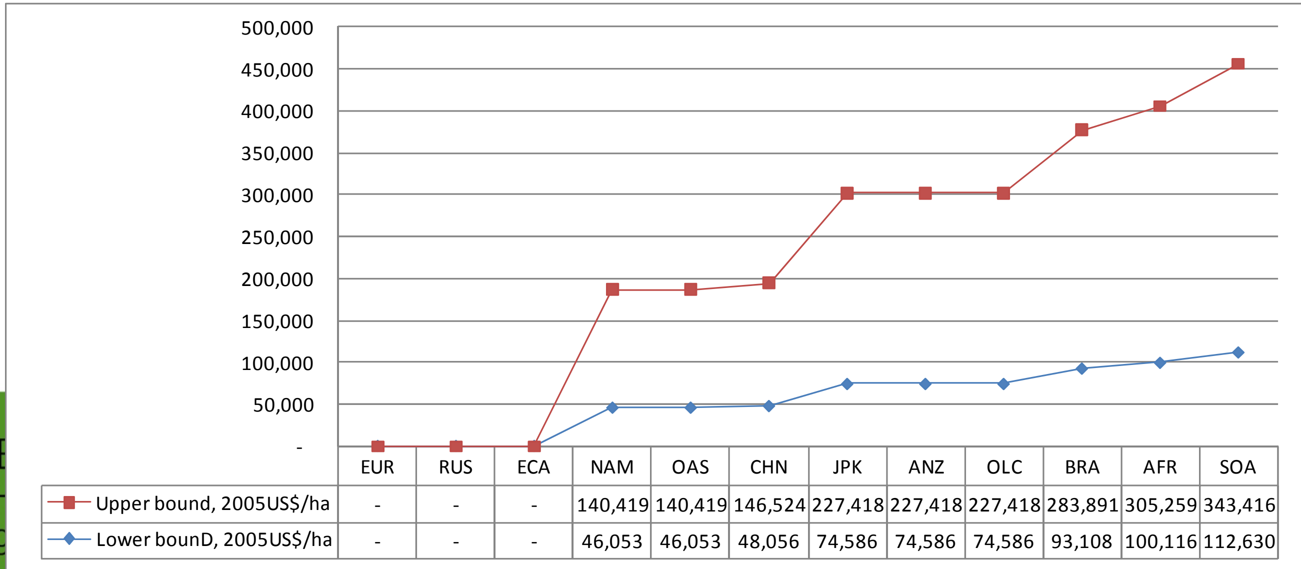
Note: (*) Directly reported from the original studies by forest type and geographical region. (**) Transferred from the original studies to similar world regions. Source: R.B. Myneni et al. (2001); H.K. Gibbs (2007).

Results: Projected stock values per hectare of carbon sequestered by world region and forest biome (2050US$/ha)

World Region	Boreal		Tropical		Warm-mixed		Temperate mixed		Cool coniferous		Temperate deciduous	
	LB	UP	LB	UP	LB	UP	LB	UP	LB	UP	LB	UP
NAM	18,707	57,038	46,053	140,419	46,053	140,419	25,529	77,841	18,707	57,038	25,529	77,841
EUR	18,707	57,038	-	-	46,053	140,419	29,734	90,662	18,707	57,038	29,734	90,662
JPK	18,707	57,038	74,586	227,418	50,058	152,629	23,702	72,270	18,707	57,038	23,702	72,270
ANZ	18,707	57,038	74,586	227,418	67,077	204,523	25,529	77,841	-	-	25,529	77,841
BRA	-	-	93,108	283,891	84,097	256,417	-	-	-	-	-	-
RUS	18,707	57,038	-	-	46,053	140,419	19,012	57,969	18,707	57,038	19,012	57,969
SOA	29,734	90,662	112,630	343,416	90,104	274,733	84,097	256,417	29,734	90,662	84,097	256,417
CHN	12,900	39,333	48,056	146,524	39,045	119,051	12,900	39,333	12,900	39,333	12,900	39,333
OAS	29,734	90,662	46,053	140,419	39,045	119,051	-	-	-	-	29,734	90,662
ECA	19,012	57,969	-	-	-	-	29,734	90,662	19,012	57,969	29,734	90,662
OLC	17,020	51,894	74,586	227,418	67,077	204,523	29,734	90,662	-	-	17,460	53,237
AFR	-	-	100,116	305,259	84,097	256,417	-	-	-	-	29,734	90,662

Note: *LB = lower bound (535ppm CO2 equivalent); UB = upper bound (640ppm CO2 equivalent).*

Results for tropical forests



Main findings and caveats

- Highest values registered for tropical and warm mixed forests in Africa, South Asia and Brazil, due to the high capacity of carbon sequestration
- Forest carbon stocks vary within each biome according to many factor not considered in this study, such as slope, elevation, drainage, soil and land-use type
- It is assumed that the projected stocked carbon is <u>linearly</u> related to the changes of forest extension, while carbon storage capacity depends on forest type and location.

ESTIMATION PROCESS:
CULTURAL SERVICES

Marginal value: cultural service

- Literature review about recreation and passive use valuation case studies (CVM, TC)
- Built a database with all the studies (EVRI, IUCN, Econlit)
- Two-step meta value-transfer approach
  - Meta-analysis to identify variables influencing WTPs estimates.
  - Value-transfer from case study sites to policy sites and scaling-up from country to world region level

Database

Ecosystem service	Forest type	study area (ha	study site type	forest size (h	Country of study	Value of the EGS	Units used in the	value ($/ year) at time
drink water supply	tropical rain fo	58323	watershed		Costa Rica	199570	US$	199570.00
water for hydroelectrical generation	tropical rain fo	58323	watershed		Costa Rica	1646143	US$	1646143.00
visitor fees for recreation	tropical rain fo	58323	park		Costa Rica	32500	US$	32500.00
tourism business	tropical rain fo	58323	park		Costa Rica	625000	US$	625000.00
biodiversity conservation for busine	tropical rain fo	58323	park		Costa Rica	10000	US$	10000.00
recreation	stunted and cl	5599	park		Costa Rica	21	US$ per visitor	1363343.12
recreation	primary and se	2309	park		Costa Rica	22	US$ per visitor	353602.01
recreation	tropical rain fo	682	park		Costa Rica	25	US$ per visitor	1591701.56
recreation	cloud forest	10500	natural reserve		Costa Rica	137.41	US$ per visitor	4426388.33
recreation	cloud forest	10500	natural reserve		Costa Rica	118.76	US$ per visitor	3825615.88
recreation	stunted and cl	5599	park		Costa Rica	11	US$ per visitor	909996.90
recreation	tropical rain fo	682	park		Costa Rica	13	US$ per visitor	761609.20
recreation	stunted and cl	5599	park		Costa Rica	23	US$ per visitor	1493185.32
recreation	tropical rain fo	682	park		Costa Rica	14	US$ per visitor	891352.87
ecotourism	cloud forest	10500	natural reserve		Costa Rica	1250	US$ per visitor	21375000.00
ecotourism	cloud forest	10500	natural reserve		Costa Rica	35	US$ per visitor	105000.00
recreation	pine-oak fores	450000	park		Mexico	3.27	US$ per visitor	179850.00
conservation	pine-oak fores	450000	park		Mexico	1.82	US$ per visitor	100100.00
recreation	seasonal semi	170000	park		Brazil	155.31	US$ per hectare per	#REF!
recreation	Atlantic Rain fo	700000	state	700000	Brazil	9.08	US$ per hectare per	#REF!
conservation	Atlantic Seaso	35000	park	35000	Brazil	60.39	US$ per hectare per	#REF!
conservation	Atlantic Seaso	35000	state		Brazil	3003463	US$ per year	3003463.00
potable water availability (quantitity	gallery forest	14400	municipality	1152	Nicaragua	10362	US$ per year for the	10362.00
water regulation and recreation (mi	Tropical monta	262300	watershed	104920	Mexico	35.6	millions US$ per yea	35600000.00
water quality	tropical	3180	watershed	2226	Honduras	5.5	US$/ha per year recieved by the service provi	
water quality	tropical	3181	watershed	2226.7	Honduras	4.1	US$/ha per year recieved by the service provi	
water quality	tropical	3182	watershed	2227.4	Honduras	2.8	US$/ha per year recieved by the service provi	
water quality	tropical	3183	watershed	2228.1	Honduras	12.4	US$/ha per year recieved by the service provi	

(1) The meta-analysis model

$$V = \alpha + \beta_{site} \log X_{site} + \beta_{forest} X_{forest} + u$$

V = forest value per hectare per year (recreational or passive use) (log)

Xforest = forest specific (forest type and forest area designated to recreation or conservation)

Xsite = context specific , includes income and population of the country

u = vector of residuals

Results of meta-regression

Table 10. Meta-regressions results for the recreational and passive use values datasets

Variables	**Forest recreational use** *Coefficiets*	**Forest passive use** *Coefficients*
Dependent		
logWTP		
Explanatory		
logINCOME	0.6252*	0.7455*
logSIZE	-0.4265***	-0.3935**
logPOP	0.3876	0.6388*
TEMP	-	-1.0082
BOREAL	0.0908	-
WARM	0.2200	1.5206
Constant	-1.6837	5.4694
Obs. number	59	27
r^2	0.4707	0.8298

Note*: * means p<0.05, ** means p<0.01, *** means p<0.001*

(2) Value-transfer and scaling-up model

$$V_{WR} = V^{*}_{Eu}\left(\frac{N_{WR}}{N_{Eu}}\right)^{\delta}\left(\frac{S_{WR}}{S_{Eu}}\right)^{\sigma}\left(\frac{GDP_{WR}}{GDP_{Eu}}\right)^{\gamma}$$

From original case studies i

Number of households

Forest area to conservation or recreation

Income or world region

V_{WR} = estimated WTP value per hectare in the $WR_{\text{-}th}$ world region.

V^{*}_{Eu} = WTP value per hectare in the *study site* world region.

(3) Projections to future scenarios

$$V_{WR,T_1} = V^*_{WR,T_0} \left(\frac{N_{WR,T_1}}{N_{WR,T_0}} \right)^{\delta} \left(\frac{S_{WR,T_1}}{S_{WR,T_0}} \right)^{\sigma} \left(\frac{GDP_{WR,T_1}}{GDP_{WR,T_0}} \right)^{\gamma}$$

Future year

Baseline year

Number of households

Forest area to conservation or recreation

Income or world region

$V_{WR,T1}$ = estimated WTP per hectare in the $WR_{\text{-}th}$ world region in a future year

$V_{WR,T0}$ = WTP value per hectare in the baseline year

S = forest area designated to recreation or conservation

N = number of households

Present value

$$PV = \sum_{t=1}^{T} \frac{(V)_t}{(1+d)^t}$$

Constant flows ⇒

$$PV = \frac{V(t)}{d}$$

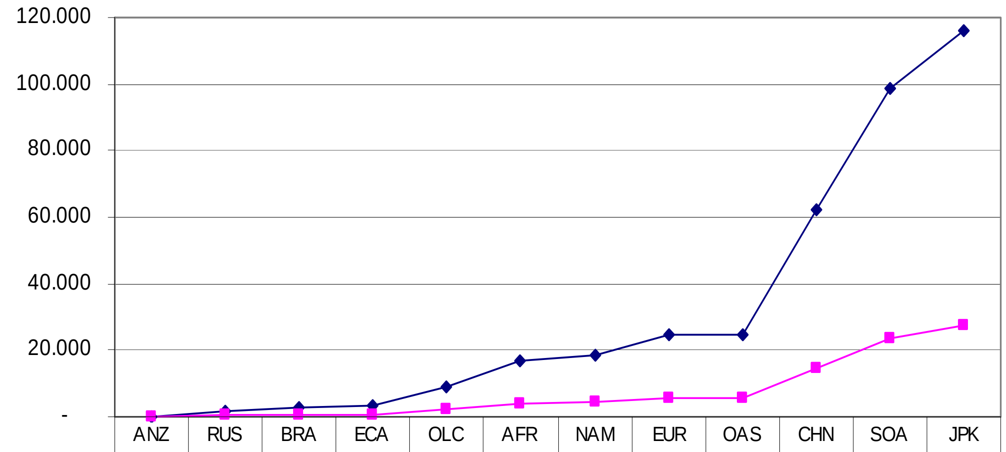
$$PV = \sum_{t=1}^{T} \frac{NV(1+g)^t}{(1+d)^t} = \sum_{t=1}^{T} \frac{NV}{(1+d-g)^t}$$

Constant flows ⇒

$$PV = \frac{V(t)}{(d-g)}$$

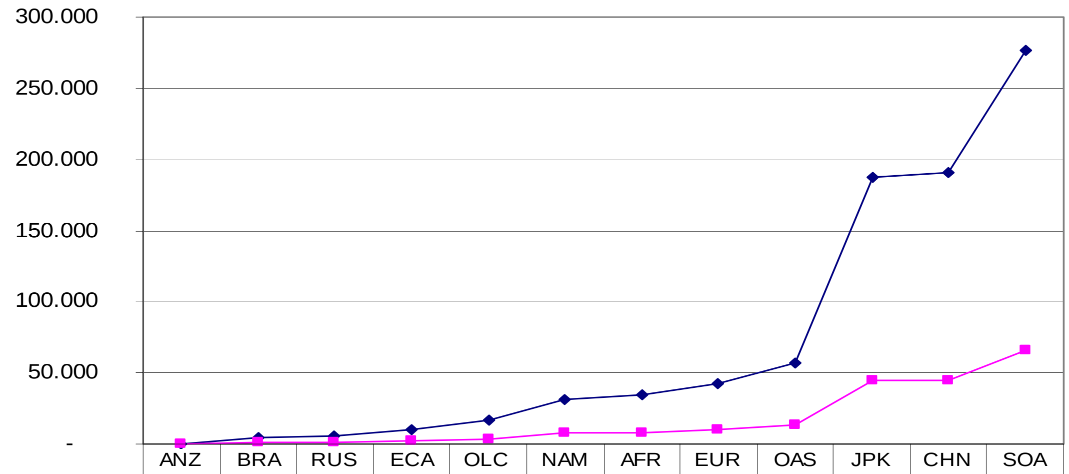
d = discount rate
g = growth rate or appreciation of the benefits over time

Meta-value transfer for recreational use (2000US$/ha)



	ANZ	RUS	BRA	ECA	OLC	AFR	NAM	EUR	OAS	CHN	SOA	JPK
Transfered mean WTP [USD 2000/ha]	230	1.675	3.037	3.461	9.240	16.764	18.646	24.575	24.810	62.421	98.909	115.895
Transfered median WTP [USD 2000/ha]	54	395	716	816	2.179	3.954	4.398	5.796	5.852	14.723	23.329	27.336

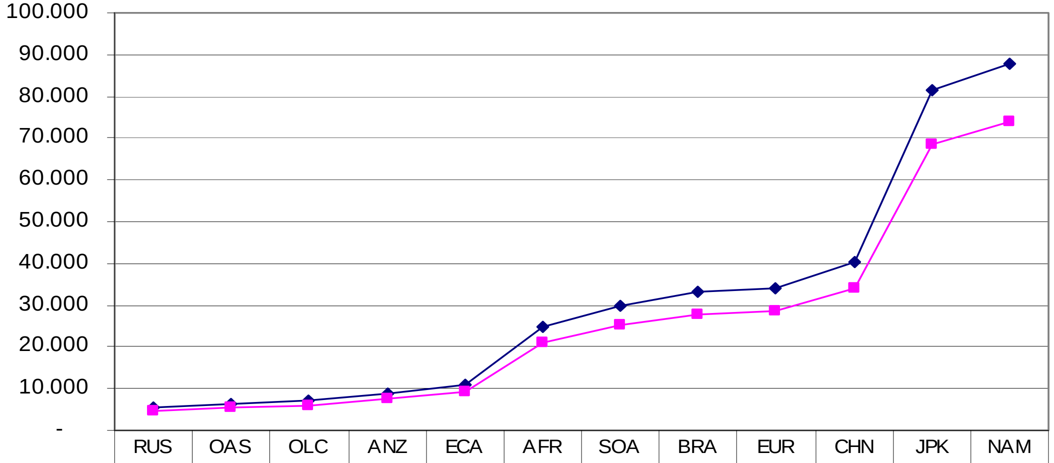
Projections to 2050 recreational use (2050US$/ha)



	ANZ	BRA	RUS	ECA	OLC	NAM	AFR	EUR	OAS	JPK	CHN	SOA
Transfered mean WTP [USD 2050/ha]	384	5.008	5.145	9.919	16.434	31.362	34.782	42.730	56.776	187.36	190.65	276.77
Transfered median WTP [USD 2050/ha]	91	1.181	1.214	2.339	3.876	7.397	8.204	10.079	13.392	44.194	44.970	65.283

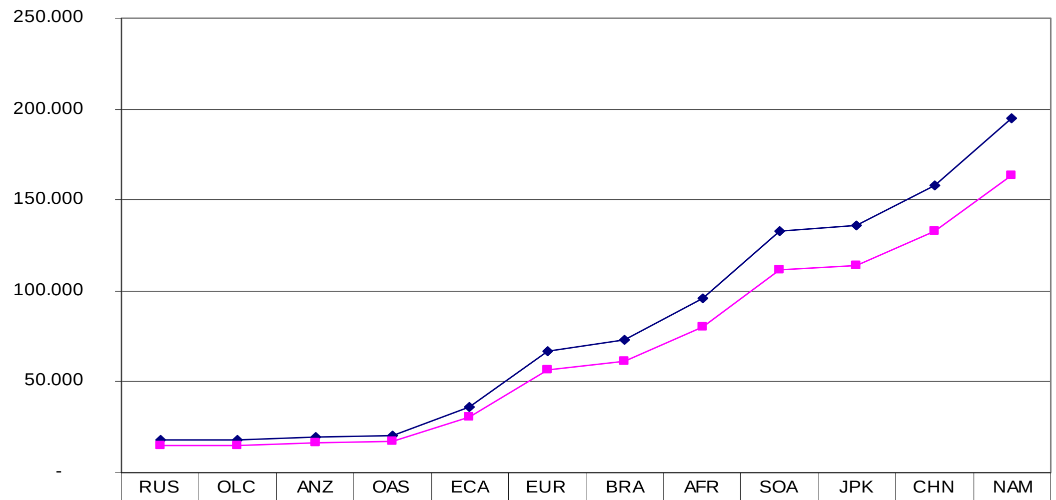
bc3 BASQUE CE
FOR CLIMA
Klima Aldaket

Meta-value transfer for passive use (2000US$/ha)



	RUS	OAS	OLC	ANZ	ECA	AFR	SOA	BRA	EUR	CHN	JPK	NAM
Transfered mean WTP [USD 2000/ha]	5.605	6.421	7.220	8.983	11.009	24.976	29.849	33.129	34.205	40.255	81.675	87.948
Transfered median WTP [USD 2000/ha]	4.711	5.396	6.068	7.550	9.252	20.990	25.085	27.842	28.746	33.830	68.640	73.912

Projections to 2050 passive use (2050US$/ha)



	RUS	OLC	ANZ	OAS	ECA	EUR	BRA	AFR	SOA	JPK	CHN	NAM
Transfered mean WTP [USD 2000/ha]	18.150	18.225	20.012	20.700	36.041	67.076	73.131	95.854	132.631	136.084	158.131	194.952
Transfered median WTP [USD 2050/ha]	15.253	15.316	16.818	17.396	30.289	56.371	61.460	80.556	111.464	114.365	132.894	163.838

Main findings

- Mean and median stock values for recreational and passive use show similar pattern, with the 6 highest estimates always including Japan and Korea, Europe, North America and China Region
- Brazil and other Asian Countries (OAS) show the highest variability between recreational and passive use values, attributable to the difference in forest area size dedicated to recreation and conservation
- For passive use, values range from 4,711 to 87,948 US$2000/ha, with the highest value for China as a sign of population effect and income effect combined to a scarce presence of conservation areas
- For recreation, values range from 4,398 to 115,895 US$2000/ha, with the highest figures in Japan due to an income effect

CASE STUDY 1:

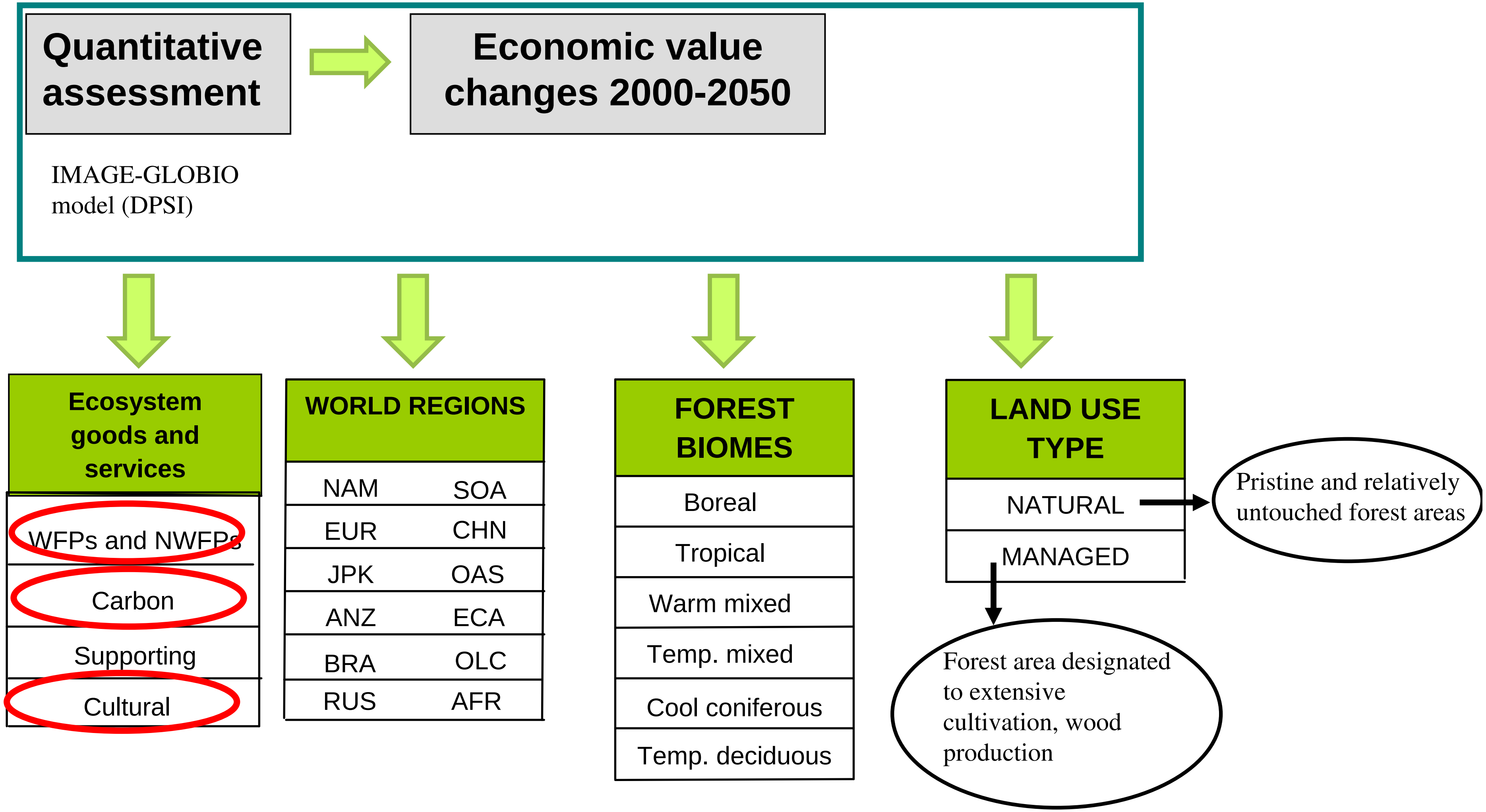
COST OF POLICY INACTION AT WORLDWIDE LEVEL

(COPI project)

Objectives

- Study developed within the EU funded project COPI “Cost of Policy Inaction: the case of not meeting the 2010 biodiversity target”
- 2010 Biodiversity policy target to “significantly reduce the rate of biodiversity loss by 2010”, agreed at World Summit on Sustainable Development in 2002 and adopted by CBD
- Objective to estimate the social <u>costs of no policy initiatives</u> to modify the current paths of dynamics, by combining ES values and land use changes
- The study provides a contribution to the national accounting systems SEEA (System of Economic and Environmental Accounting), highlighting the importance to value both stocks and flows of values associated with EGSs

The valuation approach



Major assumptions for forest change projections in GLOBIO-IMAGE model

Criteria under consideration	**Major assumptions**
	Socio-economic and environmental criteria
Population	Projected world population will be stabilized at around 9.1 billion inhabitants by 2050 (UN, 2005).
GDP	Annual growth rate at 2.8% between 2005 and 2050.
Biodiversity	It is assumed that increased GDP will increase the pressures on biodiversity.
Energy consumption	Increase from 280 EJ to 2000 to 470 EJ in 2030, and ca 600 EJ in 2050.
Agricultural production	The production will need to increase by more than 50% in order to feed a population more than 27% larger and roughly 83% wealthier than today's, with an extended 10% of agricultural area and continuous evolution of agricultural productivity.
	Major policy implications
The ¨protected area¨ policy	The implementation will not substantially change current trends.
Climate change policy	No post-Kyoto regime other than the policies in place and instrumented by 2005; the existing trading scheme for emission credits is included.
EU common fisheries policy and equivalent policies in other world region	No significant changes in the current policy implementation.
Policy for biodiversity conservation	The policies towards conservation of forests and sustainable use of biodiversity exist but remain lack of enforceability and ineffective.

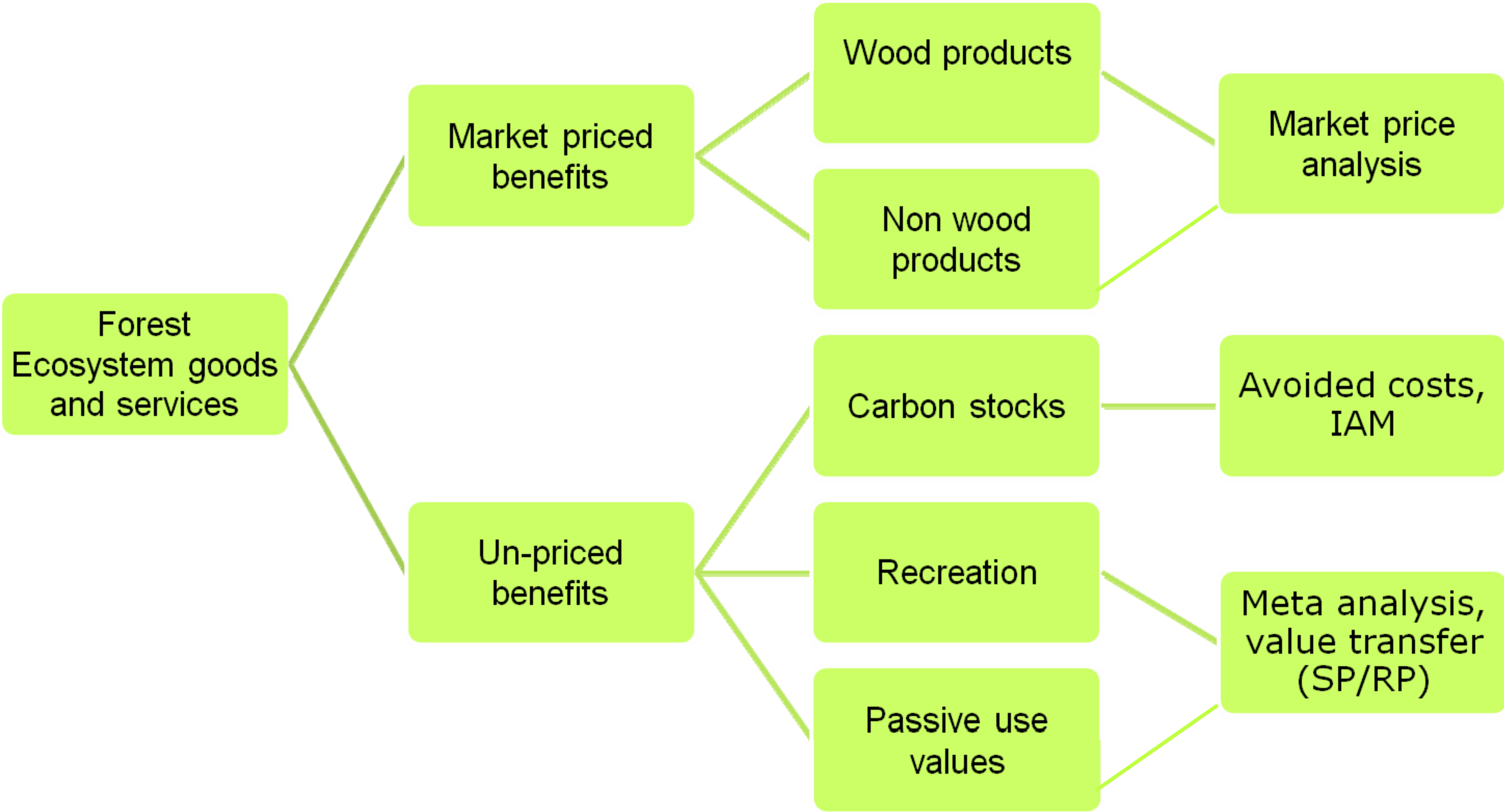
The geographical regions used in COPI and GLOBIO

World regions	Description
NAM	North America
EUR	OECD Europe
JPK	OECD Asia (Japan & Korea)
ANZ	OECD Pacific (Australia & New Zealand)
BRA	Brasil
RUS	Russia & Caucasus
SOA	South Asia (and India)
CHN	China Region
OAS	Other Asia
ECA	Eastern Europe & Central Asia
OLC	Other Latin America & Caribbean
AFR	Africa

Ecosystem services provided by land use

Ecosystem services and land cover				
Land cover	**Wood forest products**	**Carbon regulation**	**Passive use**	**Recreation and ecotourism**
Natural areas	NR	X	X	X
Forest managed	X	X	NR	NR

Economic valuation: methods



Projections of forest area changes 2000-2050 (000 ha.)

Forest biome and landuse	NAM	EUR	JPK	ANZ	BRA	RUS	SOA	CHN	OAS	ECA	OLC	AFR	Total
Boreal	**-4031**	**1867**	**27**	**-116**	**0**	**-35674**	**-760**	**212**	**-1**	**-531**	**-723**	**0**	**- 39,731**
natural	-24301	-6425	-590	-125	0	-36080	-1400	-4526	-2	-1238	-836	0	- 75,523
managed	20270	8293	618	8	0	406	639	4738	0	707	112	0	35,791
Tropical	**219**	**0**	**4**	**-24**	**-36214**	**0**	**-39**	**19**	**-6288**	**0**	**392**	**-3282**	**- 45,579**
natural	-10	0	6	-225	-41638	0	-654	-236	-16503	0	-2905	-13824	- 75,989
managed	229	0	-1	201	5058	0	615	254	10215	0	3296	10542	30,409
Warm mixed	**17**	**282**	**102**	**-1270**	**-4476**	**-1**	**-3730**	**243**	**-705**	**0**	**-4194**	**-8187**	**- 21,553**
natural	-13248	-1335	207	-1935	-5146	-1	-10089	-7811	-2018	0	-4745	-10181	- 56,303
managed	13265	1617	-105	665	1036	0	6359	8053	1313	0	552	1994	34,750
Temp. mixed	**303**	**1870**	**1666**	**-147**	**0**	**-6252**	**-427**	**12**	**0**	**-5584**	**-115**	**0**	**- 8,674**
natural	-14299	-8620	-864	-167	0	-6231	-1008	-759	0	-5254	-147	0	- 37,347
managed	14602	10489	2530	20	0	-21	580	771	0	-331	32	0	28,673
Cool coniferous	**-1252**	**-781**	**57**	**0**	**0**	**-4621**	**-437**	**-5**	**0**	**-216**	**0**	**0**	**- 7,254**
natural	-5257	-5288	-981	0	0	-4627	-869	-1078	0	-671	0	0	- 18,772
managed	4005	4507	1038	0	0	7	432	1073	0	455	0	0	11,517
Temp. deciduous	**200**	**5673**	**1366**	**-280**	**0**	**-426**	**-613**	**92**	**-25**	**-423**	**-19**	**-146**	**5,400**
natural	-8342	-4056	2424	-449	0	-422	-4092	-5043	-83	-401	-40	-153	- 20,657
managed	8542	9729	-1058	169	0	-4	3479	5135	58	-21	21	6	26,057
Total	**-4545**	**8912**	**3224**	**-1836**	**-40690**	**-46974**	**-6007**	**572**	**-7019**	**-6754**	**-4659**	**-11616**	**- 117,392**
% Δ (2000 base) TOTAL	*-0.5%*	*3.8%*	*7.0%*	*-3.3%*	*-10.5%*	*-4.2%*	*-17.3%*	*0.2%*	*-3.4%*	*-26.6%*	*-1.6%*	*-7.1%*	*-3.2%*
% Δ (2000 base) NATURAL	*-8.5%*	*-15.2%*	*0.5%*	*-5.4%*	*-12.2%*	*-4.4%*	*-70.5%*	*-8.6%*	*-9.8%*	*-34.7%*	*-3.1%*	*-15.3%*	*-8.4%*
% Δ (2000 base) MANAGED	*73.7%*	*53.9%*	*49.5%*	*66.3%*	*117.7%*	*0.8%*	*133.1%*	*92.7%*	*74.5%*	*22.7%*	*53.1%*	*180.8%*	*61.6%*

Main findings

- World's forest area expected to decrease by 117 million ha by 2050 (3.2%), with 8% loss of natural or pristine forests
- The increase in managed forests is not compensating the loss of natural areas
- The highest absolute loss projected is in tropical forests in Brazil, followed by boreal forests in Russia
- Deforestation in Russia is due to timber extraction and illegal activities, intensified by high demand for timber in China and Southeast Asia, and for pulp in Europe
- Additional stressors in Russia due to forest fires
- Deforestation in the Amazon forest is associated with the unsustainable use of land for commercial pasture, exploitation of timber and other forest products
- Major pressure in the Amazon represented by cattle ranching and small-scale subsistence agriculture
- The impact of deforestation in tropical forests more dramatic than in boreal forests, due to their high biodiversity level and slower regeneration

Economic impact due to forest area loss

Cost of policy inaction in year 2050, per geographical region and biome:

$$COST_{WR,b} = V_{WR,b} * \Delta ha_{WR,b}$$

- V estimated in one year taken as reference (baseline or 2050)
- using discount rate 3 percent (EU)

Welfare change associated with ecosystem service loss

Table 11. Changes in tota[illegible]ocks value of forests, by world region and forest biome, projected to 2050 **(bn US$, 2050)**

World Region	Carbon		WFPs & NWFPs	Recreation		Passive use		Total		Δ value per year		2050 GDP (bn.$)	% of 2050 GDP	
	LB	UP	PE	LB	UP	LB	UP	LB	UP	LB	UP		LB	UP
NAM	-75	-229	5,357	-23	-96	-1,126	-1,340	4,133	3,692	92	82	35,700	0.26	0.23
EUR	258	785	559	-14	-52	-152	-181	651	1,112	14	25	28,500	0.05	0.09
JPK	79	241	421	1	2	2	3	504	667	11	15	8,200	0.14	0.18
ANZ	-100	-305	73	0	0	-5	-6	-32	-238	-1	-5	1,800	-0.04	-0.29
BRA	-3,605	-10,993	220	-13	-56	-233	-277	-3,631	-11,105	-81	-247	3,900	-2.07	-6.33
RUS	-881	-2,686	4	-8	-11	-76	-90	-961	-2,783	-21	-62	6,400	-0.33	-0.97
SOA	-464	-1,414	576	-52	-227	-212	-252	-152	-1,317	-3	-29	26,600	-0.01	-0.11
CHN	14	44	1,314	-34	-174	-271	-323	1,023	861	23	19	45,000	0.05	0.04
OAS	-318	-969	1,306	-12	-50	-34	-40	943	247	21	5	10,600	0.20	0.05
ECA	-193	-588	10	-1	-4	-24	-29	-208	-610	-5	-14	2,200	-0.21	-0.62
OLC	-268	-818	170	-1	-7	-14	-17	-114	-671	-3	-15	6,000	-0.04	-0.25
AFR	-1,021	-3,115	1,794	-9	-39	-204	-243	558	-1,604	12	-36	14,000	0.09	-0.25
TOT	**-6,574**	**-20,045**	**11,806**	**-167**	**-714**	**-2,350**	**-2,796**	**2,715**	**-11,749**	**60**	**-261**	**195,000**	**0.03**	**-0.13**
Δ value per year	-146.09	-445.45	262.35	-3.71	-15.88	-52.21	-62.13	[illegible]	[illegible]	1.34	-5.80	-	-	-
% of 2050 world GDP	-0.07	-0.23	0.13	-0.002	-0.01	-0.027	-0.032	0.03	-0.13	0.001	-0.003	-	-	-

Main findings (1)

- Final results show that using lower bound or upper bound values per hectare can lead to different welfare impacts
- At a world level, for the 4 EGSs analyzed, the results range from an economic benefit to an economic loss (2,700-11,800 bn US$2050), corresponding to a range from +0.03% to -0.13% of 2050 world GDP
- The world regions that are expected to gain from the business as usual policy in both scenarios (lower and upper bound), include mostly developed countries such as NAM, EUR, JPK, due to an increase in managed forest and timber exploitation
- For countries like EUR, JPK and CHN, a benefit is expected also from increased carbon stocks due to an expansion in total forest area projected in these regions (natural and managed)

Main findings (2)

- The majority of the world regions show nevertheless an economic loss due to policy inaction, attributable to a loss of carbon stocks due to a reduction of 8% in natural forests worldwide
- Highest loss expected in tropical forests in Brazil, 2%-6% of 2050 GDP (3,600-10,900 bn US$2050), attributable to a large reduction in the Amazonian forest area (12%)
- Carbon shows the major economic loss, 6,500-20,000 bn US$2050, expected mainly in BRA, followed by AFR, RUS and SOA
- Conservation and recreational services show a loss of 2,300-2,800 and 170-700 bn US$2050
- Timber products present always an economic gain, due to the projected increase in managed forests

CASE STUDY 2:

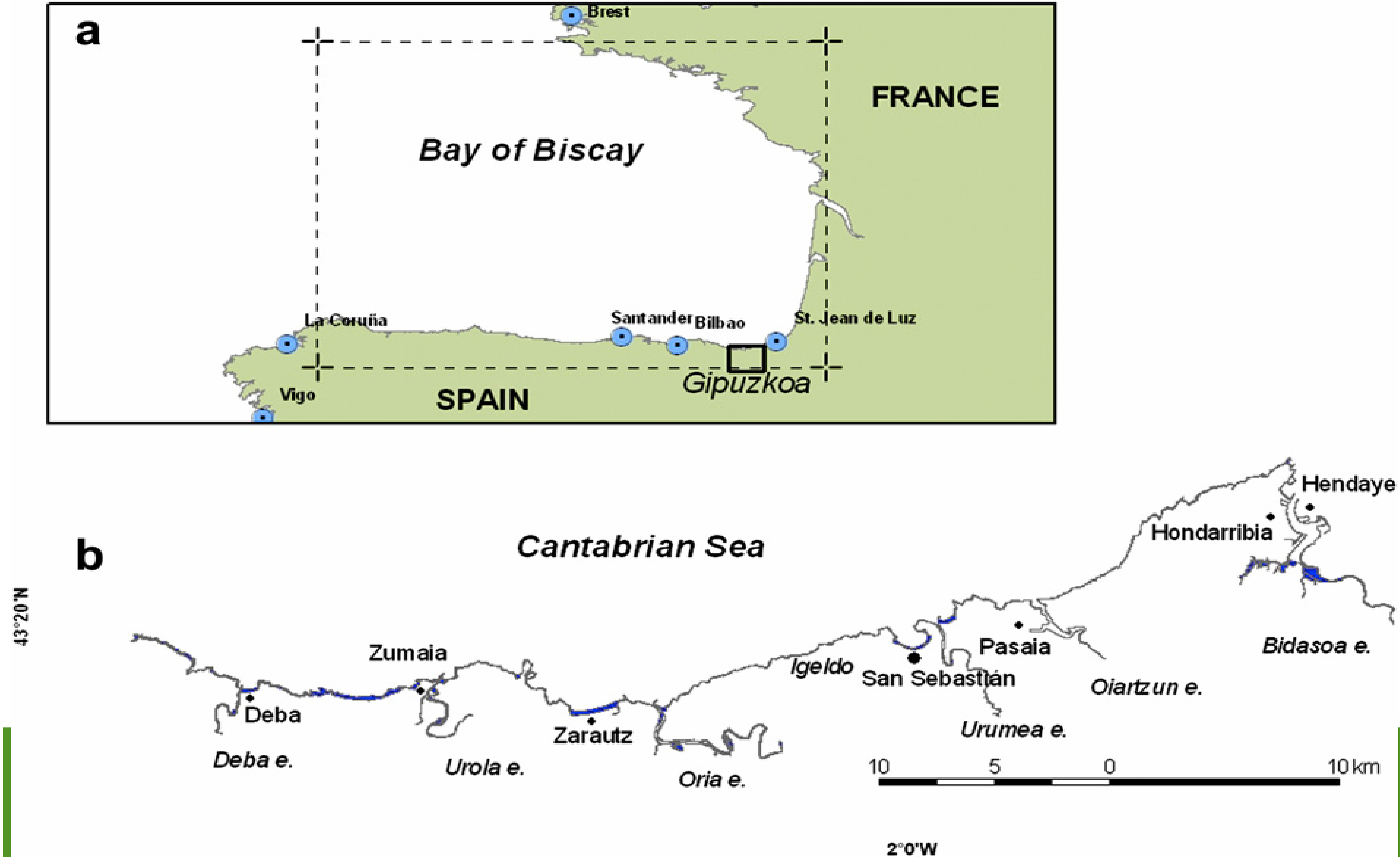
Economic impact due to sea level rise in the Basque coast

(K-Egokitzen project)

The study area

- Coast of Gipuzkoa, located within the Bay of Biscay, 198 km long at low tide
- Coast very steep, dominated by rocky substrata with vertical cliffs and intercalated by small estuaries with sandy beaches at the mouth of the rivers (Borja et al, 2004)
- Basque coast represents only 12% of the total surface of the Basque country
- It supports nevertheless 60% of the overall population and 33% of industrial activities (Cearreta et al, 2004)

Study area: Gipuzkoa within the Bay of Biscay



The impact

- Global climate change models predict a sea level rise between 0.18 m and 0.59 m by 2100, with high regional variability
- Several studies show a see level rise for the Bay of Biscay slightly higher than the global rates
- AOGCM models - Atmosphere-Ocean Coupled General Climate Models - used within the Bay of Biscay:
  - ✓ Projections for 2100: increase in seal level between 28.5 and 48.7 cm, as a result of regional thermal expansion and global ice-melting, under scenarios A1B and A2 of IPCC

Projected flooded area in the Basque coast 2100 (up-scaling)

HABITAT	Total area ha (2004)	Flooded area ha (2100)	Flooded area (%)
Sandy and shingle beaches and muds	165.32	22.35	13.5%
Vegetated dunes	36.23	7.59	20.9%
Sea cliffs and supralittoral rock	254.75	13.15	5.1%
Wetlands and saltamarshes	178.4	11.63	6.5%
Terrestrial habitats	61.16	45.54	74.5%

Results from Chust et al, 2009

Results: non-market valuation (use and non-use) (2% discount rate, €2005)

Habitat	Value category	V/ha (1.000 €)	Welfare loss (1.000 €)
Sandy and shingle beaches and muds	Recreational value Passive use value	1.152-2.063 241-605	31.134-59.630
Sea cliffs and supralittoral rock	Passive use value	1.052-3.273	13.833-43.040
Wetlands and saltmarshes	Total economic value	101	1.171
Terrestrial habitat (riparian woodland by rivers around wetlands)	Carbon Recreational value Passive use value	1,4-4,1 2,4-10,1 904-2.779	41.328-127.200
Total loss			**87.466-231.032**
Loss per hectare			**872-2.304**

Results: non-market valuation (use and non-use) (1% discount rate, €2005)

Habitat	**Value category**	**Welfare loss (1.000 €)**
Sandy and shingle beaches and muds	Recreational value Passive use value	71.979-132.776
Sea cliffs and supralittoral rock	Passive use value	34.794-108.262
Wetlands and saltmarshes	Total economic value	2.841
Terrestrial habitat (riparian woodland by rivers around	Carbon Recreational value Passive use value	104.255-320.925
Total loss		**213.869-564.804**
Loss per hectare		**2.133-5.633**

Main findings of the study

- Economic loss (2% discount): **88-231€ million** (2005€) equivalent to **0.87–2.3€ million/ha** (2005€)
- Economic loss (2% discount): **214-565€ million** (2005€) equivalent to **2–5.6€ million/ha** (2005€)
- Estimated values per hectare are quite high and comparable to average price per ha of the land for residential/industrial use in the Basque country

CASE STUDY 3:

Economic impact of climate change on water-related services in Costa Rica: the hydropower sector

(CLIMBE project)

Objetives of the case study

1. Estimate the economic value of water contribution to the generation of hydropower in tropical forests in Costa Rica

2. Predict the economic impact associated with climate change in the hydropower sector

The database

- 43 hydropower plants in Costa Rica
- Cross-sectional data (1 dimension)
- Information on runoff and vegetation type by watershed

Planta	Powerkw	Storage	Caudal	Caida	Generation_kwh	Revenue	Runoff	Dry_HZ	Moist_HZ	Wet_HZ	Rain_HZ
AGUAS ZARCAS	14208	75	7	133	126079526.50	5331549.47	2626	0	0	168.3686326	841.8431632
ANGOSTURA	172202	10900	112.6	142.2	779381415.70	68879379.48	2157	0	12122.54155	94791.54018	37798.75803
ARENAL	157398	2416000	97.5	217.8	733538788.25	60523586.23	1176	0	926.0274795	3030.635388	0
AVANCE	240		0.2	148	1690084.85	139914.28	1532	0	0	1178.580428	84.18431632
BIRRIS 122	22720				111820798.26	6798874.45	1230	0	0	3451.556969	1683.686326
CACAO	672		1.2	46	4452983.30	373870.38	1854.362637	0	0	9681.196377	0
CACHI	100800	51000	54.3	219	601593256.50	49358155.14	1936.712121	0	12122.54155	49837.11526	22898.13404
CAÑO GRANDE	2905			47	17657734.19	1180577.25	2997.294118	0	0	1094.396112	336.7372653
CARRILLOS	2000			142	32173232.67	2000055.63	1854.362637	0	0	9681.196377	0
DON PEDRO	14000	70	4.1	401.31	62702050.60	5209467.77	3127.136364	0	0	1852.054959	168.3686326
DOÑA JULIA	16470	190	15.62	120.85	100585756.66	8229770.61	2796.051282	0	0	6987.298255	168.3686326
ECHANDI	4696	2.7	2.5	200	28537645.05	2430712.46	1759.168831	1010.211796	3114.819704	12459.27882	0
EL ANGEL	3424			87	19085087.09	1050368.07	2779.578313	0	0	7071.482571	505.1058979
EL EMBALSE	2000			0	8698872.25	524191.12	2664.185185	0	0	1852.054959	589.2902142
EL GENERAL	39000	192	18.5	247.5	165900905.84	12338852.71	2608.164384	0	252.552949	6818.929622	252.552949

The production function

Stata

Statistical analysis

- Function: generation electricity by hectare

Variable	ols1_loggenerat_ha	ols_cr1_loggenerat_ha
logrunof~_ha	0.95955***	0.96461***
logpowerkw	0.98133***	0.99424**
logcaida	-0.10819	-0.09606
logstorage	0.02299	0.01775
_cons	-15.04054***	-15.26211***

legend: * p<.1; ** p<.05; *** p<.01

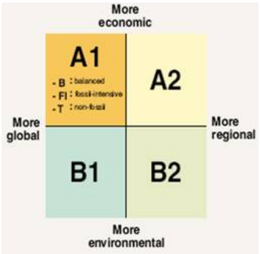
$$lnQ = \beta_0 + \beta_1 lnX_{runoff} + \beta_2 lnX_{power} + \mu$$

- Revenues per hectare

Variable	ols1_logrevenue_ha	ols_cr1_logrevenue_ha
logrunof~_ha	0.92854***	0.93418***
logpowerkw	0.96427***	0.97866**
logcaida	-0.04900	-0.03548
logstorage	0.03632	0.03048
_cons	-17.30504***	-17.55193***

legend: * p<.1; ** p<.05; *** p<.01

Projections of runoff under climate change scenarios



Economic impact

- Runoff data are projected in 2100 and incorporated in the production function

$$\ln Q = \beta_0 + \beta_1 \ln X_{runoff} + \beta_2 \ln X_{power} + \mu$$

ΔProduction | Projections | Constant

- We obtain the expected change in energy generation and revenues of hydropower plants

Results

Results for Costa Rica

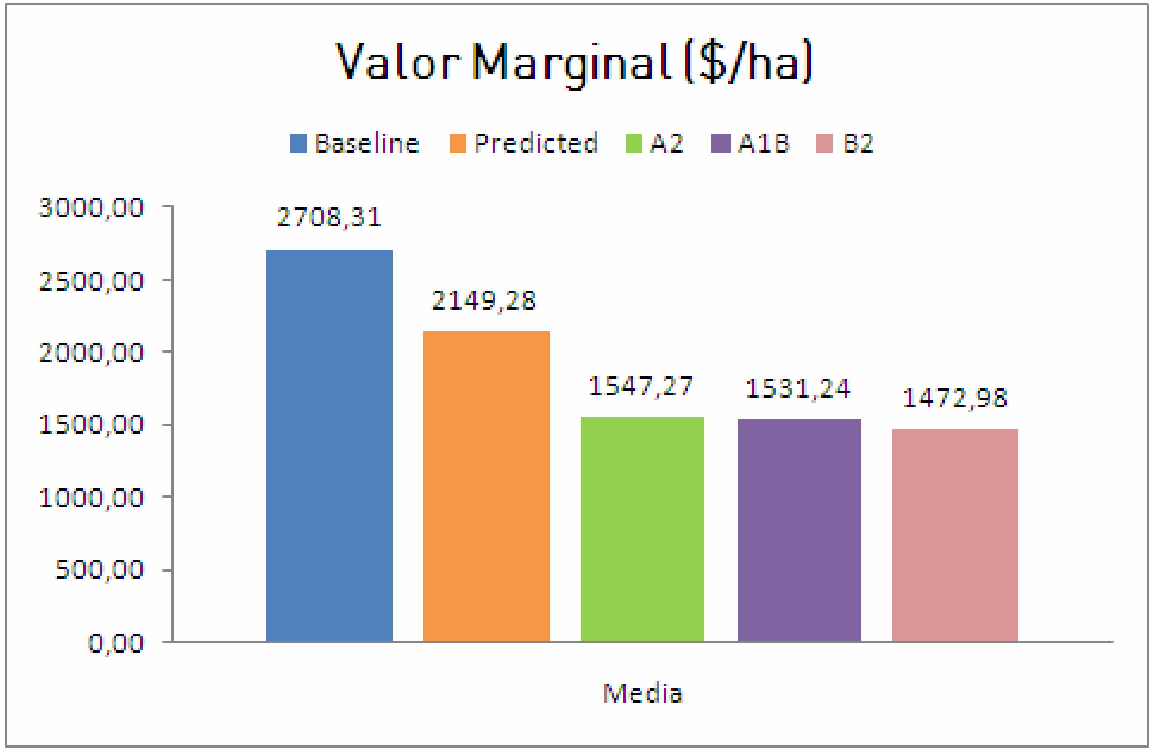
- Economic values:

Revenues ($/ha) (baseline and projections 2100)

	Baseline	Predicted	A2	A1B	B2
Mean	**2.708,31**	**2.149,28**	**1.547,27**	**1.531,24**	**1.472,98**
Median	491,87	401,27	250,59	241,10	272,46
Range	2,96-42.106	15,43-31.710	11,98-29.416	9,51-30.249	12,07-21.762

Results

Results
Costa Rica



Results

Results
Costa Rica

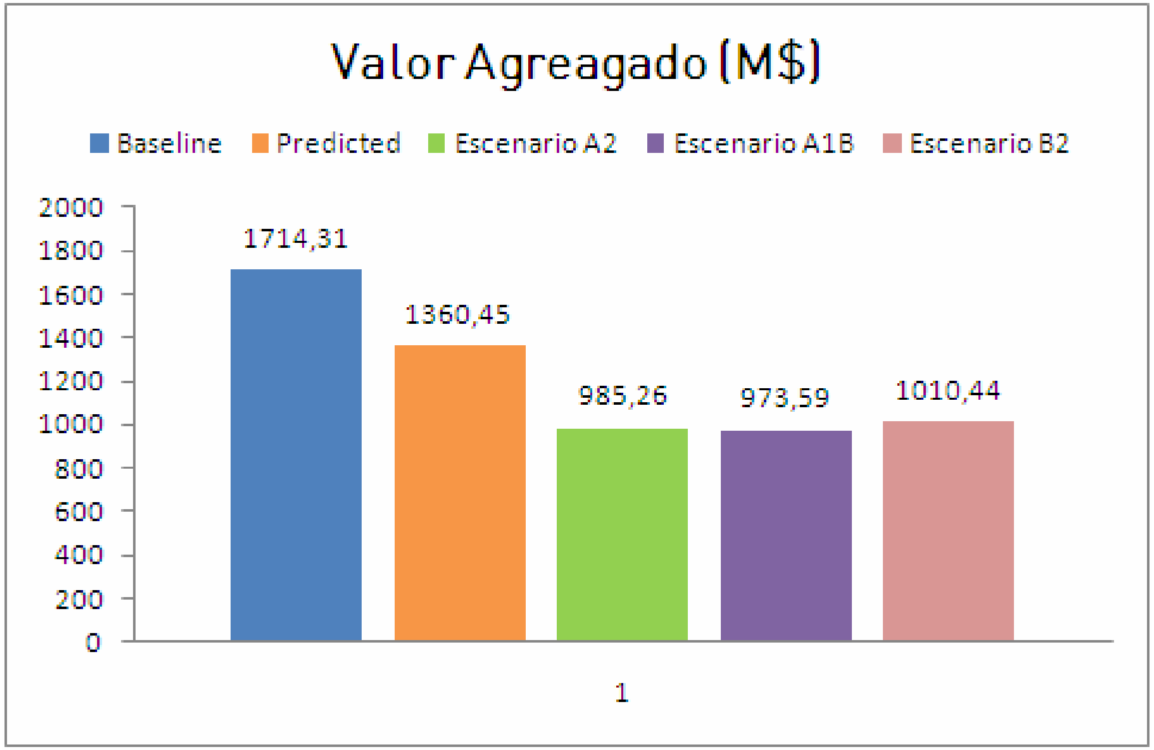
- Economic impact (aggregated value):

Total revenues (M$) (baseline and projections 2100)

	Average (M$)	Median (M$)	Variation	
Baseline	1714.31	311.35	-	
Predicted	1360.45	254.00	-	
Scenario A2	985.26	159.57	-729.05	-42.5%
Scenario A1B	973.59	153.30	-740.72	-43.2%
Scenario B2	1010.44	186.90	-703.87	-41.1%

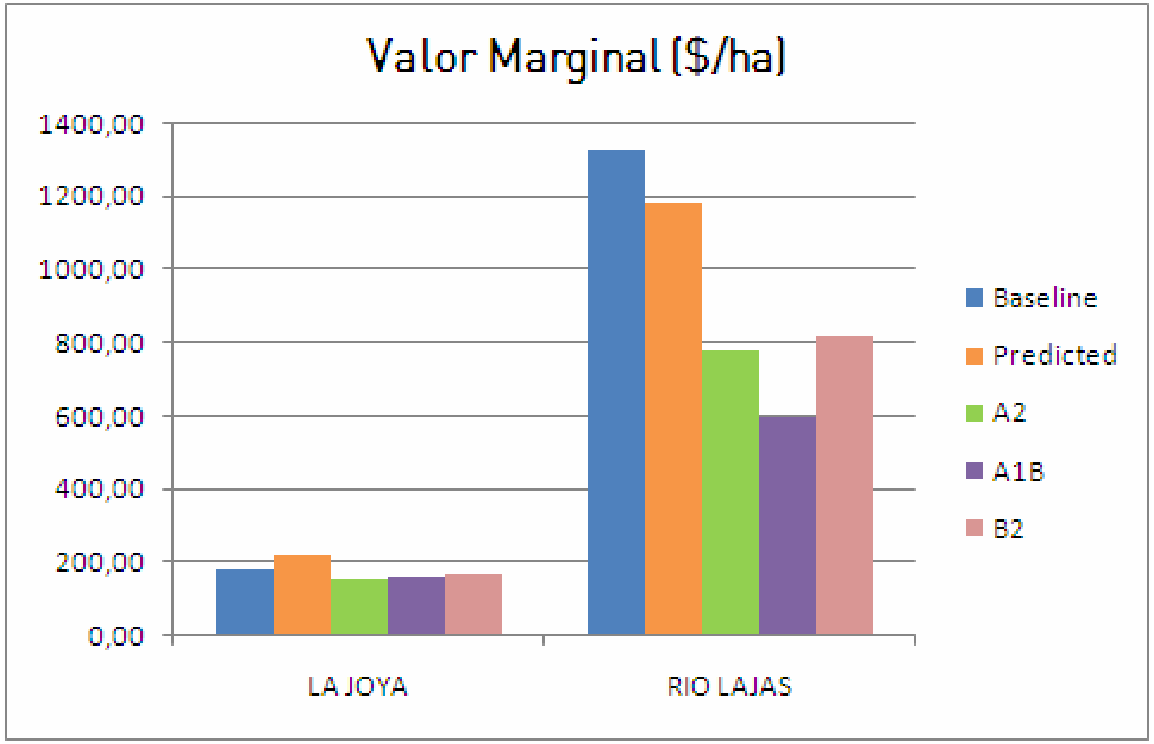
Resultados

Results
Costa Rica



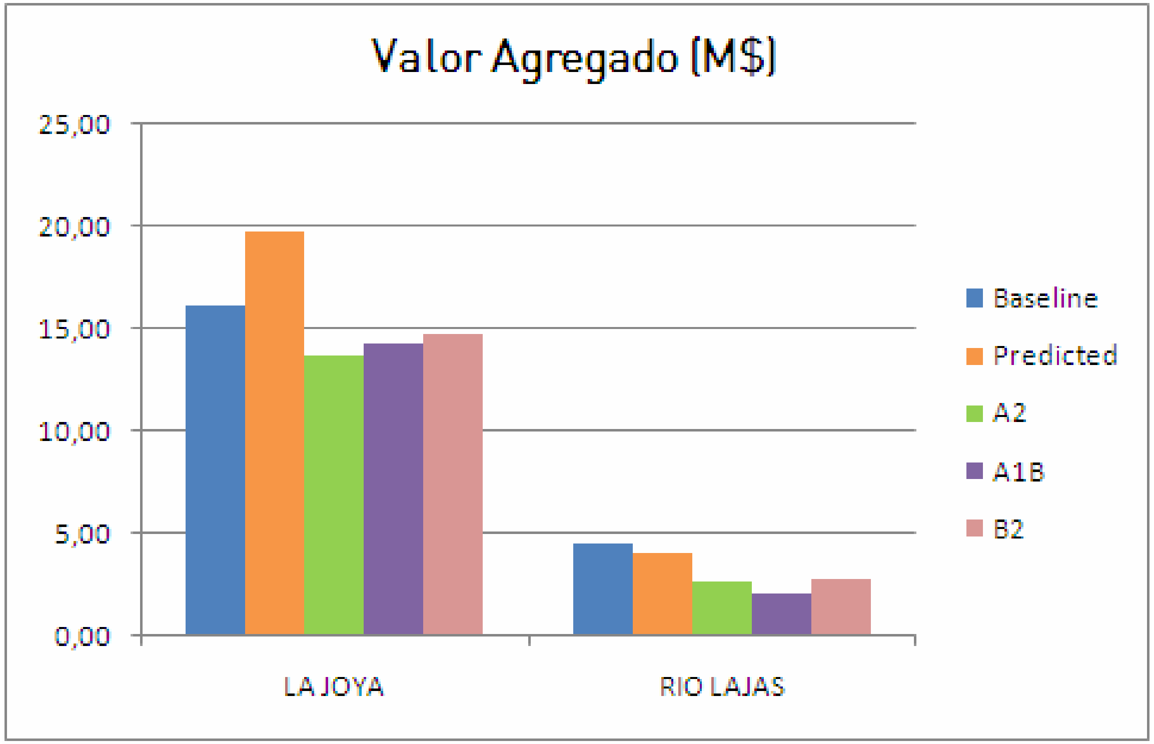
Results by hydropower plant

Results by plant



Results by hydropower plant

Results
by plant



Conclusions

- Climate change is expected to reduce the revenues of the hydropower sector in Costa Rica.
- The reduction is lower in scenario B2, which is more environmental oriented.

Muchas gracias!

Eskerrik asko!