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Using Multi-Criteria Analysis Method for Assessment the Impacts of Integrated Land-use/cover Management on the Provision of Ecosystem Services in Protected Area of Lakes Prespa

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Abstract: There is a growing need of integrating ecosystem services into management strategies of protected areas. The objective of this study was to develop a framework for assessment the effects of integrated land-use/cover management on the provision of ecosystem services in a protected area. The framework was tested in Prespa Park, a watershed with fragile environments. Within this framework, first to provide ecosystem services were used a modified approach compared to the Millennium Ecosystem Assessment. Then was employed a "benefit transfer" and "expert-based assessment" approach to assess contribution of the land cover classes in case study region to the provision of ecosystem services. In a subsequent step, the services were combined to ecosystem services groups that were designed together with regional stakeholders, considering their ideas, concerns and experiences in regional decision making. The latter was analyzed in a weighting experiment, in which different weighting approaches were tested. For the case study, were identified 16 CORINE land cover classes, 13 ecosystem services and related ecosystem services indicators? Based upon this, was analyzed the performance of the case study region to provide ecosystem services. It was concluded that land-use/cover management was found to affect ecosystem services directly. Results showed that the different data gathering methods: "benefit transfer" and "expert-based assessment" have a considerable impact on the evaluation outcomes, and that the combination of selected services and land cover data can contribute to regional planning by communicating the effect of land cover change on ecosystem services groups. Finally, the results revealed that the proposed framework can be used to determine qualitative estimation of regional potentials to provide ecosystem services as a prerequisite to support regional development planning.

Keywords: *Multi-criteria assessment, benefit transfer, expert-based assessment, stakeholder weighting, ecosystem services, landscape planning*

Introduction

Ecosystems provide various goods and services to society, which in turn directly contribute to our well-being and economic wealth (Costanza, 2000; de Groot *et al*., 2010; Farber *et al*., 2002). As a consequence of global increase of economic and societal prosperity, ecosystems and natural resources have been substantially exploited, degraded, and destroyed in the last century (MA 2005). To prevent further abatement of the quality of ecosystems, the ecosystem services concept has become a central issue in conservation planning and environmental impact assessment (Burkhard *et al*., 2010; Fisher & Turner, 2008).

Land management is an important factor that affects ecosystem services provision. Land cover and land use changes (LCC/LUC) can significantly improve or degrade the provision of ecosystem services (Foley *et al*. 2005; MA 2005). The basic problem is the quantification of ecosystem services in required detail, as their provision varies considerably as a function of land cover/land use and site conditions such as climate, soil, topography, neighborhood effects, land management practices, and time (Daily & Matson, 2008; Grazhdani 2014a,b; de Groot *et al*. 2010; Meersmans *et al*. 2008).

Existing methods of ecosystem services assessment often draw attention to (model-based) up-scaling of monitoring data that has been assessed at the level of the management planning unit (forest

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stand/field), at the level of an economic entity (forest district/farm) or at a catchment scale to become linked to an ecosystem service (Balvanera *et al*., 2005; Dale & Polasky, 2007; Pert *et al*., 2010; Posthumus *et al*., 2010; Sandhu *et al*., 2008). Here, literature and expert-driven approaches for bundling knowledge on the provision of ecosystem services on the landscape scale might be a solution (Bolliger & Kienast, 2010; Eigenbrod *et al*., 2010).

Consistent and comprehensive frameworks that link human society and economy to biophysical entities, and include impacts of policy decisions, have been developed during the last decades. In this study, for the analysis of ecosystem services such a framework was developed in the context of the Millennium Ecosystem Assessment (MA 2005), which was itself based on DPSIR (Driver, Pressure, State, Impact Response) framework. It was adapted the frameworks by TEEB (2010) and Haines-Young & Potschin (2010) for indicator selection. These frameworks are among the most recent and comprehensive ecosystem services assessment frameworks.

In this paper is presented a multi-criteria assessment framework for the qualitative estimation of regional potentials to provide ecosystem services as a prerequisite to support regional development planning. In this study, the first step was to apply a modified set of ecosystem services compared to the definitions and terms used in the Millennium Ecosystem Assessment (MA 2005) and the most recent study on The Economics of Ecosystems and Biodiversity (TEEB 2010). In comparison to the MA and the TEEB study, the set of ecosystem services was adapted in a participatory process to the concrete needs of the regional planning actors in the Lakes Prespa region. So, to develop an applicable framework, were taken first a set of eleven ecosystem services from the Millennium Ecosystem Assessment (2005) approach to which were added two economy-related services that were proposed by regional actors in the case study region. The resulting thirteen ecosystem services were assessed through (a) a benefit transfer approach, and (b) a qualitative assessment based on expert interviews.

Material and Methods

Case study Lakes Prespa region

The framework for assessment of the effects of integrated land-use/cover management on the provision of ecosystem services was applied in a protected area of Prespa Park, officially inaugurated in February 2000, and is located at the border triangle with Albania, Greece and Macedonia. The Prespa Park comprises both terrestrial and aquatic components and its boundaries.

The territory of the Lakes Prespa Park includes on the terrestrial part agricultural lands, dedicated for the production of field crops, vineyards and orchards, forests, pastures and meadows, settlements, roads, rocky and otherwise unproductive areas, and the entire aquatic component of the two interconnected Prespa Lakes (Figure 1).

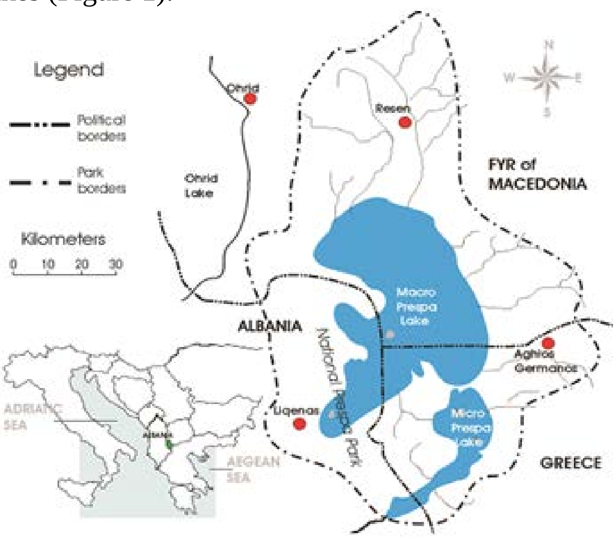

Figure 1. Lakes Prespa Park region

The region hosts populations of numerous rare, relict, endemic, endangered or threatened species. The rate of endemism and sub-endemism among species in the region, which is partly due to the great habitat diversity concentrated in a small area, makes it unique and extremely important from a biodiversity conservation perspective at any scale, be that European or global.

In the case of Lakes Prespa, relevant CORINE land cover classes were selected from the whole set of 44 classes in a first step. This means, only land cover types occurring in the chosen case study area were considered. In a second step, the list of 23 ecosystem services was checked for relevance in the particular study. For simplification and because of their small share, were regrouped some classes, which resulted in a final set of 16 classes.

Ecosystem services and indicator selection in Lakes Prespa area

At the beginning of this study were identified together with regional actors from land use, regional planning and regional management a set of six ecosystem services groups to be considered within the study. It was achieved consensus with the stakeholders to consider *supporting services* (ecological integrity), *cultural services* (aesthetic value), *provisioning services* (provision of fresh water and air, defined in the case study as contribution to *human health and well-being*; *bio-resource provision* including timber, food, and fibers), and *regulating services* (formulated as mitigation of climate change impact). In the discussion process with regional working groups and with actors participating in the creation of regional development plans, was recognized the need to incorporate economic aspects of land use. Regional economy was introduced to account for the (measurable and marketable) economic outputs that land use (mainly agriculture and forestry) can generate.

In order to assess the ecosystem services groups at the top were selected first suitable ecosystem services from literature (Burkhard *et al*., 2009; de Groot *et al*., 2010; MA 2005). This set comprises (1) provision of food and fodder, (2) provision of wood/timber, (3) clean air provision, (4) local climate regulation, (5) global climate regulation, (6) water balance regulation, (7) clean water provision, (8) soil erosion protection, (9) recreation and ecotourism, (10) aesthetic value, and (11) biodiversity. With respect to the ecosystem services group regional economy, were added two services that were called (12) income/returns from land-based production and (13) contribution to the overall added value (Table 1). The above described ecosystem and economic services were in a second step validated by regional actors. In a third step, was come to a consensus on the final set of ecosystem services to be bundled into our ecosystem service groups (Table 1).

To operationalize the framework, it is important to select indicators that provide accurate information on all main aspects of ecosystem services provision. From these investigations and through discussion within the research group was derived one suitable indicator for each ecosystem service (Table 1).

Table 1. Ecosystem services and indicators that are used in the assessment framework

Ecosystem services		State (s) and performance (p) indicators	Assessed through	
			(a) Benefit transfer	**(b) Experts**
1.	Food/ fodder	(p) Harvest/Yield [dt ha^{-1} a^{-1}]	x	x
2.	Wood/Timber	(p) Harvest/Yield [m^3 ha^{-1} a^{-1}]	x	x
3.	Clean air provision	(s) Green volume [m^3 ha^2]	x	x
4.	Climate regulation (local)	(p) Cool air production [m^3 ha^{-1} h^{-1}]	x	x
5.	Climate regulation (global)	(s) Storage of C in vegetation [kg C ha^{-1}]	x	x
6.	Water (balance) regulation	(s) Surface roughness [Mannings n]	x	x
7.	Maintenance of healthy water bodies	(s) N-export with seepage water [kg N ha^{-1} a^{-1}]	x	x
8.	Soil erosion protection	(s) Run-off coefficient [ψ]	x	x
9.	Recreation and ecotourism	(s) (Suitability for outdoor recreation)		x
10.	Aesthetic	(s) (Scenic beauty, visual quality)		x
11.	Biodiversity	(s) Number of vascular plant species	x	x
Economic services		**State (s) and performance (p) indicators**	**Data source**	
12.	Income/returns from land-based production	(p) Contribution margin [€ ha^{-1} a^{-1}]	x	x
13.	Contribution to overall value added	(p) Regional tax, revenue, trade tax [€ ha^{-1} a^{-1}] (non-land-based production)		x

Data gathering methods

a) Benefit transfer

In a first step, was used a benefit transfer method (Plummer 2009; Troy & Wilson 2006), which can be described as an up-scaling of data assessed on smaller spatial units to larger areas that are assumed to be homogenous. This included a met analysis of primary studies and look-up tables to provide the indicator values. For this reason, first the study was focused on data from regional investigations and tried to select studies that provide values for different land uses. In most cases values were available only for the main land cover classes such as arable land, forest, and grassland/pasture. Therefore, were estimated lacking values for other land cover types on the basis of these values (semi-quantitative assessment). Finally, were standardized the values obtained from literature to a relative scale (0–100 value points).

b) Expert-based assessment

The services (9) recreation and ecotourism, (10) aesthetic, and (13) contribution to the overall added value were assessed by expert based opinion. Here, were asked experts to assign values ranging from 0 (no relevant contribution) to 100 (maximum possible contribution) in a scoring exercise with 10 point steps to all land cover classes. In addition to an assessment table which translated the evaluation categories into verbal meanings, the experts were provided with a short description of ecosystem services and indicators to increase consistency with the benefit transfer results. The 8 experts in this exercise were 2 physical geographers, 3 forestry scientists and 3 environmental engineers. According to the number of land cover classes (16) and services (13), the assessment matrix offered 208 fields the experts had to fill in. Where used again standardized mean values to have a data matrix that can be compared with the one obtained from the benefit transfer assessment.

Multi-criteria aggregation framework

Bundling of ecosystem services to groups

Finally, was applied a MCA (Belton and Stewart, 2002) to aggregate the single services to the six ecosystem services groups. The ecosystem services groups were assessed by integrating the following services: **a)** Ecological integrity: Water (balance) regulation (6), clean water provision (7), biodiversity (11); **b)** Aesthetic value: Recreation and ecotourism (9), aesthetic value(10); **c)** Human health and well-being: Clean air provision (3), clean water provision (7), recreation and ecotourism (9); **d)** Mitigation of climate change impact: Local (4), and global climate regulation (5), water (balance) regulation (6), soil erosion protection (8); **e)** Bio-resource provision: Food and fodder (1), and wood/timber provision (2); **f)** Regional economy: Income/returns from land-based production (12), contribution to overall value added (13).

Weighting methods

The use of hierarchical multi-criteria techniques requires the implicit or explicit application of weights. Were applied explicit weights as the importance of the various ecosystem services might differ with respect to the context, the included stakeholders, and the investigated region. Therefore, was used **(i)** pair wise comparison of services as described in the Analytical Hierarchy Process (AHP) (Saaty, 1977), **(ii)** Likert categories, and **(iii)** equal weights of our ecosystem services/economic services. The aim was to obtain a prioritization of the services that have been assigned to the six ecosystem services groups, and to reflect the importance of the services weights for final assessment of the performance of the model region in providing ecosystem services.

Aggregation procedure

In order to obtain an overall performance value for each alternative land cover class against each of the six ecosystem services groups, was used a linear additive value function to combine individual services. Figure 2 summarizes the steps necessary for producing an overall value per land cover class and ecosystem service group.

The steps necessary for producing an overall value per land cover class and ecosystem service group, were as follows. In step 1 and 2 were token the data that were collected though benefit transfer and-if necessary expert questioning about qualitative and semi-quantitative indicators. During step 3 they were standardized. During step 4, was attributed a weight to each of the selected services. In step

5 were aggregated the standardized services values and weights to an overall value per land cover class with respect to each ecosystem services group. In step 6, prior to their application, a further standardization of the produced aggregated values was needed to have as final output value scores ranging from 0 to 100.

The results of this mixed-method approach were compared with outcomes from the exclusive use of expert-estimations. Finally, were compared the results of the three weighting exercises.

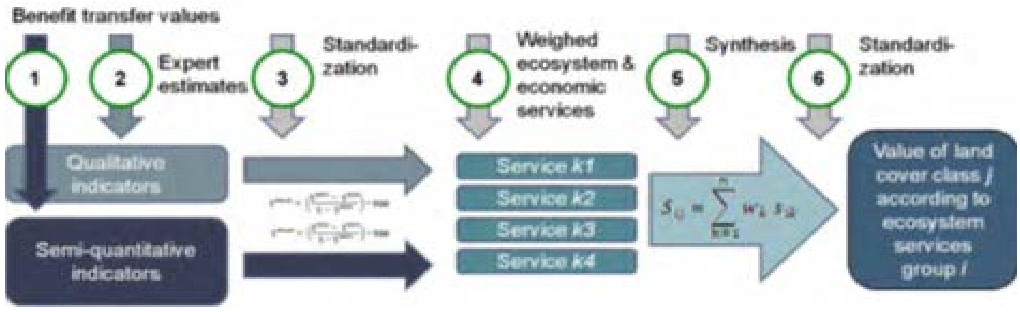

Figure 2. MCDA aggregation scheme for the combination of assessment data

Data analysis

The results of the different data gathering methods were compared to detect convergences and divergences. This was done through application of Spearman's rank correlation coefficient with SPSS version 17.0.

Results and Discussion

Data gathering results

To assess different land cover types' capacities to provide ecosystem services, a matrix was created. On the y-axis of this matrix, the 16 CORINE land cover types are placed. On the x-axis, the 13 ecosystem services are placed. At the intersections (altogether 208), different land cover types' capacities to provide the individual service were assessed on a scale consisting of: 0 = no relevant contribution, and 100 = very high relevant contribution.The final, standardized values per land cover class and service obtained by the benefit transfer approach are also shown in table 2, while table 3 displays the standardized values obtained from the expert opinion assessment.

Table 2. Standardized values per land cover class and ecosystem services obtained by the benefit transfer approach

	Ecosystem services												
CLC-classes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Industrial or commercial units, ports													
Road and construction sites	0	0	0	6	0	4	22	26	-	-	28	0	-
Dump sites	0	0	0	25	0	4	23	8	-	-	26	0	-
Urban green, sport and leisure	0	0	0	6	0	0	22	72	-	-	34	0	-
facilities													
Non-irrigated arable land	0	0	4	81	28	41	68	72	-	-	29	0	-
Fruit trees, vineyards and orchards	54	0	2	81	7	22	0	83	-	-	5	100	-
Pastures													
Complex cultivation patterns	100	0	27	56	52	56	66	87	-	-	36	100	-
Land princip. occ. by agriculture	39	0	5	81	31	84	73	87	-	-	6	45	-
Broad-leaved forest	25	0	12	100	15	35	34	87	-	-	11	36	-
Coniferous forest	24	0	6	100	15	26	55	87	-	-	10	36	-
Mixed forest	0	81	100	56	100	92	77	100	-	-	75	15	-
Natural grassland	0	100	85	56	100	83	46	100	-	-	23	12	-
Moors, heathland, inland marshes	0	91	84	56	100	100	63	100	-	-	100	14	-
Transitional woodland-shrubs	15	0	4	81	26	90	100	88	-	-	16	14	-
Water courses, water bodies	0	0	4	56	27	48	100	100	-	-	16	0	-
	0	29	19	56	52	100	100	100	-	-	16	0	-
	0	0	0	100	0	0	34	100	-	-	0	0	-

Table 2 and 3 are shows concentrations of high capacities to provide a broad range of ecosystem services for the different forest land cover types, moors and heath lands. Moreover, it reveals rather high capacities of many natures near land cover types to support ecological integrity. The highly human-modified land cover types, industrial or commercial areas, and dump sites, have very low or no relevant capacities to provide ecosystem services. Hence, a pattern emerges which matches well with the results one would assume.

Table 3. Standardized values per land cover class and ecosystem services obtained from the expert opinion assessment

	Ecosystem services												
CLC-classes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Industrial or commercial units, ports	0	0	0	0	0	0	0	0	0	0	0	0	100
Road and construction sites	0	0	0	0	0	0	0	0	0	0	0	0	55
Dump sites	0	0	0	8	0	0	0	10	0	0	9	46	14
Urban green, sport and leisure facilities	9	16	46	58	25	33	33	36	55	55	35	17	9
Non-irrigated arable land	100	28	39	44	46	37	22	32	29	29	29	100	47
Fruit trees, vineyards and orchards	100	22	55	65	49	56	50	60	55	57	53	90	38
Pastures	65	15	55	59	48	64	50	60	66	69	65	60	26
Complex cultivation patterns	71	27	65	66	47	57	50	60	76	91	74	70	37
Land princip. occ. by agriculture	66	11	55	65	57	52	50	65	77	69	66	60	28
Broad-leaved forest	15	91	100	100	100	100	100	100	93	92	87	66	25
Coniferous forest	15	100	100	93	100	100	90	100	88	77	78	77	23
Mixed forest	15	100	100	100	100	100	100	100	100	100	100	76	23
Natural grassland	21	0	55	61	63	81	890	90	89	86	92	23	0
Moors, heathland, inland marshes	7	16	55	61	77	90	83	90	94	92	100	0	0
Transitional woodland-shrubs	13	33	75	61	75	76	82	98	94	98	93	29	0
Water courses, water bodies	32	0	25	61	24	71	47	0	94	97	47	34	23

**Depicted are the standardized mean values of all judgments*

The land cover class "non-irrigated arable land" was estimated to perform less well by the benefit transfer method. Based on the chosen indicators, even industrial and commercial units, ports etc. performs better.

A comparison of the methodologies was limited to services that could be quantified in the benefit transfer method. Of the services that could be compared, good to very good correlation between both assessment methods was found for all ecosystem services except biodiversity by application of Kendall-Tau and Spearman-Rho (Table 4). For the service biodiversity, the difference of the final scores (mean values) obtained from our two methods amounted on average 36 points over all land cover classes (maximum 86 points), whereas average difference of all services was only 20 points.

Table 4. Correlation analysis of indicator-based and expert based data

	Ecosystem services								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**11**
Kendall-Tau	0.764	0.608	0.832	0.489	0.838	0.669	0.567	0.786	0.034
Spearman-Rho	0.859	0.765	0.913	0.637	0.878	0.796	0.767	0.761	−0.033

N = 16; Correlation is significant at the 0.01 level (two-tailed).

Performance of the Lakes Prespa area towards ecosystem services groups

For aggregating the ecosystem services to the ecosystem service groups, were applied different weighting methods. The weights obtained from stakeholder weighting are given in Table 5. Using the AHP software, a consistency factor is given as a measure for the logical rationality of responses. A factor of lower than or equal to 0.1 is considered satisfactory (Saaty 2005). Consistency of the ecosystem services groups aesthetic value, bio-resource provision and regional economy was perfect (0.0) since only two services have been compared (only one decision). For the ecosystem service group's contribution to ecological integrity, human health and wellbeing and mitigation of climate change impact mean inconsistency of weights was 0.276, 0.141, and 0.132, respectively. The mean standard deviations (SD) of services weights were 0.19 (ecological integrity), 0.27 (aesthetic), 0.16 (human health and well-being), 0.15 (mitigation of climate change impact), 0.23 (bio-resource provision) and 0.24 (regional economy). SD of weighted services show that ambiguous judgments of services have been made mainly within the ecosystem services group's aesthetic value and regional economy. In contrast, people have been more coherent comparing services used to assess human health and well-being and mitigation of climate change impact.

Table 5. Results of stakeholder weighing using AHP, Likert Scale and equal weights towards ecosystem services groups

Service		AHP		Likert Scale		Balanced* (1/n)
		Weights	SD**	Weights	SD	Weights
Contribution to ecological integrity						
6	Water (balance) regulation	0.345	0.207	0.373	0.067	0.366
7	Clean water provision	0.456	0.279	0.397	0.055	0.378
11	Biodiversity	0.309	0.201	0.373	0.052	0.356
Aesthetic value						
9	Recreation and ecotourism	0.557	0.256	0.586	0.108	0.587
10	Aesthetic	0.497	0.269	0.504	0.103	0.597
Human health and well-being						
3	Clean air provision	0.462	0.208	0.393	0.064	0.366
7	Clean water provision	0.409	0.207	0.384	0.081	0.377
9	Recreation and eco-tourism	0.208	0.178	0.312	0.093	0.355
Mitigation of climate change impact						
4	Climate regulation (local)	0.291	0.217	0.298	0.108	0.298
5	Climate regulation (global)	0.208	0.204	0.266	0.101	0.285
6	Water (balance) regulation	0.279	0.178	0.288	0.106	0.275
8	Soil erosion protection	0.356	0.179	0.293	0.107	0.264
Bio-resource provision						
1	Food and fiber	0.643	0.283	0.607	0.099	0.555
2	Wood/Timber	0.371	0.299	0.499	0.087	0.554
Regional economy						
12	Income/Returns from land-based production	0.666	0.296	0.577	0.105	0.555
13	Contribution to overall value added	0.408	0.287	0.501	0.114	0.555

** - equal weights used to test sensitivity of final evaluation of the six ES groups as a result of aggregation*
*** - standard deviations.*

The results of the stakeholder based weighting using the Likert scale showed a slight prioritization for recreation and ecotourism (9) in comparison to aesthetic (10) within the ecosystem services group aesthetic value. Concerning human health and well-being, clean air provision (3) was prioritized. As to bio-resource-provision, food and fodder (1) was more important for the respondents than the provision of wood/timber (2). The variance of stated importance was highest for recreation/ecotourism (9) and aesthetic (10), followed by the economic services (12, 13), and local climate change mitigation (4).

The trends of the distribution of weights were similar for both weighting methods. Most notably was the preference of stakeholders towards recreation and ecotourism (9) compared to aesthetic (10) in the ecosystem service group aesthetic value, and the provision of food and fodder (1) in comparison to wood/timber (2) in the ecosystem service group bio-resource provision.

Table 6 shows that the impact of both weighting exercises on the assessment of the ecosystem service groups in the model region is negligibly small for the final result obtained from the two different data gathering methods. Therefore, we dropped the results of the weighting exercise from the subsequent analysis of the differences between the data gathering methods.

The scores for the ecosystem service group's contribution to ecological integrity, human health and well-being, and bio-resource provision differed considerably. The benefit transfer method estimates them to be lower by 23, 17, and 26 points, respectively.

Considering the ecosystem service group contribution to ecological integrity, the study region performed with 28 (benefit transfer based) against 51 (expert-based) points. In contrast, mitigation of climate change impact scores 11 points better when the benefit transfer method is applied. Note however, that the data for the services recreation and ecotourism (9), aesthetic (10), and contribution to overall added value (13) could only be obtained from the assessment of expert-based assessment.

Table 6. Assessment results of the study region according to the six ecosystem services groups

Ecosystem services groups	Ecological integrity		Aesthetic value		Human health and well-being		Climate change mitigation		Bio-resource provision		Regional Economy	
	(a)*	(b)**	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
AHP-weights	30	51	44	45	32	51	67	53	58	84	63	79
Likert-weights	28	51	44	45	33	51	63	54	58	84	65	80
Balanced weights	28	51	44	45	34	51	62	53	58	84	66	81

* Results from use of mixed data derived mainly from benefit transfer; ** Resulting value points when only data of the expert-based assessment are use

Conclusion

The results of this study showed that the combination of selected services and land cover data can contribute to regional planning by communicating the effect of land cover change on ecosystem services groups.

A benefit from this study was the opportunity to integrate both, expert based opinion and literature values. It was demonstrated that the different data gathering methods “benefit transfer” and “expert-based assessment” have a considerable impact on the evaluation outcomes. A problem revealed in this study is that different data gathering approaches lead to different appraisals of such areas. Based on our experiences, it is concluded that expert estimation might be the more appropriate approach to estimate the regional potential to provide ecosystem services though the representativeness of expert or stakeholder groups.

The framework presented in this paper is useful to better understand and quantify the interactions between land-use/cover management and the provision of ecosystem services. It is worthwhile and meaningful to support regional planners and resource managers to come to a sustainable and adapted landscape composition, to detect undesirable patterns, and, finally, to estimate the impacts of land use policies. The framework is suited for a generic comparison of different regions based on easily accessible CLC data. It could be of considerable significance to encourage discussion among stakeholders and communication of possible effects of land cover changes.

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