BASICS OF AN INTEGRATED ECOSYSTEM SERVICE EVALUATION SYSTEM FOR THE TISZA RIVER BASIN

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ABSTRACT
The present study aims to lay the foundations of an ecosystem services evaluation system for land cover categories in the Tisza River Basin. Scientific data and international trends of international environmental policy indicate that evaluation of ecosystem services should play an increasing role in strategic decisions on land use also in Hungary. A new protocol was used to calculate the profitability of the main agricultural sub-domains in the study area. On the basis of the management data of the forestry district containing the smaller sample area (namely the site of the planned Nagykörű flood control reservoir), the wood production of the forests concerned was computed. The flood risk reduction potential of land use changes was calculated using former literature (flood models and the project materials of the reservoir), while inland excess water exposure was computed using Pálfai's relevant spatial database. For the Nagykörű sample area, the land-cover-based economic values of the different ecosystem services were gathered into a matrix, and the economic values of the present and the potential land use were compared. The methods used were examined in terms of reliability and portability as well.

Keywords: ecosystem services, evaluation matrix, Tisza River Basin, Nagykörű flood control reservoir, land use change

INTRODUCTION

Valuing ecosystem services has been an important field of environmental management and rural development in the recent years, from a scientific point of view and with several practical applications as well. Ecosystem services are those functions and goods of nature that contribute directly or indirectly to human well-being. Four main groups of them are provisioning (e.g. food production, timber, etc.), regulating (e.g. local and global climate regulation, etc.), supporting (primer production, biodiversity, etc.) and cultural services (e.g. recreation and tourism, spiritual inspiration). The services' contribution to human well-being is quantified possibly in economic value. The increasingly important role of this approach in international environmental policy is indicated by the huge reports of Millennium Ecosystem Assessment (MEA, 2005) and TEEB (TEEB, 2010a, b), launched by the UN and the G8 countries, and the recent establishment of the IPBES (Intergovernmental Panel on Biodiversity and Ecosystem Services), which is supposed to be as influential in environmental policy as the IPCC (winner of the Nobel Peace Prize in 2007).

A basic principle in most of the developed countries, especially in the EU is the multi-functional agriculture. This means partly the recognition and monetary compensation of the ecosystem services that the agricultural use provide, by the users of those services, which is the whole society. Thus these can be regarded as huge Payments for Ecosystem Services systems. In particular, agri-environmental payments are mainly for non-provisioning services of extensive land uses. In connection with this, there is a growing demand for establishing such payment systems or modifying the existing ones so that they

finance targets which really contribute to the sustainable use of ecosystem services (PLIENINGER ET AL., 2012), and they should be of the magnitude of the services' economic value. It would be also desirable if the methodology could be implemented in other fields of spatial planning as well (regional development concept plans, master plans).
To achieve the goals above, there is the urgent need to work out methods of monetary valuation of different types of ecosystem services in Hungary, especially the GIS-based methods, and using them in Hungarian applications. Relevant objectives are emphasized in the EU Biodiversity Strategy for 2020, among others. Mapping methods can be categorized basically to the main groups of indicator mapping, land cover based assessments and spatial modelling. In our contribution, we present the process of creating a land cover based evaluation system and its application in a case study to evaluate the effects of land use change on ecosystem services in a study area in the Middle Tisza District.

MATERIAL AND METHODS

There are some examples of land cover based evaluation systems in the literature. According to the general distinction aspect, mapping approaches can also be categorized to monetary and non-monetary methods. A well-known example for the first group is the global assessment of COSTANZA ET AL. (1997), which can be considered as the cornerstone of the field, and which formed a base of several other studies in smaller case studies. The work of BURKHARD ET AL. (2009) was a non-monetary evaluation matrix based on indicators relevant for each of the services and expert opinion, and the values were extrapolated to a 1-5 scale. Our monetary evaluation system refers to two provisioning and two regulating services of ecosystems of the Tisza River Basin.

The study area

The wider study area is the Tisza River Basin; some of the services were valued on this scale. The smaller study area is the Nagykörű floodplain area, where the completed evaluation matrix was implemented, and this was the scale of assessment of some of the services. The Tisza River Basin is one of the main scope of environmental and regional development problems of Hungary: contemporaneous presence of flood risk, drought and inland excess water hazard, socio-economic problems (high unemployment and low level of incomes). These ideas initiated the New Vásárhelyi Plan in the early 2000's, including the Nagykörű area as one of the flood control reservoirs, with partial renewal of the traditional floodplain farming system. In the working documents of the project (VÁTI, 2005), the potential places of land use change interventions were selected, thus the proportion of different land use types before and after the project could be estimated (*Table 1*, *Figure 1*).

Table 1. The planned land cover in the Nagykörű flood control reservoir, compared with the present land use (in hectares)

Land use	Actual land use	Future land use
Arable land	2957,3	364,1
Grassland	200,0	737,5
Forest	19,0	988,3
Lakes and wetlands	0	633,0
Fruit trees	80,3	364,1
Other	4,6	174,2

Source: VÁTI (2005)

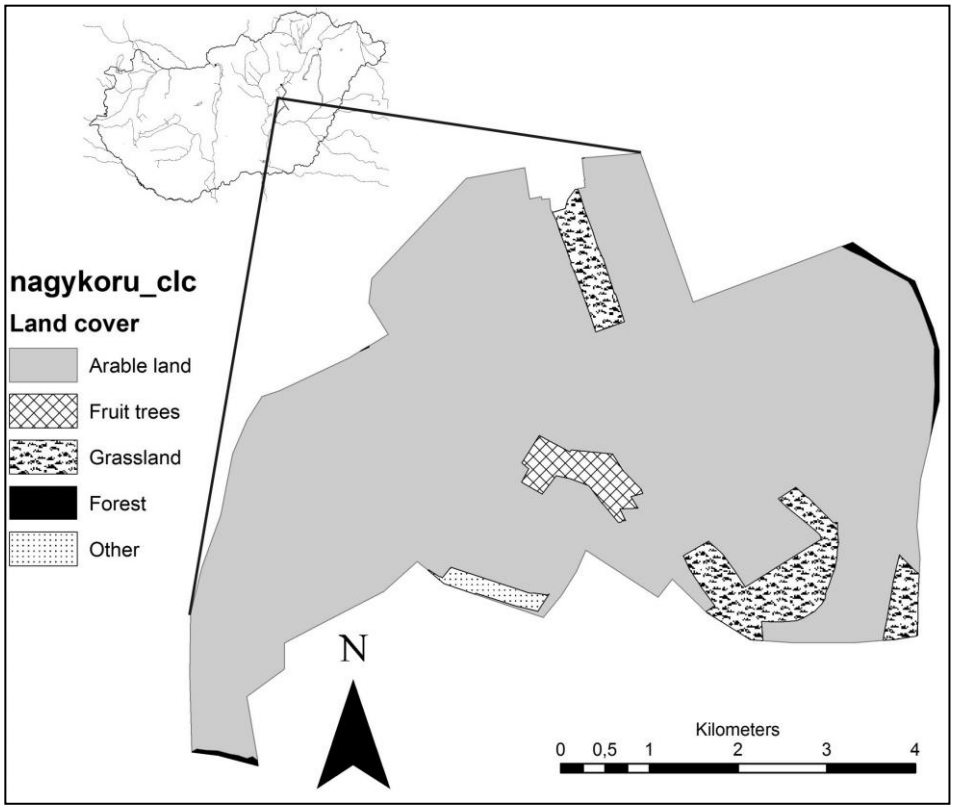

Figure 1. Actual land use of the Nagykörű flood control reservoir
Based on VÁTI (2005)

The calculation process

The evaluation of the provisioning ecosystem services was made for the individual agricultural sectors as follows. The profitability of the crop production domains was assessed on the basis of the annual cost and revenue analyses made by the Research Institute of Agricultural Economics (AKI) (BELÁDI-KERTÉSZ, 2007-2010, 2012). Subtracting the direct national subvention from AKI's sectoral profit ("ágazati eredmény") data (meaning the difference of the total income and the total expenditure), a kind of "net" profitability was calculated. The annual supersectoral profitability was computed weighting the plant species level profitability values according to the relevant acreage data, collected by KSH (Hungarian Central Statistical Office – http://www.ksh.hu). The calculations described were made concerning the last 5 years for which AKI's cost and revenue analyses were available (2006-2010). The annual data computed were discounted using the agricultural Producer Price Indices of the relevant years, and the average of the five present values was considered as the overall profitability of the agricultural supersector concerned.

The profitability of the grassland sector was calculated from the relevant values of the „rét" („meadow") domain, and the beef and sheep husbandry sectors. Concerning the latter ones, weighting had to be done to take the present livestock into account; the basis were KSH's livestock data and the average per hectare numbers. The profitability of fishery was computed using an agronomy coursebook analysis (NÁBRÁDI ET AL. 2007), which was also based on farm-level data acquisition. The profitability of wood production (that can be considered as the provisioning service of the forests concerned) was calculated for the forestry district containing the Nagykörű sample area on the basis of wood production economic models made by the Hungarian Forest Research Institute (ERTI, 2007). The

models mentioned compute cost and production data for each relevant tree species, grouped by wood production categories. The species and habitat distribution of the forests concerned were acquired from the operative forestry map of the relevant district (OLÁH A. (ed.), 2006).
Concerning regulating ecosystem services, economic benefit from flood risk reduction was calculated using former relevant Hungarian modelling studies made by BME VKKT (Budapest University of Technology and Economics, Department of Sanitary and Environmental Engineering) in 2008, while basic land use distribution data were acquired from design materials of the Nagykörű reservoir (VÁTI, 2005). Area values of different elevation categories were derived from digital elevation model, and were mapped into aggregate land use proportions using the preference ranking of land uses for each elevation category; thus, by-land-use distinction concerning regulating ecosystem service provision became available. The inland excess water exposure of the different land uses performs as "negative service", so they are accounted as negative values in the evaluation system as well. The inland excess water exposure of the different land uses was calculated using ArcGIS 9.2 software and Pálfai's inland excess water exposure map (PÁLFAI, 2003), executing a GIS crosstab procedure; the harvest loss computed was considered as the relevant economic damage.

RESULTS AND DISCUSSION

The completed evaluation matrix, containing the annual net profitability values (per hectare) of the investigated services can be seen in *Table 2*.

Table 2. The completed ecosystem service evaluation matrix for the Nagykörű area (1000 HUF/ha/year)

Land use type	Provisioning services (food and timber production)	Inland excess water hazard	Flood risk reduction
Forest	32	-1	135
Arable land	15	-2	50
Grassland	5	-1	101
Lakes and wetlands	102	0	87
Fruit trees	45	-6	50

The results with our calculation methods for the provisioning services show the lowest profitability values for the cropland and grassland farming. The quite poor market situation of the Hungarian agricultural sectors (especially the animal husbandry) is well-known, many of them is loss-yielding without the subsidy payments. In the case of forests, the growth results valued for the study area are close to model-based results for the same study area (KOZMA ET AL., 2012). Inland excess water damages calculated with our methodology resulted above 10% on average, in the ratio of yields (and revenue). It seems to be a good estimation in the order of magnitude, compared with the results of PINKE (2012) and PÁLFAI (2006). The distribution of the flood risk reduction service is a consequence of the methodology applied (the higher values are provided by the main land use types of traditional floodplain farming: forests, wetlands, grasslands). The economic value of this service is in accordance with other Hungarian results (DERTS, 2012, PINKE, 2012). These values should not be used directly in calculating agricultural subsidies, but they can be considered during the planning of land use structure. Applying the evaluating matrix in the

Nagykörű area, the quantity of the ecosystem services (in per year value) could be approximately doubled if the proposed land use changes were performed.
The relative proportions of values of the services are in the order of magnitude of other evaluating systems' values. These are global average values or characterized by great variance, which was also observed at our agro-economic calculations. The appendix of the first TEEB report (TEEB, 2010b) contains value intervals for every ecosystem types (based on literature review), the leading role of wetlands is easily observable there as well. In the work of BURKHARD ET AL. (2009), the well-known indicator-based evaluating system, forests were given the highest values, and natural ecosystems (owing to regulating services and ecological integrity, which are used to substitute supporting services) are highly above agro-ecosystems in service supply.

CONCLUSIONS

The comparisons above highlight the usability and limitations of these types of assessments. Because of the heterogeneity of the study areas and the several factors affecting the profitability, it is practically impossible to give one well-defined economic value for most of the services. This can be the case only at exactly quantifiable services, when individual compensatory systems are planned (e.g. carbon sequestration of ecosystems and the emission trading systems). Though, integrated evaluating systems, like our matrix for the Tisza River Basin are usable partly to estimate the order of magnitude of different services and their proportion compared to each other, and, in territorial assessments (min. landscape scale), for overview-type assessments (e.g. land use change dynamics models, without direct decision-making targets). In summary, monetary valuations are suitable mainly in the preparation phase of the policy implementation of the methodology, to call attention to the economic importance of ecosystem services. In concrete environmental planning or impact assessment processes, indicator-based assessments and site-specific spatial models are more reliable.

ACKNOWLEDGEMENTS

We would like to thank Zsuzsanna Marjainé Szerényi and Gergő Gábor Nagy for their useful comments during the research. The publication/presentation is supported by the European Union and co-funded by the European Social Fund. Project title: "Broadening the knowledge base and supporting the long term professional sustainability of the Research University Centre of Excellence at the University of Szeged by ensuring the rising generation of excellent scientists." Project number: TÁMOP-4.2.2/B-10/1-2010-0012

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