FROM POTENTIALS TO ECOSYSTEM SERVICES - THE ASSESSMENT OF ECOSYSTEM SERVICES IN SLOVAKIA

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Abstract
This paper aims to evaluate selected ecosystem services at national level (Slovakia). In this research we used our own data created by use the methodology for assessing the natural capital of the country developed during our solution of the ENVIRO PLUS project, based on geosystem approach with use of our nationwide land-use data. Each assessed ecosystem service has created statistic. The results of our study consist of two types of outcomes. Firstly, we provide tables with average and median values for each assessed ecosystem service in Slovakia and secondly, we have created maps which can help to see a broader image of spatial arrangement of benefits. We see that this research can be very helpful to provide the basis for further evaluation and environmental management of the Slovakia.

Keywords: ES, potential, benefit, recreation potential

Introduction

Exploring the relationship between nature and human societies is essential in addressing modern environmental concerns. Appreciating the pivotal role of ecosystem services is fundamental in guiding policies and practices towards sustainable development, as they constitute the natural capital upon which our societies depend (Daily et al., 1997). If we want to make a high-quality assessment of natural potential and capital, we need sufficient and objective information, whether about the properties of individual landscape-forming components that determine the value of natural resources and potentials, as well as information about the requirements, demands and effects of human activities on the landscape and individual resources. The availability and processability of open information and its quality is an important factor for the correct derivation of the properties of the country's natural capital. The amount of spatial information that is used in geography, ecology, landscape ecology or environmental science in the evaluation of the country's resources and potentials has increased many times in the recent period. New sources of information increase the potential for better assessment and management of the use of the country's natural capital. The main aim of our study is assessment of ecosystem services in Slovakia. The outcome of the evaluation of individual ecosystem services are separate maps (raster with 10x10 meter resolution) and for purpose of this paper also calculation for values for geomorphological units and table for each assessed ecosystem service providing a picture of spatial arrangements of benefits and its amount.

Material and methods

When evaluating selected ecosystem services, we used the procedures we developed as part of the ENVIROPLUS project (2023), aimed at evaluating natural capital of Slovakia, with the use of our other data and procedures.

ES01 Biomass for wood production and ES02 Biomass for food production - providing agricultural crop yields

For assessment of two ecosystem services – ES01 Biomass for wood production and ES02 Biomass for food production - providing agricultural crop yields, we used Absolute bioproduction potential as base (Izakovičová, Miklós, & Špulerová, 2024). The absolute bioproduction potential expresses the capability of the primary structure of geoecosystems - the abiotic complex - to produce biomass. This potential represents the fundamental utility value for the primary ecosystem service to human life - the production of biomass as food and other essential bioproducts - thereby fundamentally conditioning the utilization of various geoecosystems.
This base potential has been created based on following determinants:
Climate conditions, Potential natural vegetation, Terrain relief, Substrate (geology), Soil subtype, Soil depth, Rock content in the soil, Soil granularity and Slope.

Each category of each determinant was assigned a value of potential for bioproduction and a weight of each determinant in the calculation of bioproduction potential. Subsequently, we used the land use layer created by us (ESPRIT, 2020) to identify areas where this potential is actually used as Biomass for food production - providing a harvest of agricultural crops or Biomass for wood production. Finally, we categorized the resulting values for both ecosystem services into 10 categories using the Quantile method.

ES03 Summer tourism
Summer tourism is one of the lighter forms of tourism. It is mostly hiking, which includes shorter and longer walks in the mountains as well as easier hikes on flatter trails. For modelling we uses habitats, tourist paths density, average temperature in July, average rainfall in July, duration of sunshine, slope- type of relief, and land use.

ES04 Winter sports
Sports related to snow represent sports and recreational activities that are seasonally limited and related to the winter season. Among the most important activities in this area in our country are cross-country skiing, sledding and downhill skiing, ski mountaineering has also developed more recently and snowboarding. The development of sports and recreational activities depends on several factors. Of the natural factors, it is mainly the relief (types and forms, altitude, slope of the territory, angle of inclination, orientation, glare) and climate (air temperature, snow cover).
For assessment we used layers of habitats, climate, number of days with snow coverage, average temperature in January, relief, slope and land use.

ES05 Scientific and educational tourism
This is a special type of tourism, the main goal of which is to observe landscape structures as well as to learn and understand the phenomena and processes taking place in the country. Scientific tourism refers to special groups that carry out scientific activities in selected locations. For assessment we used layers of habitats, endemic species, genetic fund areas, historical landscape structures, historical gardens and parks, tourist paths density, protected areas, internationally protected areas, spa places, hunting areas, ecological networks, land use, naturalness degree, traditional agriculture landcape and important geological areas.

ES06 Natural heritage
Natural heritage represents a set of valuable natural components that arose as a result of the evolutionary processes of nature. From the point of view of landscape-ecological significance, natural ecosystems with a rich representation of rare and endangered plant species, their communities and animal species bound to them belong to the most valuable. For assessment we use layers of habitats, historical landscape structures, protected areas, ecological stability coefficient, naturalness coefficient, internationally protected areas and land use.

ES07 Support of species and ecosystem diversity
For the assessment of the service of support of biodiversity and ecosystem diversity, we created tool in ESRI ArcGIS for assessment of Support of species and ecosystem diversity. For assessment is necessary to determine four characteristics for each polygon included in the assessment in the area of interest: Significance of the habitat, state of habitat, expansion of habitat and ecosozological importance. Based on the specified characteristics, the final value of the ecosystem service was calculated. Results of assessment of this ecosystem service for whole Slovakia is not present in this paper due to need of assessment of all habitats in the territory, which is time-consuming in the case of all-Slovak assessment, but it is possible to use this procedure to assess any smaller areas, while the resulting values are mutually comparable in within the whole of Slovakia.

Summary assessment of selected ecosystem services
For the purposes of this paper, for greater clarity, we have recalculated the values of the assessed ecosystem services to areas. We selected geomorphological units for suitable calculation. We calculated minimum, maximum, average and median values for each

geomorphological unit using zonal statistics tools. At the end, the total value of selected evaluated ecosystem services was calculated.

Results

We present the recalculated results and geomorphological units in Table 1. In the table, we present the average and median value for each evaluated service. The initial intention was to also list the minimum and maximum values achieved, but they were the same for most geomorphological units, and due to the large scale of the table, we decided not to list these data. Summary value of assessed ecosystem services are shown in Table 1 and also in Figure 1.

Tab.1: Results of assessment (mean, median and summary values)

		ES01		ES02		ES03		ES04		ES05		ES06		
Geomorphological unit	**REPGES CODE**	M	MDN	M	MDN	M	MDN	M	MDN	M	MDN	M	MDN	SUMMARY VALUE
Burda	1.1.1	6,43	6	4,23	4	8,29	10	3,86	4	3,82	4	6,57	7	28,35
Krupinská planina	1.1.2	7,19	8	1,87	2	4,13	4	4,92	5	3,01	3	5,13	6	21,64
Cerová vrchovina	1.1.3	8,25	9	4,17	3	6,02	6	4,65	5	5,07	5	5,54	7	28,07
Slovenský kras	1.1.4	5,68	6	3,69	3	7,52	8	5,44	5	6,23	7	7,61	9	30,65
Bodvianska pahorkatina	1.1.5	9,25	9	3,09	3	5,37	5	3,73	4	2,72	3	4,32	5	21,79
Juhoslovenská kotlina	1.1.6	9,35	10	6,18	6	3,30	2	3,21	3	2,23	2	2,99	1	13,08
Dolnomoravský úval	1.2.1	9,95	10	7,06	7	6,49	6	2,48	2	3,42	3	3,65	3	19,67
Borská nížina	1.2.2	9,46	10	5,94	6	6,03	5	2,56	3	3,49	3	4,57	5	20,36
Chvojnická pahorkatina	1.2.3	9,21	9	5,10	5	3,77	3	2,47	2	2,63	2	2,06	1	12,62
Podunajská rovina	1.2.4	9,88	10	7,65	8	2,73	1	1,27	1	2,82	2	1,97	1	11,24
Podunajská pahorkatina	1.2.5	9,66	10	6,01	6	2,42	1	2,02	2	2,42	2	1,89	1	11,11
Košická kotlina	1.2.6	8,89	9	3,96	4	3,08	2	3,46	3	2,04	2	2,52	1	11,43
Východoslovenská rovina	1.2.7	9,83	10	6,98	7	2,41	1	2,50	2	3,32	2	2,59	1	11,02
Východoslovenská pahorkatina	1.2.8	9,29	9	4,54	4	3,55	2	3,31	3	2,84	2	3,13	1	11,65
Zemplínske vrchy	1.2.9	7,11	8	5,43	4	6,27	7	3,91	4	6,37	6	4,63	5	26,50
Malé Karpaty	2.1.1	6,56	7	2,48	2	8,29	9	4,65	5	8,36	9	6,89	8	34,51
Myjavská pahorkatina	2.1.2	7,78	8	1,92	2	5,34	4	4,07	4	3,22	3	3,37	2	15,66
Považský Inovec	2.1.3	5,33	5	2,49	2	7,70	9	5,44	5	3,70	4	5,92	7	28,41
Tribeč	2.1.4	6,54	7	2,42	2	7,92	8	5,00	5	6,16	7	6,77	7	30,71
Strážovské vrchy	2.1.5	3,74	3	2,44	2	6,80	7	6,84	7	4,76	4	6,69	7	26,85
Súľovské vrchy	2.1.6	3,86	3	1,21	1	6,78	7	6,76	7	6,27	7	6,94	7	29,65
Žiar	2.1.7	4,28	4	2,19	3	7,73	8	6,93	7	3,55	3	6,67	7	27,92
Branisko	2.1.8	2,59	2	1,02	1	6,15	6	8,05	8	4,30	4	6,72	7	26,03
Veporské vrchy	2.1.9	3,30	3	1,06	1	6,98	7	8,01	8	4,72	4	6,86	7	28,15
Spišsko-gemerský kras	2.1.10	2,71	3	1,14	1	6,42	6	8,25	8	6,82	7	8,73	9	30,99
Stolické vrchy	2.1.11	3,67	3	2,17	1	6,66	7	7,52	7	3,75	3	6,55	7	26,03
Revúcka vrchovina	2.1.12	6,23	6	2,77	2	6,03	6	5,56	6	3,01	3	5,70	7	25,78
Volovské vrchy	2.1.13	3,51	3	1,11	1	6,43	6	7,45	8	5,38	5	6,70	7	27,75

Čierna hora	2.1.14	4,83	5	1,61	1	6,47	7	6,18	6	4,05	4	6,19	7	25,75
Vtáčnik	2.1.15	4,94	5	4,23	2	7,00	7	6,70	6	5,11	4	6,84	7	27,52
Pohronský Inovec	2.1.16	5,89	6	1,64	2	8,29	9	5,80	6	4,55	5	6,41	7	31,40
Štiavnické vrchy	2.1.17	5,84	6	2,52	2	6,97	8	5,52	6	7,18	7	7,11	8	32,80
Kremnické vrchy	2.1.18	4,56	5	1,76	1	6,88	7	7,36	7	4,92	5	6,31	7	28,90
Poľana	2.1.19	3,58	3	1,05	1	7,12	7	8,32	8	7,24	7	7,68	8	32,00
Ostrôžky	2.1.20	6,34	6	1,44	1	6,97	8	6,05	6	2,75	3	6,16	7	27,54
Javorie	2.1.21	5,50	6	1,19	1	6,75	7	6,68	7	3,14	3	6,32	7	26,76
Slanské vrchy	2.1.22	4,78	4	1,42	1	6,95	8	6,61	7	5,10	5	6,55	7	29,93
Vihorlatské vrchy	2.1.23	4,53	4	2,49	1	5,74	6	6,91	7	6,35	6	7,37	7	27,84
Považské podolie	2.1.24	7,65	8	4,56	5	4,52	3	3,37	3	2,98	3	2,95	2	14,40
Hornonitrianska kotlina	2.1.25	8,22	9	3,54	3	5,61	5	4,01	4	3,15	3	3,50	3	17,75
Žiarska kotlina	2.1.26	8,88	9	3,86	3	4,62	4	3,58	3	2,60	2	3,08	2	13,31
Zvolenská kotlina	2.1.27	6,79	7	2,86	3	6,18	7	4,95	5	4,01	4	4,43	5	23,80
Pliešovská kotlina	2.1.28	8,20	8	2,18	2	4,06	3	4,23	4	2,55	2	3,55	4	14,96
Horehronské podolie	2.1.29	6,09	6	1,68	2	6,50	7	6,04	6	5,67	6	5,99	7	28,47
Rožňavská kotlina	2.1.30	8,21	9	3,34	3	5,21	4	4,23	4	3,54	4	3,45	3	17,44
Biele Karpaty	2.1.31	6,10	6	1,54	1	6,72	7	5,99	6	5,95	7	6,49	7	30,77
Žilinská kotlina	2.2.1	6,79	7	1,96	1	4,89	4	4,94	5	2,75	3	3,53	3	16,37
Malá Fatra	2.2.2	2,45	2	2,16	1	4,98	5	9,02	10	5,92	6	7,65	7	29,16
Veľká Fatra	2.2.3	2,25	2	1,71	1	5,25	5	8,94	9	7,29	7	8,23	8	29,92
Starohorské vrchy	2.2.4	2,65	3	1,26	1	6,03	6	8,44	9	8,01	8	7,43	8	32,98
Chočské vrchy	2.2.5	2,29	2	1,04	1	5,41	5	8,69	9	6,30	6	7,38	7	28,11
Tatry	2.2.6	1,91	2	1,00	1	2,77	2	9,08	9	7,19	7	8,88	9	27,11
Nízke Tatry	2.2.7	1,65	1	1,15	1	4,71	5	9,24	10	7,01	7	8,39	8	30,49
Kozie chrbty	2.2.8	3,12	3	1,10	1	7,22	8	7,58	8	5,32	5	6,87	7	29,39
Turčianska kotlina	2.3.1	7,98	9	2,83	2	5,05	4	4,68	4	3,75	3	3,52	3	16,29
Podtatranská kotlina	2.3.2	6,51	7	1,54	1	5,08	5	5,48	5	4,73	5	4,86	5	21,38
Hornádska kotlina	2.3.3	5,73	6	1,43	1	4,63	3	5,10	5	3,04	3	3,37	3	15,47
Javorníky	2.4.1	4,47	4	1,84	1	6,25	6	7,48	7	5,17	5	6,46	7	27,80
Moravsko-sliezske Beskydy	2.4.2	3,25	3	0,00	0	5,82	6	9,24	9	8,20	8	8,00	8	33,44
Turzovská vrchovina	2.4.3	5,13	5	1,39	1	6,11	6	7,54	8	5,87	6	6,42	7	29,94
Jablunkovské medzihorie	2.4.4	5,50	5	1,41	1	5,46	6	6,49	7	4,02	4	5,04	5	24,14
Kysucké Beskydy	2.4.5	3,63	4	1,15	1	5,51	5	8,36	9	6,11	7	7,13	8	32,07
Kysucká vrchovina	2.4.6	4,06	4	1,47	1	5,66	6	8,01	8	6,00	6	6,86	7	29,50
Oravské Beskydy	2.4.7	3,75	4	1,00	1	5,45	5	8,76	9	7,76	8	7,82	8	33,11
Podbeskydská brázda	2.4.8	6,99	8	1,22	1	4,51	4	6,58	6	7,08	8	5,41	7	27,01
Podbeskydská vrchovina	2.4.9	4,60	4	1,81	1	5,17	5	7,98	8	7,53	8	6,77	7	30,26

Oravská Magura	2.4.10	2,93	2	1,38	1	5,92	6	9,33	10	6,09	6	7,20	7	30,55
Oravská vrchovina	2.4.11	5,30	6	2,20	1	5,62	6	6,95	7	4,72	5	5,02	5	25,36
Skorušinské vrchy	2.4.12	3,61	3	1,39	1	5,60	6	8,24	8	4,10	4	6,09	7	26,97
Podtatranská brázda	2.5.1	5,76	6	1,26	1	5,40	6	7,65	8	5,73	6	6,79	7	28,89
Oravská kotlina	2.5.2	7,49	8	1,62	1	4,65	4	5,07	5	5,82	5	4,54	5	19,59
Pieniny	2.5.3	3,84	4	1,11	1	4,98	5	7,95	8	5,60	6	7,30	8	28,20
Ľubovnianska vrchovina	2.5.4	4,26	4	1,36	1	5,89	6	7,57	8	4,16	5	6,25	7	28,68
Čergov	2.5.5	3,31	3	1,07	1	6,08	6	8,10	8	4,70	5	6,83	7	28,47
Spišská Magura	2.5.6	4,30	5	1,67	1	5,33	5	8,06	8	4,86	5	7,06	7	28,05
Levočské vrchy	2.5.7	2,86	3	1,09	1	4,86	5	8,29	8	3,37	3	6,21	7	24,72
Bachureň	2.5.8	4,17	4	1,18	1	5,91	6	7,61	8	3,11	3	5,58	6	25,02
Spišsko-šarišské medzihorie	2.5.9	6,51	7	2,04	2	3,72	3	5,61	5	2,81	3	3,72	5	17,84
Šarišská vrchovina	2.5.10	6,38	6	1,43	1	4,93	5	5,58	5	2,33	2	4,25	5	19,38
Busov	2.5.11	4,88	5	1,02	1	6,98	7	7,48	7	4,95	5	6,59	7	29,44
Ondavská vrchovina	2.5.12	6,65	7	1,91	2	5,40	6	5,57	6	3,44	3	5,03	5	23,64
Laborecká vrchovina	2.5.13	6,26	7	1,73	2	5,01	4	6,61	7	5,19	4	6,57	7	26,87
Beskydské predhorie	2.5.14	6,90	7	2,65	2	5,14	5	4,93	5	3,45	3	4,48	5	21,25
Bukovské vrchy	3.1.1	5,24	5	1,73	1	5,71	6	7,41	7	7,60	8	8,47	9	33,18

Legend: M-Mean Value, MDN – Median Value, ES0x- Code of Ecosystem Service

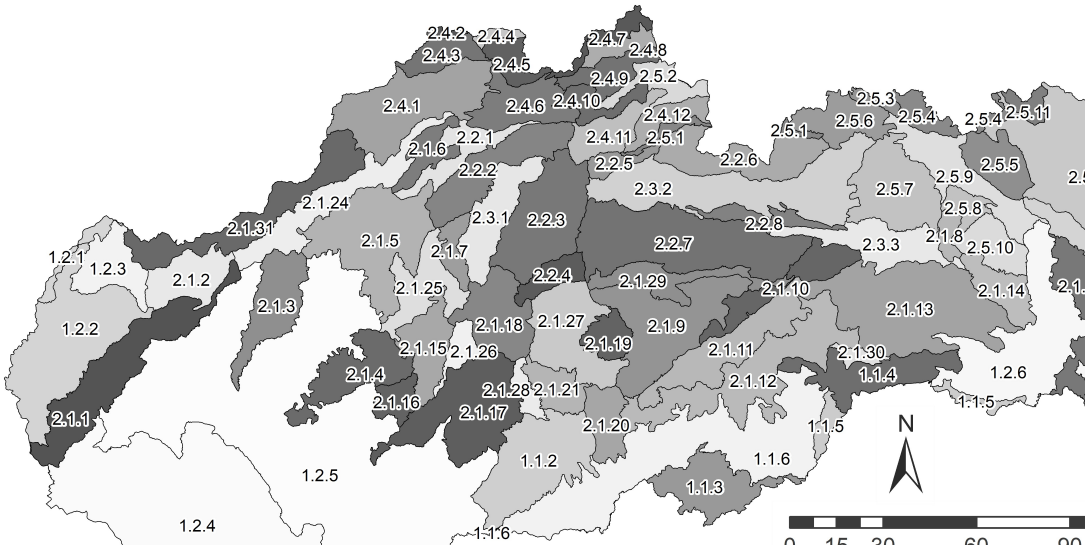

Fig.1: Location of Geomorphological units with codes and summary values

Discussion

The highest total values in Slovakia are achieved by mountain areas, due to the fact that the majority of evaluated services are cultural ecosystem services, where protected areas, the presence of tourist routes, etc. are often included in the evaluation as an important factor. In further research, we would like to focus on how to weigh individual services in a summary assessment of ecosystem services. We also plan to focus on factors that threaten the provision of ecosystem services or reduce their level. Environmental loads, residential development,

construction of roads as well as increasing the intensity of agriculture are significant threatening factors for biomass production, but also the quality of soil and water resources, which have an impact on the overall bioproduction potential of the territory and represent a hygienic risk for living organisms, including human health. The bioproduction potential of agricultural soils is also limited by erosion-accumulation processes, such as landslides, and manifestations of water and wind erosion. We need to find out how much this factors affects level of providing of ecosystem services and how to include these factors in the assessment.

Conclusion

In our research, we have proposed innovative methods for ecosystem service assessment and applied these assessment methods to the assessment of ecosystem services in Slovakia.
We see that this research can be helpful to provide the basis for further evaluation and environmental management of the area, created by different individual geosystems.

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Souhrn

Tento článek důkladně zkoumá ekosystémové služby na Slovensku, přičemž využívá data získaná v rámci projektu ENVIRO PLUS a používá geosystémový přístup. Hodnotí řadu služeb, od produkce biomasy po cestovní ruch, s přihlédnutím k různým faktorům, jako je klima, charakteristika terénu a způsob využívání půdy. Pomocí podrobných tabulek a map studie nabízí detailní pochopení toho, jak jsou tyto služby prostorově rozděleny po celé zemi. Zdůrazňuje zásadní vzájemné působení mezi přírodou a lidskou společností a zdůrazňuje význam ekosystémových služeb pro podporu udržitelného rozvoje. Do budoucna si výzkum klade za cíl hlouběji prozkoumat váhu jednotlivých těchto služeb a zabývat se naléhavými hrozbami pro poskytování ekosystémů, jako je degradace životního prostředí a rozšiřování měst. V konečném důsledku tato studie představuje inovativní metodiku hodnocení ekosystémových služeb, čímž vytváří základ pro informovaný environmentální management a další zkoumání přírodních zdrojů Slovenska.

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