THE ASSESSMENT OF ECOSYSTEM SERVICES IN TRNAVA (SLOVAKIA) AND SURROUNDING REGION

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Abstract
Ecosystem services represent the contributions and benefits of ecosystems. This paper aims to evaluate highly relevant ecosystem services in Trnava as a regionally significant city and in the functional area which consist of 15 surrounding villages. In this research we used our own progressive methods using complex spatial units (representative potential geoecosystems and representative real geoecosystems) to define the most important ecosystem services in the area. The results of our study consist of two types of outcomes. Firstly, we provide assessment for each spatial unit for various ecosystem services in urban functional area of Trnava and secondly, we have created maps which can help to see a broader image of spatial arrangement of benefits.

Key words: ES, REPGES, potential, benefit, recreation

Introduction

Ecosystem services represents the contributions and benefits which are provided by ecosystems, as for example water, food, wood, soil formation, air and water purification, flood and dry protection, pollination of crops and more. However, human activity destroys biodiversity and reduces the resistibility and ability of healthy ecosystems to provide this broad range of goods and services. Potential representative geoecosystems (here and after REPGES) (Miklós, Izakovičová et al. 2006) represents complex landscape-ecological units characterized by a set of abiotic components (relief, geological background, soil, water and air) and biotic components (especially vegetation, including biogeographic aspects) and are a representation of the potential state of the landscape if humankind did not get involved in it in the past. Since REPGES are based on natural structures and processes in the landscape, they express the conditions for natural ecosystem functions – the potential for providing ecosystem services. Representative real geoecosystems are a representation of the current state of the landscape. Real geoecosystems are the basis for evaluating the current options for providing ecosystem services (ES) in the model territory and are the basis for designing a functional green infrastructure. The main aim of our study is assessment of ecosystem services of urban functional area (UFA) of Trnava (Slovakia). The outcome of the evaluation of individual ecosystem services are separate maps in scale 1:50 000, providing a picture of spatial arrangements of benefits provided by individual geosystems and are the basis for further evaluation and environmental management of the area.

Material and methods

Trnava was defined for the purpose of promoting sustainable urban development as an county city, together with a functional territory consisting of 13 municipalities: Biely Kostol, Bohdanovce nad Trnavou, Brestovany, Bučany, Dolné Lovčice, Hrnčiarovce nad Parnou, Jaslovské Bohunice, Malženice, Šelpice, Špačince, Zavar, Zeleneč, Zvončín. Based on local relations and functional links, the UFA was extended with the municipalities Ružindol and Suchá nad Parnou. From a geomorphological point of view, the territory consists of a geomorphological unit - Podunajská nížina (part of Trnavská pahorkatina and Podunajská rovina). Podunajská nížina is built by neogeneous clay, sand, and gravel, which are covered with loess in the hill-lands parts and with river sediments in river alluvium. On loess is binded the existence of black soils which towars to Little Carpathians passes into brown soils and represents the most fertile lands of Slovakia. From the natural resources in the territory point of view, there are high quality soils which, with favourable climatic conditions, create a high potential for agricultural development. From the functional typization point of view, rural villages have an agricultural character with a residential, partially recreational function (Kamenný Mlyn). From an industrial point of view, UFA belongs to the most advanced areas of Slovakia. Industrial production is concentrated in city of Trnava.

Analysis and assessment of the potential of UFA Trnava using methodology of ecosystem services

Within the analysis of the potential of area using ecosystem services methodology, the most important ecosystem services have been selected (categorisation based on CICES (Haines-Young, Potschin, 2013):

ES01 – Biomass for food production – providing harvested crops

The evaluation was based on the classification of real geosystems. The following features of geoecosystems were included in the evaluation: soil quality, workability of soil and climate type.

ES02 – Water for drinking and for technical purposes - drinking water supply, irrigation, industry

The assessment fully reflects the potential of geoecosystems to provide water for drinking, irrigation, and industry. The surface water potential is expressed as an indicator of the average annual flow rate for individual flows. Groundwater potential was expressed by a combination of indicators:

• Usable groundwater resources in the hydrogeological region
• Replenishment of groundwater reserves
• Protection zones of water sources

ES03 - Air quality regulation - improvement of air quality, hygienic benefits

The assessment fully reflects the potential of geoecosystems for air quality. Impact on air quality have been assigned to individual categories of landscape structure (three categories for negative and three for positive impacts). The impact of road and rail transport was weighted based on the intensity of road transport and the type of railway line.

ES04 - Water quality regulation -improvement of groundwater and surface water quality

The assessment fully reflects the potential of geoecosystems for the quality of surface water and groundwater. The impact of geoecosystems on the quality of surface and groundwater was synthetically expressed through three indicators:

• Buffering function of the soil
• Buffering function of the current landscape cover
• The volume of the surface runoff from the geoecosystem

ES05 – Water flow control, flood protection - water retention and drainage regulation

The assessment fully reflects the potential of geoecosystems to regulate water flows and to protect against floods. The potential was determined based on the evaluation of the retention capacity of the current geoecosystems. For each type of the current geoecosystem, a surface runoff coefficient was modeled, which represents synergistic result of the influence of hydrophysical properties of the geological base, soil, relief, and current land use. It indicates which percentage of rainfall may be drained by the surface runoff.

ES06 – Micro and regional climate regulation - local climate regulation

The assessment fully reflects the impact of geoecosystems on the micro and regional climate regulation and local climate. Individual climatic categories were assigned an impact on climate. The impact of the landscape structure was calculated with the weighted distance of impact of the individual categories.

The impact of road and rail transport was weighted based on the intensity of road transport and the type of railway line (electric vs. diesel) and the distance from line elements. By spatial synthesis with global radiation, we expressed the overall impact of the geoecosystem on local climate regulation. By showing the leeward sides of georelief and the areas affected by the moisture deficit, the negative influence of the geosystem on the local climate was highlighted.

ES07 – Support for natural soil composition

The assessment fully reflects the potential of geoecosystems for supporting natural soil composition. The current water erosion has key importance for preserving the natural composition of the soil in evaluated area. Current erosion was calculated for the area using the erosive model RUSLE, which employs empirical calculation based on rainfall erosivity factor, topographic factor (slope, contributing surface), soil erodibility factor and the cropping factors) for erosion soil transport calculation. For environmental management of the area, it is important to identify the geoecosystems in which their current use has a large anti-erosive effect, that means those areas in which the erosion threat could increase greatly if their current use is changed. For this purpose, a model of potential erosion was calculated without including the protective effect of vegetation. By comparing current and potential erosion, the layer of anti-erosive effect of the current usage of geosystems was interpreted.

Complex spatial units were used for the evaulation of ecosystem services:

- representative potential geoecosystems (processed as synthesis of abiotic and biotic elements of the landscape)
- representative real geoecosystems (identification and evaluation is based on land use)

Results and Discussion

Identification and specification of potential representative geoecosystems (REPGES)

The basis of the synthesis for the allocation of REPGES in the model territory were:
1) Units of potential vegetation - a total of 4 types of potential vegetation according to bioclimatic conditions and 2 types allocated based on azonal conditions were allocated to the UFA area.
2) types of abiocomplexes. In the model territory, we have singled out 9 types of abiocomplexes in two basic categories (plains, uplands). Within each group, we have allocated other subgroups. Within the plains, 6 sub-groups were allocated, within the uplands, 3 subgroups were allocated. UFA area is dominated by poorly corrugated loess tables. Based on the synthesis of the mentioned indicators, we have allocated 19 basic types of REPGES.

Identification and evaluation of recent geoecosystems

The current landscape structure reflects the current state of land use in the area of interest. It reflects the combination of a set of elements of the natural, semi-natural (man-altered elements of the landscape structure) and the artificial (man-made elements of the landscape structure) character. As a result of the development of economic activities, the natural REPGES of the area of interest gradually changed to agricultural and also artificial ecosystems. Thus, many natural REPGES have not only been altered but also destroyed. The dominant position in the current structure of land in the area of interest has agricultural land. The territory occupies 21 675 ha, which is 80% of the total area. Up to 95% of farmland is intensively used as arable land with character of large-scale arable land.

Assessment of ES

ES01 – Biomass for food production – providing harvested crops
It should be stressed that the absolute potential for food production in the area is very high as it is the area with our most productive soils.
In general, the central parts of the area in the flat parts of the Trnava Tableland with black soil have the highest potential for providing agricultural crops.
ES02 – Water for drinking and for technical purposes - drinking water supply, irrigation, industry
Based on our model, it can be concluded that groundwater recharge in the UFA is generally low compared to typical values for the territory of the Slovak Republic and ranges from a negligible 8 mm per year in the Trnava agglomeration area to values of 88 mm in the northwestern parts of the UFA, where they are the result of both a larger rainfall surplus and favourable seepage conditions. Increased groundwater recharge is also associated with areas of fluvial sediments.
ES03 - Air quality regulation - improvement of air quality, hygienic benefits
The most negative impact on air quality is in the regional city of Trnava with a high concentration of traffic and a large proportion of industrially exploited land. With the exception of built-up areas, negative to very negative impacts were identified in the immediate vicinity of roads (depending on traffic intensity) and in the vicinity of the Jaslovské Bohunice nuclear power plant. Smaller forested areas have a positive impact on air quality.
ES04 - Water quality regulation -improvement of groundwater and surface water quality
With the exception of built-up areas, we identified negative to very negative impacts in the northwestern part of the UFA with lower sorption capacity of soils and in areas with greater slope and thus greater runoff coefficients.
ES05 – Water flow control, flood protection - water retention and drainage regulation
The current geoecosystems with the lowest runoff coefficient have the highest retention capacity. In this respect, apart from built-up areas, geoecosystems with the steepest slopes, heavy soils and landscapes with little water retention capacity have the lowest retention capacity. Conversely, areas with minimal slope on relatively lighter soils have the highest retention capacity, irrespective of landscape cover.
ES06 – Micro and regional climate regulation - local climate regulation
The most negative impact is in areas with residential development and industrial complexes with significant heat accumulation in the vicinity of the regional city of Trnava. The area of the nuclear power plant Jaslovské Bohunice also has a significantly negative impact. Smaller forest areas and areas along watercourses and reservoirs have a positive impact.
ES07 – Support for natural soil composition
The highest erosion rates are associated with geoecosystems with steeper slopes and arable land, which are predominantly located in the northwestern, more rugged part of the area and on the more sloping transitions of the loess table into the watercourse floodplains. Other geoecosystems are little erosion-prone.

The results of ecosystem service assessment using innovative assessment approach that is not based solely on land cover and average values applied to each land cover type, as is the case for matrix assessment of ecosystem services based on land cover types (Burkhard et al. 2009), but take into account a wide range of factors affecting the level of ecosystem services provided, promise the potential for more accurate assessments. However, further research is needed and our next step will be to compare assessment results with each other using both approaches on the same area of interest.

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 the urban functional area of Trnava. By taking into account various factors affecting the level of provided services, we have refined the assessment of ecosystem services of the area of interest, which is very similar in terms of landscape cover and land use within individual municipalities, but the level of provided ecosystem services varies even within the same landscape cover classes.

We see that this research can be very helpful to provide the basis for further evaluation and environmental management of the area, created by different individual geosystems.

References

Burkhard, B., Kroll, F., Müller, F., & Windhorst, W. (2009). Landscapes' capacities to provide ecosystem services – A concept for land-cover based assessments. *Landscape Online*, 15. https://doi.org/10.3097/LO.200915

Haines-Young, R. and Potschin, M. (2013): Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. EEA Framework Contract No EEA/IEA/09/003

Miklós, L. Izakovičová, Z. et al. 2006. Atlas reprezentatívnych geoekosystémov Slovenska. [Bratislava]: Slovenská akadémia vied. ISBN 80-969272-4-8

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Souhrn

Tento vědecký článek hodnotí ekosystémové služby v Trnavě (Slovensko) a okolních regionech. Studie hodnotí potenciál poskytování ekosystémových služeb pomocí reprezentativních potenciálních geoekosystémů (REPGES), což jsou krajinně-ekologické jednotky, které představují potenciální stav krajiny, pokud by do ní člověk v minulosti nezasahoval. Reálné geoekosystémy, které reprezentují současný stav krajiny, jsou použity k vyhodnocení současných možností poskytování ekosystémových služeb a k návrhu funkční zelené infrastruktury.

Analýza potenciálu území Trnavy pomocí metodiky ekosystémových služeb se zaměřuje na nejdůležitější ekosystémové služby, které jsou kategorizovány na základě Společné mezinárodní klasifikace ekosystémových služeb (CICES). Vybranými ekosystémovými službami jsou biomasa pro produkci potravin, voda pro pitné a technické účely, regulace kvality ovzduší, regulace kvality vody a regulace vodních toků a ochrana před povodněmi. Hodnocení jednotlivých ekosystémových služeb vychází ze specifických vlastností geoekosystémů, jako je kvalita půdy, zpracovatelnost, klima, potenciál povrchových vod, využitelné zdroje podzemních vod a ochranná pásma vodních zdrojů. Výsledkem výzkumu jsou samostatné mapy, které znázorňují prostorové uspořádání přínosů poskytovaných jednotlivými geoekosystémy. Tyto výstupy jsou podkladem pro další hodnocení a environmentální management ÚPD Trnavy.

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