JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2022, 23(3), 162–173
https://doi.org/10.12911/22998993/145327
ISSN 2299–8993, License CC-BY 4.0

Received: 2021.12.10
Accepted: 2022.01.13
Published: 2022.02.01

Map Based Information Support System on Land Use: Case of Horná Nitra, Slovakia

Petra Pipíšková[1], Zlatica Muchová[1*], Dávid Dežerický[1]

[1] Institute of Landscape Engineering, Faculty of Horticulture and Landscape Engineering, Slovak University of Agriculture, Hospodárska 7, 949 76 Nitra, Slovakia

* Corresponding author´s e-mail: zlatica.muchova@uniag.sk

ABSTRACT

A significant problem of the current land management in Slovakia is the long-term separation of usage and property rights. More than 91% of agricultural land is leased and used by larger agricultural enterprises (9%). Current common agricultural policies of the EU have been the subject of criticism for a long time, as inappropriate settings force farmers to manage unsustainably with a negative impact on biodiversity. Substantial, reliable and beneficial mutual information sharing between those who do business on the land, who own the land and who use the surrounding landscape, either as a living space for housing or relaxation and recreation might help to mitigate some issues. In this paper, the authors present an implemented proposal for multi-layer map and analytical support for land and soil use assessment. The model area includes the land units managed by the Agricultural Cooperative of Horná Nitra. The approach includes the identification of undesirable combinations according to criteria (degree of protection, area, type of use, erosion risk, and ecological stability) on each land block. This concept enabled the visualization and quantification of risks in the area in question through an online GIS application with a web interface.

Keywords: cooperative, information support system, WebGIS system, LPIS, crops, environmental land management.

INTRODUCTION

Due to collectivization and inefficient registration of landowners, property and legal relations in the Slovak Republic (SR) have undergone changes in the past, the consequences of which are still observable today. The arrangement of ownership, use and lease relations to the land as well as the legal regulation of land ownership cause a significant problem for the transformation and modernization of agriculture (Urban 2020). According to Eurostat (2010) more than 91% of agricultural land in Slovakia is leased and used by larger agricultural companies (9%). The remaining 9% of agricultural land is used by smaller farms (less than 100 ha), mainly by private farmers (SHR). Enviroportál (2018) states that of the total area of agricultural land (2,379,101 ha) the largest landlord is the Slovak Land Fund (SPF), which manages about 17% of agricultural land, of which 142,313 ha is state land (6% of the total agricultural land in Slovakia) and 258,742 ha land of unknown owners (11%). The remaining 83% of agricultural land (1,978,046 ha) is privately owned. In Poland, private farms use 76% of the total agricultural land in agricultural enterprises with an average of 6.3 ha (50% under 5 ha). In Bulgaria these values are 53% and 1.48 ha (86% under 1 ha), in Romania 52% and 1.94 ha (40% under 1 ha). Only 17% of Hungarian land is used by private farms in units of 0.81 ha (but with 42% over 10 hectares) and in the Czech Republic and Slovakia they are even less dominant (Dijk 2003). In the Slovak Republic, situation is aggravated by land ownership fragmentation resulting in 12.5 million land plots with an average plot size of 0.45 ha and an average number of 12 co-owners per plot, which has not changed significantly since the early 1960s. (Urban 2015). The fact that the lease of agricultural land dominates and only a very small percentage of owners also use agricultural land is a consequence of historical development, Lazíková and Bandlerová (2011) and Bandlerová (2007). The intensification of agriculture was related to the collectivization and removal of hedges and riparian vegetation, reduction of the mosaic of arable fields, grasslands and forests. Landscape mosaics have been transformed into large-scale fields. Only in less accessible, less fertile localities has the original agricultural landscape been partially preserved and has not lost the appearance of a cultural-historical landscape (Špulerová et al. 2010; Dobrovodská et al. 2019). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES 2019) warned that the rate of biodiversity loss is unprecedented in human history as approximately one million animal and plant species worldwide are currently threatened with extinction. The report by the European Environment Agency (EEA 2020) on the state of the environment claims that the intensification of agriculture remains one of the main causes of the biodiversity loss and the decline of ecosystems in Europe. In many parts of Europe, intensification has previously transformed a diverse landscape, consisting of many small fields and habitats, into a single, uninterrupted terrain cultivated by large machines (Janus, Bozek 2019; Baude et al. 2019). Regulation or new incentives to reduce land blocks can help to improve the condition. According to the European Environment Agency (2021) the cost of inaction on soil degradation exceeds 50 billion EUR per year. Mutual information helps farmers (and other stakeholders) to decide on good farming practices (Demiryurek et al. 2008). Maningasa et al. (2000) argue that the information available to farmers can significantly strengthen their powers and help control their resources and decision-making processes.

An information system (IS) for agriculture should provide an environment in which the information is modeled, transformed, disseminated, consolidated, received and retrieved in a way that makes it more significant and accessible for support, education and use by farmers themselves (Rolling 1988). Each type of information has its types of users who use it for different purposes, as researchers, educators, students, production managers, company employees, individual farmers and owners (Zaman 2002). One of the information services in Slovakia is the SKEAGIS system (www.skeagis.sk) that assists with processing of data from the cadaster of real estates, simplifies the creation of leases, creates outputs for managed land units in graphic and textual form and provides reminders on the compliance with legislation with regard to control bodies. Another service in the field of primary agricultural production is AgroCont (www.isat.sk) providing animal records, legal advice on cadaster of real estates and leases, measuring and demarcating of plot boundaries using GPS devices, creating new or expanding production areas. Geodesy, Cartography and Cadastre Authority of the Slovak Republic (ÚGK) is the provider of Geoportal GIS (ZBGIS) (https://www.geoportal.sk/sk/geoportal.html). ZBGIS application allows extraction of certain data including the geodetic ones at https://zbgis.skgeodesy.sk/mkzbgis. The service includes the possibility to access the ownership deeds and plots in the C and E registers. Soil Science and Conservation Research Institute in Bratislava (SSCCRI), http://www.podnemapy.sk, enables, via a map server, viewing of information on soil protection based mainly on information on certified soil ecological units (BPEJ), including data on crop production, cultivation costs, total land price, LPIS, nitrate directive or susceptibility of agricultural land to compaction. The GSAA (Geospatial Aid Application) application provides land register maps for information on agricultural subsidies (https://gsaa.mpsr.sk). Above mentioned systems do not have their databases interconnected and not all information is freely accessible.

The aim of this paper is to give an example of implementation of an support system based on visually clear map layers and analytical tools for soil and land use assessment suitable for all stakeholders (owners in particular) and interested parties. It can serve as an archiving tool on land use as well as offers modeled information sets for subsequent decision-making, especially in relation to the landscape management and protection. Combination of information offered for a given area provides basis for the owner's own assessment on whether the land user manages the soil and land within natural capacity limits in an ecologically sustainable way.

METHODOLOGY

Information support system presented here is implemented on the area of land units managed by the Agricultural Cooperative Horná Nitra, PDHN, (Figure1). The model locality belongs to the Trenčín self-governing region and the Prievidza district. Premises of the PDHN are based in the cadastral area of Nedožery. Land units are located in 12 cadastral areas: Bojnice, Brezany,

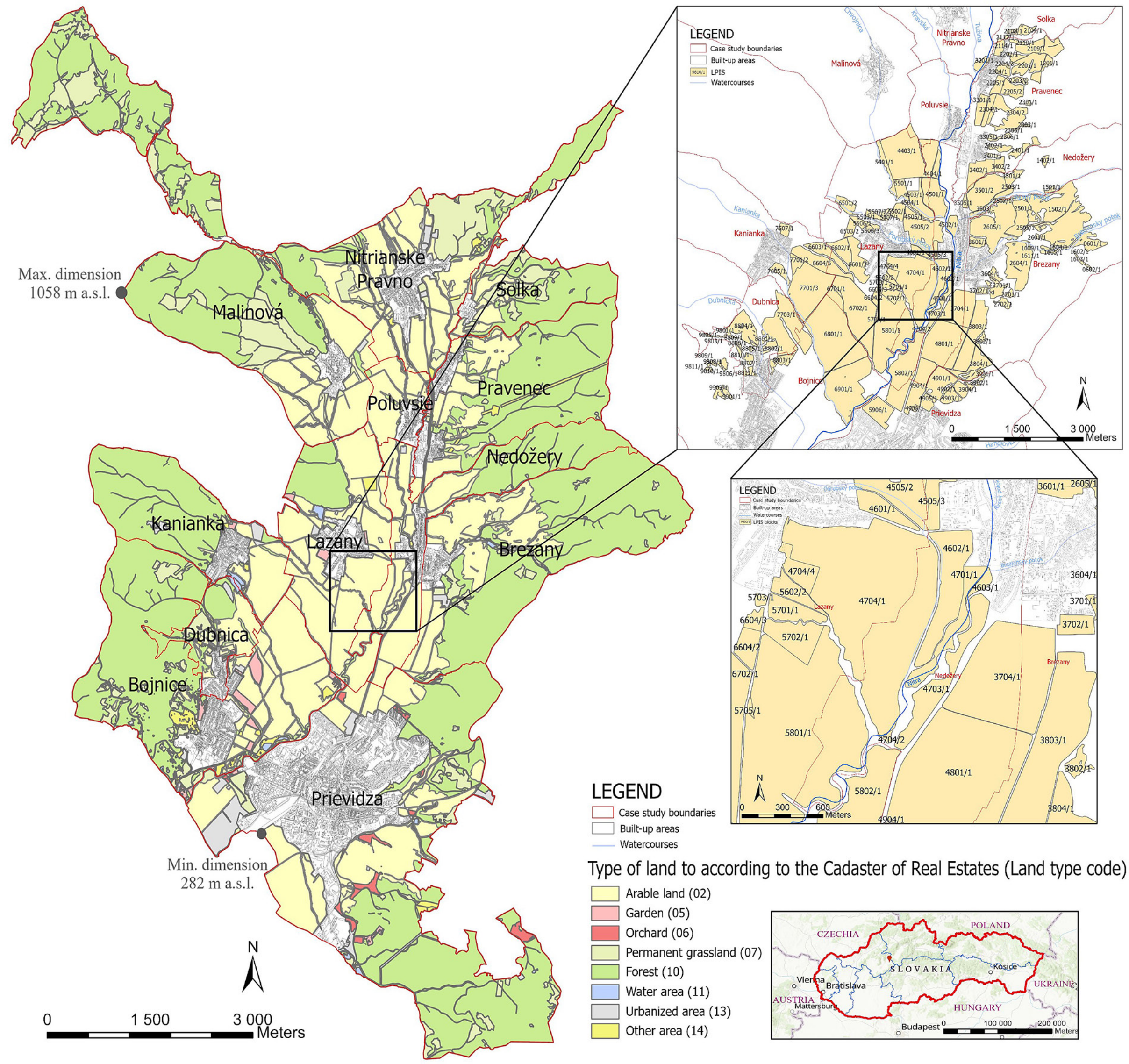


Figure 1. Map of the current land use with details of managed land units

Dubnica, Kanianka, Lazany, Malinová, Nedožery, Nitrianske Pravno, Poluvsie, Pravenec, Prievidza a Solka. PDHN is focused on plant production. It manages 140 blocks with an area of 2264.52 ha on 127 plots. According to the data from the cadaster of real estates (Table 1) PDHN owns 3.86% of land and 3.1% is under the management of the Slovenský pozemkový fond (Slovak Land Fund). More than 2000 ha are privately owned, which represents 93% of the land.

The structure of crop production in 2020 included 12 crops. Winter barley had the largest share with 334.61 ha, rapeseed 321.92 ha, spring barley 302.48 ha, winter wheat 248.64 ha, and sunflower 131.64 ha. The detailed representation of crops is provided by the information support system at https://arcg.is/1n0Cn00.

The model area is located in highland to mountainous terrain with an altitude from 282 to 1058 m above sea level. The slope ranges from plains suitable for agricultural production to slopes above 17° (30.57%) due to the adjacent mountains. On the area of 2264.51 ha 21 types of main land units are present, mainly pseudogley cultivated in the area of 942.54 ha (42.38%), fluvisol cultivated in the area of

Table 1. Land ownership in the area under consideration according to the Cadaster of Real Estates

Ownership	Area (ha)	Area (%)
Agricultural cooperative Horná Nitra	83.11	3.86
Slovak land fund	66.88	3.10
Privately owned	2001.29	93.03

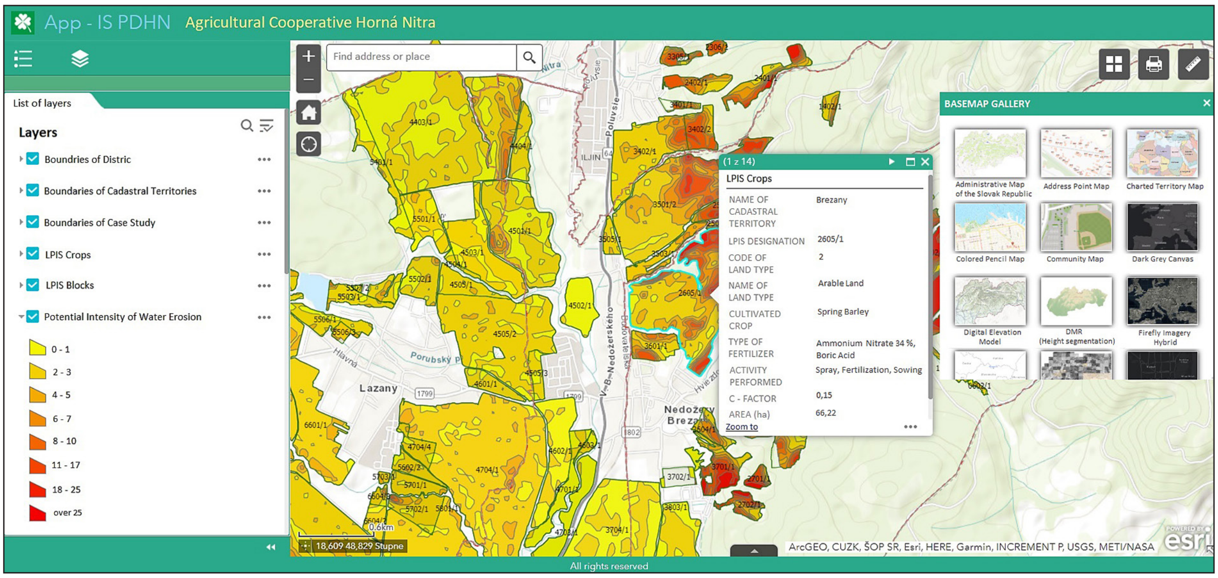


Figure 2. Preview of the information system

245.50 ha (11.04%) and cambisol cultivated in an area of 233.13 ha (10.48%). From the climatic point of view, it is a sufficiently warm, dry and hilly climate region, which with total average annual temperatures above 10°C, with 231 days above 5°C. Average air temperature for the growing season is 15.5°C. The average number of icy days per year (less than 0.1 °C) is 30. The average total precipitation is 850 mm. The distribution of precipitation during the year is uneven. The most precipitation falls in the summer months (June and July), while the minimum amount falls from January to March (Faško and Šťastný 2002). Upper Nitra Basin belongs to the areas with minimal wind of around 2.4 $m \cdot s^{-1}$, with prevailing winds in the direction of the basin axis, i.e. northern and southern winds, Lapin and Tekušová (2002). The snow cover lasts on average 70 days annually. Hydrologically, the area belongs to the basic catchment area of the Nitra River (Kišš et al. 2021). Flow and hydrogeological productivity in the concerned land units is moderate (T = 1.10^{-4}–1.10^{-3} $m^2 \cdot s^{-1}$) (Malík and Švasta 2002). Land units are located in the beech zone and in the crystalline-Mesolithic area (Plesník 2002). A significant part is located in the Carpathian oak-hornbeam forests with an area of 1577.91 ha (69.68%), ash-elm-oak forests in the Nitra river basin (hard floodplain forests) with an area of 542.36 ha (23.95%) and alder forests on the floodplains of foothills and mountain watercourses with an area of 75.27 ha (3.32%) (Maglocký 2002).

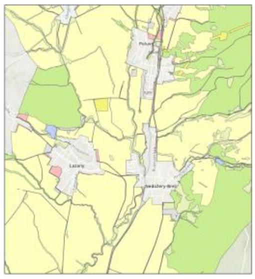
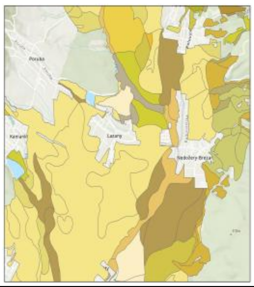
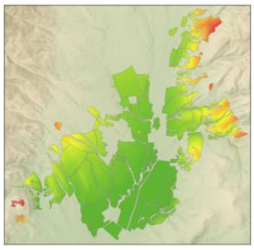
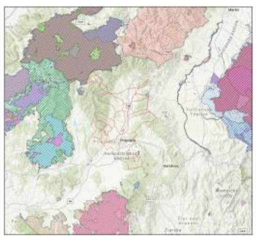
Input database consists of 6 map layers (Table 2) forming the basis of the information support system (basic share layers). Map layers are processed from publicly available databases and form a framework for subsequently derived analyzes.

Derived share layers (Table 3) include the following: 1 – Erosion risk of the area, 2 – Ensuring ecological stability and landscape appearance of the area, 4 – Size of land units, and 5 – Sowing procedures. Standard methods and procedures for modelling and calculations supported by GIS software were used.

Erosion risk has been estimated by area representation of endangered localities (SEOP). Five categories of SEOP are as follows: soil loss risk up to 1 t $ha^{-1} \cdot year^{1}$ (SEOP1), from 1 to 2 t $ha^{-1} \cdot year^{1}$ (SEOP2), from 2 to 7 t $ha^{-1} \cdot year^{1}$ (SEOP3), from 7 to t$ha^{-1} \cdot year^{1}$ (SEOP4), and in excess of 28 t $ha^{-1} \cdot year^{1}$ (SEOP5). The universal soil loss equation (USLE) (Wischmeier and Smith 1968) in the form $Sp = R \cdot K \cdot L \cdot S \cdot C \cdot P$ has been used to determine the intensity of soil water erosion. The values of permissible erosion depending on the soil depth are defined in the Slovak Republic by STN 75 4501 and Act no. 220/2004 Coll.

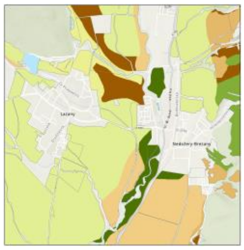
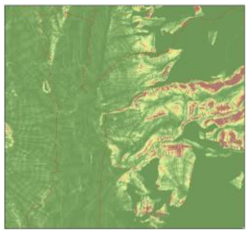
When processing the ecological quality of the area, 6 levels (0-5) according to Löw (1995) have been used, ranging from natural elements and elements close to nature (5th degree of ecological stability) to anthropogenic, vegetation-free and artificially created elements (0th degree of ecological stability). KES, the coefficient of ecological stability for the concerned cadastral areas is given as follows:

Table 2. Input characteristics and sources of basic share layers

Layers Source	Layer characteristics	Detail
The border https://www.geoportal.sk	The border is a line separating administrative units (states, regions, districts, cadastral territories). The Slovak Republic has 8 regions, 78 districts, 3559 cadastral territories.	
LPIS blocks https://gsaa.mpsr.sk/2021/	LPIS is an identification system for agricultural areas. It represents the vector boundaries of the agricultural landscape and carries information about the unique code, area, culture / land use. It is based on parts of land blocks as a source for direct subsidies for applicants.	
Current land use https://zbgis.skgeodesy.sk/	The current landscape structure is composed of elements with a specific spatial delimitation (e.g. forests, meadows, fields, houses, roads). In the initial breakdown, they are categorized according to land types according to the cadaster of real estates.	
BPEJ http://www.podnemapy.sk/	BPEJ are the most homogeneous soil-ecological units. Encoding is based on main soil and climatic areas, that are categorized in more detail according to slope, exposure of the slopes to the cardinal directions, skeletal content, soil depth and grain size of the surface horizon. In Slovakia, 7140 BPEJ codes are distinguished.	
Terrain https://zbgis.skgeodesy.sk/	Terrain is the current fragmentation of the earth's surface.	
Protected areas http://maps.sopsr.sk/	Protected area is a geographically defined area that is designated or regulated and managed with the intention of achieving specific conservation objectives under Act 543/2002 Coll. on nature and landscape protection, as amended.	

Depth are defined in the Slovak Republic by STN 75 4501 and Act no. 220/2004 Coll.

Table 3. Factors and sources of basic share layers

Factors	Brief characteristics	Detail
Rain factor (R) (MJ ha^{-1} cm h^{-1}) (Malíšek 1990)	Erosive efficiency factor of torrential rain has been taken from ombrographic records of the nearest ombrographic station in Trenčín.	Value 14.21
Soil erodibility factor (K) (t MJ^{-1}) (Ilavská et al. 2005)	The K factor on the given land units ranges from 0.2 to 0.41. Values of 0.3 (48.87%) have pseudogleys cultivated from loess and polygenetic clays, 0.34 (11.04%) - fluvisols cultivated from gleys and 0.35 (10.48%) - cambisols cultivated from pseudogley of sloping clays. The lowest representation is for values of 0.39 (0.77%) - modal rendzina and 0.26 (0.92%) - fluvisols cultivated from gley, heavy.	
Topographic factor (LS) (-)	The factor expresses the ratio of land loss from the investigated slope to the loss of land from the unit plot. The value of the LS factor ranges from 0 to 109.26 in the concerned cadastral areas.	
Vegetation protection factor (C) (-)	Expresses the protective effect not only of the sowing procedure but also of the used agricultural technology. The value of the C factor on cultivated land units ranges from 0.005 to 1.	
Effectiveness factor of anti-erosion measures (P) (-)	For the concerned soil units, the value of P factor (1), which defines the ratio between the erosion intensity on the concerned land with applied anti-erosion measures and the erosion intensity on the same land cultivated in the direction of the slope, has been determined.	Value 1

$$LC_{KES} = \frac{P_5+P_4+P_3}{P_2+P_1+P_0} \quad (1)$$

where: LC_{KES} – coefficient of ecological stability of the area for the purposes of land consolidation (LC), *P5* – area of land use elements classified in 5th level (ha), *P4* – area of land use elements classified in 4th level, *P3* – area of land use elements classified in 3rd level, P2 – area of land use elements classified in 2nd level, *P1* – area of land use elements classified in 1st level, *P0* – area of land use elements classified in 0th level. Two levels of ecological stability for model area have been considered: low (containing level 0, 1, 2) and high (containing level 3, 4, 5).

Land blocks have been assessed according to whether they support modern agricultural technology and at the same time whether they are bounded by a system of ecological measures which increase the ecological stability and biodiversity of the area. The limiting size of land blocks for land use warnings is over 50 ha outside protected areas and over 20 ha in protected areas. Those values were set on the basis of the prepared ecosystem criteria for the years 2023–2027 in given climatic environment. Criteria for hilly areas have been applied to assess the percentage of land homogeneity. 75% homogeneity is required in terrain fragmented areas.

Sowing procedures have been evaluated in a time sequence of 4 years in order to check optimal rotation of individual crops in relation to the susceptibility of agricultural land to water erosion. Archiving of sowing procedures offers an excellent source of information for forecasting and retrospective evaluation of the landscape. Without the possibility of archiving, the data on the territory are gradually lost.

The ArcGIS Online Publishing (www.arcgeo.sk) environment has been used to create the on-line web-application.

RESULTS AND DISCUSSION

Information system is accessible via the following web address: https://arcg.is/1n0Cn00. The initial loading of the website provides a view of the model area bordered by land blocks under the management of an agricultural cooperative with the current representation of cultivated crops (Figure 3).

The complex of soil characteristics is represented by a set of superimposed layers that comprehensively document the real state. Soils with a skeleton content of up to 10% (71.60%) have the largest share; with soil with high skeletal content of more than 50% (4.55%) having the lowest share. 86.53% of the land area belongs to deep soils at a depth of 60 cm and more. Medium-deep

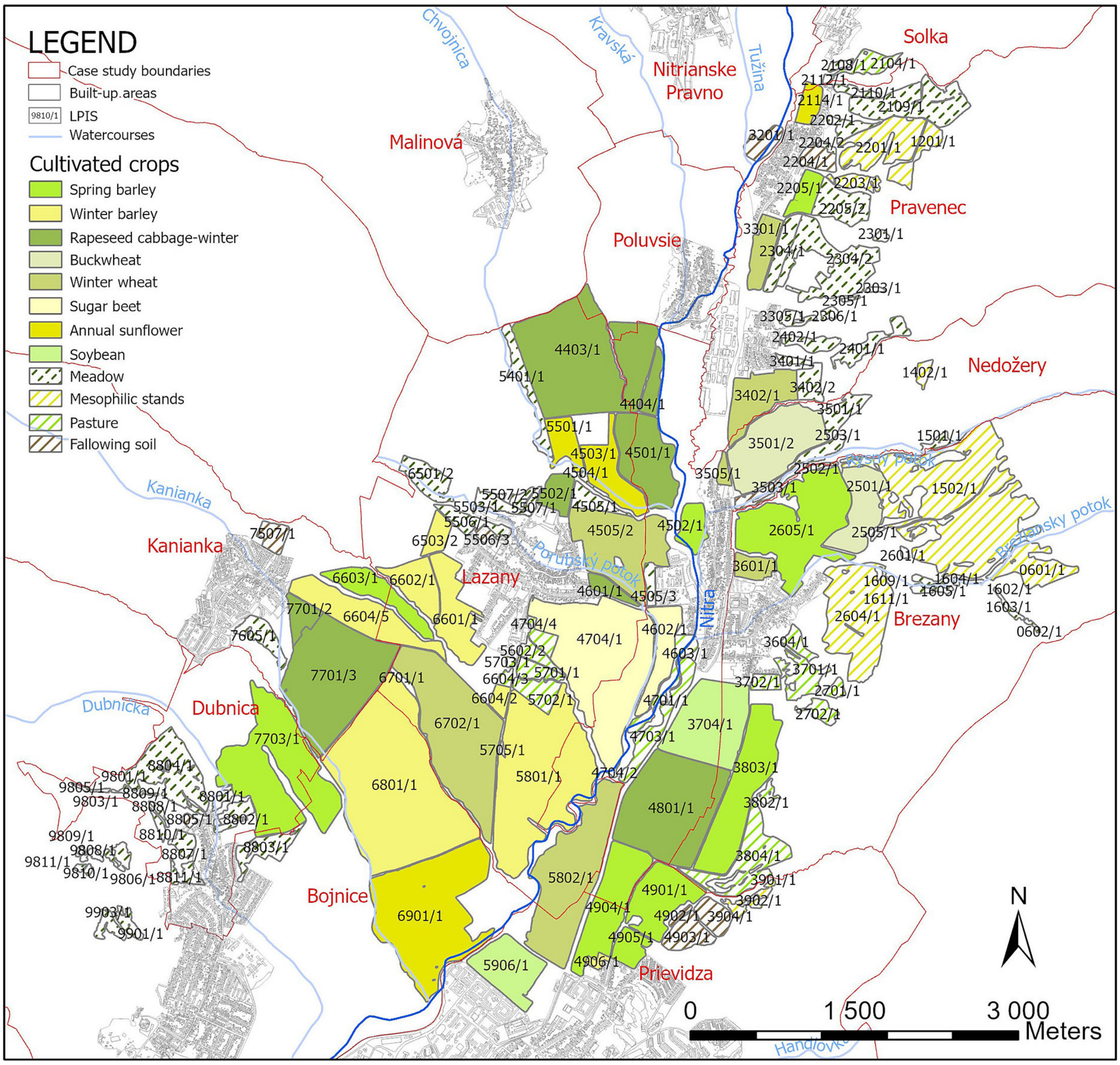


Figure 3. Sowing procedures on cultivated land units in 2020

soils at a depth of 30 cm to 60 cm (8.83%) and shallow soils up to 30 cm have a low share (4.64%). Grain size corresponds mainly to medium-heavy clay soils (59.33%) and medium-heavy and lighter sandy-clay soils (29.59%). Light sandy and loamy soils (2.74%) and heavy loam-clay soils (8.34%) have a very low share. On the land units belonging to the potentially arable land, the largest share belongs to the less productive soils (54.21%). In the alternating fields, the largest share belongs to lesser productive fields and temporary grasslands (7.66%). Permanent grasslands have the 4.87% share of land units. Of the 9 specified soil quality groups, 7 occur in land units. Managed land units have the largest share of soil quality group 6 (52.54%) and soil quality group 7 (18.91%). Soil values (not a market price!) of agricultural land are in the range from 0.022 to 0.300 € per m^2. A total area of 787 ha includes land containing fluvisols cultivated, gley, the value of which is 0.102 € per m^2. The smallest share belongs to land with the soil value of 0.061 € per m^2. A total of 40.90% of land units are without protection and up to 59.10% of land is protected from non-agricultural activity.

From the ecological point of view, the concerned area is characterized by a high proportion of afforestation, permanent grasslands, watercourses and their accompanying ecosystems, which are characterized by high ecological stability. On the other hand, there are significant large blocks of arable land, which weakens the stability of the area against stress phenomena (Figure 4). The largest share is represented by landscape elements with natural and nature-friendly vegetation of very great importance (46.47%). The calculated LC_{KES} for the concerned areas is 1.58, in terms of a comprehensive assessment of the area this means the need to focus attention primarily on the implementation of eco-stabilization and management measures of existing natural structures.

The most erosively endangered soils (according to USLE) with the potential soil loss value of more than 48 t ha^{-1} year^{-1} are in land units with an area of 29.94 ha, currently lying fallow. Slightly increased values of erosion risk

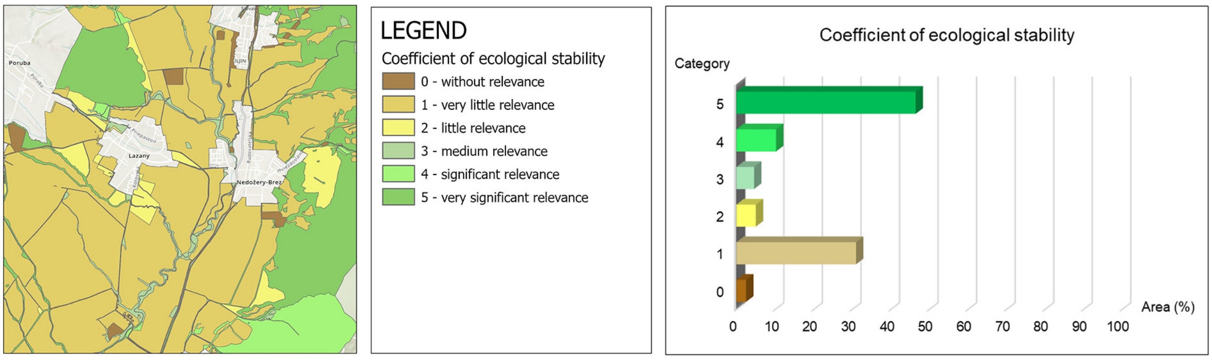


Figure 4. Coefficient of ecological stability of the area

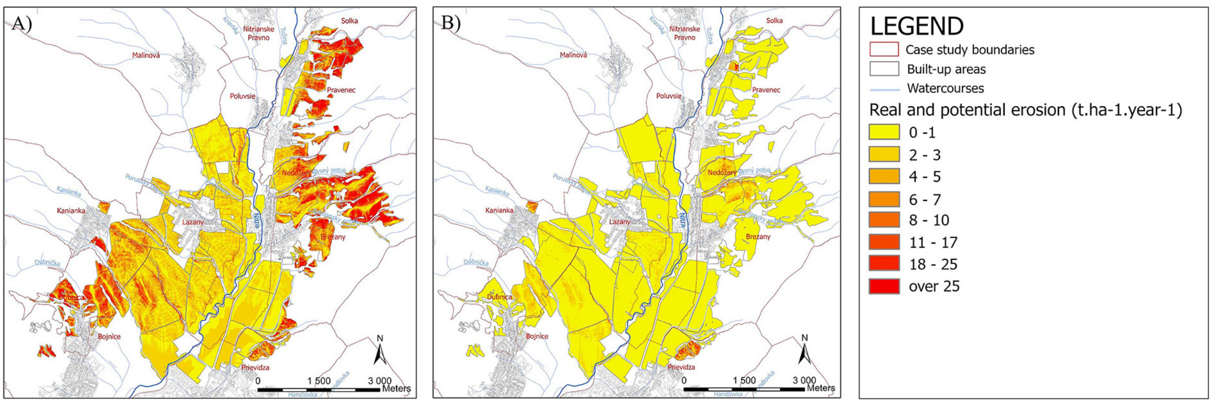


Figure 5. Water erosion intensity a) Potential provided that C, P = 1; b) Calculated (real) assuming that C < 1, P = 1

were also found on plots with an area of 549.58 ha (Figure 5). The cultivation of spring barley, winter barley, buckwheat, sugar beet and sunflower predominates in the given land units. The crops were sown with a strip-till seeding system. The areas of individual soil loss categories by water erosion are shown in Table 4.

The majority of land units are located in the 1st erosion risk degree, which means that the soil is either not endangered or slightly endangered. Figure 6, shows the potential degree of soil erosion risk. According to STN 75 4501, land units with an area of 7.59 ha (0.34%), located in the western and eastern part of the territory are catastrophically endangered (Figure 6A). Pursuant to Act no. 220/2004 (Figure 6B), the land units in the western and eastern part of the territory are classified in 1 to 4 risk degree. Land units in non-endangered and slightly endangered locations have the largest share with an area of 2018.92 ha (89.15%) (Table 5). By the reconnaissance in place, authors found out that identified endangered land units are formed by potholed erosion, erosive ravines and regular waterlogging of the soil.

Current land management in Slovakia is adversely affected by the long-term separation of usage and property rights. The use of agricultural land is associated with agricultural subsidies on EU level. Inappropriate settings force farmers to manage unsustainably with a negative impact on biodiversity, e.g. Pe'er et al. (2014), Dicks et al. (2014). The application of greening did not bring the expected results. The European Court

Table 5. Degree of soil erosion risk (SEOP, potential)

SEOP	SEOP – potential			
	According to STN		According to Act no. 220/2004 Coll.	
	(ha)	(%)	(ha)	(%)
1. class	1890.11	83.47	2018.92	89.15
2. class	181.91	8.03	143.32	6.33
3. class	135.93	6.00	92.75	4.10
4. class	48.98	2.16	9.53	0.42
5. class	7.59	0.34	-	-

Table 4. Area of soil loss in soil units for the calculated potential and real intensity of water erosion

Soil loss ($t\ ha^{-1}\ year^{-1}$)	Area for the calculated potential intensity of water erosion (ha)	Calculated potential intensity of water erosion (%)	Area for the calculated real intensity of water erosion (ha)	Calculated real intensity of water erosion (%)
0–1	422.52	18.66	2016.37	89.04
2–3	985.37	43.51	185.33	8.18
4–5	257.57	11.37	30.95	1.37
6–7	132.83	5.87	9.74	0.43
8–10	131.59	5.81	8.27	0.37
11–17	154.36	6.82	6.08	0.27
18–25	79.88	3.53	2.77	0.12
over 25	100.40	4.43	5.01	0.22

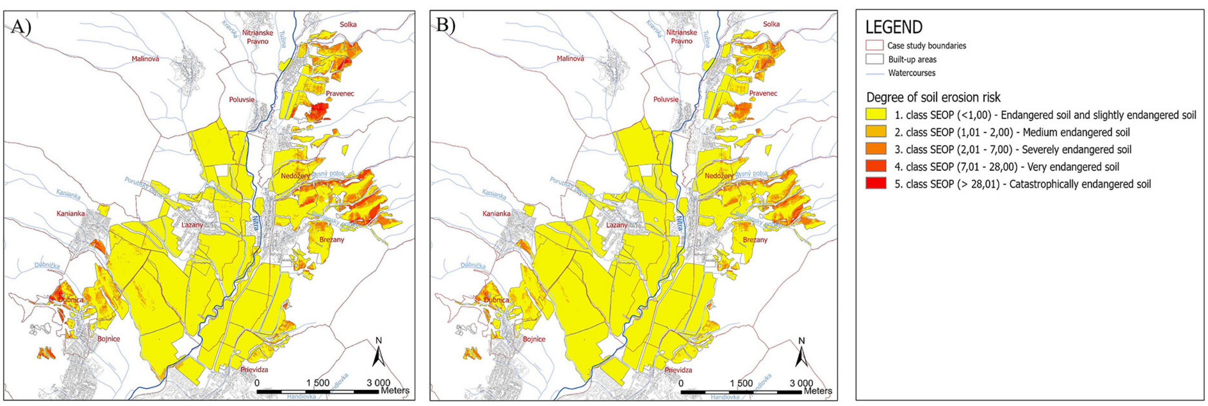


Figure 6. Degree of soil erosion risk - potential, a) according to STN 75 4501, b) according to Act no. 220/2004 Coll

of Auditors (2015) has also found that, due to exceptions and inappropriate measures, greening has been inefficient and to some extent harmful. Ridzoň (2021) claims that the main reason for the decline in biodiversity comes from agricultural subsidies, on the basis of which Slovak farmers have to intensively use every square meter of their land with no room left for (diverse/other) life. Since 2005, rare species of birds tied to the agricultural landscape have disappeared in Slovakia. Natural areas with no use of chemicals are disappearing. Grasslands and meadows are also being lost. Large area fields make the landscape less diverse with very few elements where different species of animals and plants could survive. The state and the EU have so far not implemented any significant tools at all that would make land use more environmentally friendly; not only in protected areas, but also in the rest of the country. Subsidies to motivate farmers to be more environmentally aware do not work in practice. Eco-schemes could bring change, but they must be motivating for farmers.

Even the landowner does not have specific information on how the tenant maintains the land. According to Julény (2018) the only way to establish order and fair relations between landowners and land users is through public information and its sharing in open access media. None of the available systems in Slovakia so far provides the owner with information on sites that are threatened by erosion caused by poor land management. In case that land owners find that there is a great deal of degradation and removal of quality soil on the leased land, they should be able to enter into a process of remediation with the land user and demand changes. Figure 7 depicts basic relations between the user, the owner and expectations of inhabitants or visitors of a site.

While some relationships are clearly given by e.g. contract, application or economic evaluation, other relationships are problematic to describe. Authors see difficulties mainly in the assessment of the extent of soil care, soil / landscape quality, soil susceptibility to erosion, aesthetics and environmental quality in areas where intensive agricultural activity takes place. Presented system with combination of basic and derived layers allows to classify and condition the method of management in order to provide benefits for the owner, user and to support the protection and shaping the landscape, e.g. as a basis for defining ecosystems in subsidies. The significance for the owner lies in one overlap of the available layers, from which the owner can find out whether the property is managed in a protective manner.

CONCLUSION

The approach based on identification of undesirable combinations on a land block according to criteria such as degree of protection, area, method

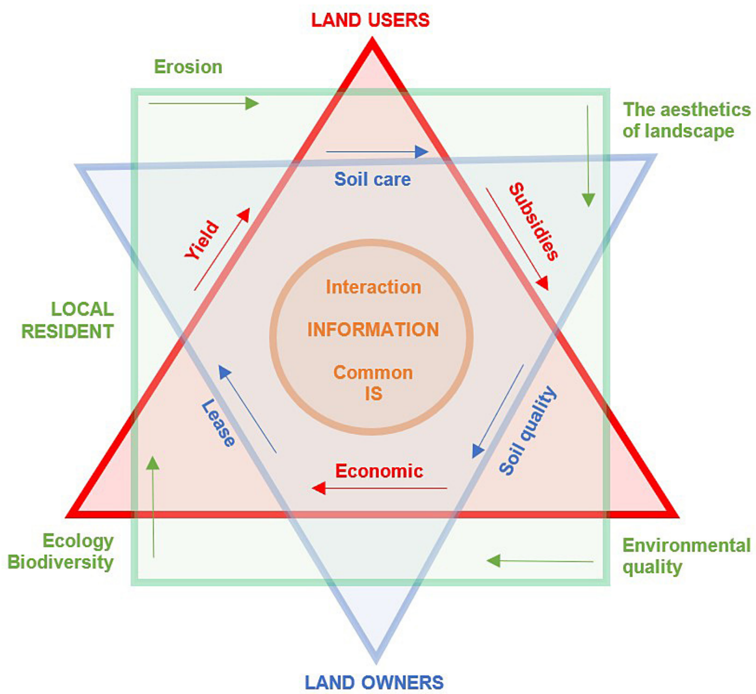


Figure 7. Mutual interaction of different land use actors in one space

of use, erosion risk, ecological stability, allowed for visualization and quantification of risks in the model area formed by land units in the agricultural cooperative Horná Nitra through online GIS application web interface. In one overlap of the presented layers, it is possible to find out how the land is managed in a given locality. The system set up in this way with the obligation to update can provide targeted support for active and sustainable land management. A similar application has so far been absent in Slovakia, as far as the authors know. In case of unwanted combinations on the land block, information support system provides warnings, cautions and sanctions at different levels of responsibility.

Acknowledgments

This contribution is a part of a work that was supported under the Integrated Infrastructure Operational Program for the project: "Data and knowledge support for decision-making and strategic planning systems for adapting agricultural land to climate change and minimizing agricultural land degradation" (code ITMS2014 + 313011W580), co-financed by the European Parliament's Regional Development Fund and the research projects VEGA no. 1/0244/21 „Appropriate criteria-based selection of localities for land consolidation respecting environmental aspects".

REFERENCES

1. Bandlerová A., Lazíková J., Ilková Z., Schwarcz P., Muchová Z., Drenková L. 2007. European Union agricultural law. SPU v Nitre, Nitra. (in Slovak)
2. Bandlerová A., Schwarcz P., Marišová E. 2011. Land Tenure and Rural Development - Case of Slovakia. Acta regionalia et environmentalica, 8(1), 6–15.
3. Baude M., Meyer B.C., Schindewolf M. 2019. Land use change in an agricultural landscape causing degradation of soil based ecosystem services. Science of The Total Environment, 659(1), 1526–1536. DOI: 10.1016/j.scitotenv.2018.12.455
4. Demiryurek K., Erdem H., Ceyhan V., Atasever S., Uysal O. 2008. Agricultural information systems and communication networks: the case of dairy farmers in Samsun province of Turkey. Information Research, 13(2), 343. http://InformationR.net/ir/13-2/paper343.html
5. Dicks L.V., Hodge I., Randall N., et al. 2014. A transparent process for 'evidence-informed' policy making. Consery, 7(1), 119–125. DOI: 10.1111/conl.12046
6. Dijk T. 2003. Scenarios of Central European land fragmentation. Land Use Policy, 20(2), 149–158. DOI: 10.1016/S0264-8377(02)00082-0
7. Dobrovodská M., Kanka R., David S., Kollár J., Špulerová J., Štefunková D., Mojses M., Petrovič F., Krištín A., Stašiov S., Halada Ľ., Gajdoš P. 2019. Assessment of the biocultural value of traditional agricultural landscape on a plot-by-plot level: case studies from Slovakia. Biodiversity and Conservation, 28, 2615–2645. DOI: https://doi.org/10.1007/s10531-019-01784-x
8. European environment agency 2020. Agricultural biodiversity land: the CAP contribution has not stopped decline.13(1), 15–20. DOI: 10.2865/1514
9. European environment agency 2021. European Parliament resolution of 28 April 2021 on soil protection. https://www.europarl.europa.eu/doceo/document/TA-9-2021-0143_SK.html#def_1_40
10. Eurostat 2010. Archieve: Agricultural census in Slovakia. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agricultural_census_in_Slovakia
11. Faško P., Handžák Š., Šrámková N. 2002. Average number of days with snow cover, 1: 2000 000. Atlas SR, Bratislava.
12. IPBES 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. 43–48. DOI:10.5281/zenodo.3831673
13. Janus J., Bozek P. 2019. Land abandonment in Poland after the collapse of socialism: Over a quarterof a century of increasing tree cover on agricultural land. Ecological Engineering, 138(1), 106–117. DOI: 10.1016/j.ecoleng.2019.06.017
14. Juleny A. 2018. Current problems of access to land, ownership and lease of agricultural land and direct payments. Komora pozemkových úprav. Slovakia. http://www.kpu.sk/clanky-nazory/aktualne-problemy-pristupu-k-pode-vlastnictva-najmu-polnohospodarskej-pody-priamych/ (in Slovak)
15. Kišš V., Tárník A., Čimo J. 2021. Climate change impact on meteorological drought and soil water storage in the Nitra River basin for the period 2015–2019. Acta Horticulturae et Regiotecturae – Special Issue, 17–123. DOI: 10.2478/ahr-2021-0017
16. Lapin M., Tekušová M. 2002. Wind speed, 1:2000 000. Atlas SR, Bratislava. (in Slovak)
17. Löw J. 1995. Handle of the designer of the local territorial system of ecological stability - methodology after processing the documentation. Agroprojekt, Brno, 124. (in Czech)
18. Maglocký Š. 2002. Potential natural vegetation, 1:500 000. Atlas SR, Bratislava. (in Slovak)

19. Malík P., Švasta J. 2002. Main hydrogeological regions, 1:1000 000. Atlas SR, Bratislava. (in Slovak)
20. Maningas R.V., Orlando V., Perez G., Jane A. 2000. Electronic information dissemination through the farmers information and technology services. Retrieved October. DOI: 10.1.1.202.7673
21. Pe´er G., Dicks L.V., Visconti P., et al. 2002. EU agricultural reform fails on biodiversity. Science, 344(6118), 1090–1092. DOI: 10.1016/j.ecoleng.2019.06.017
22. Plesník P. 2002. Phytogeographical-vegetation division, 1:1000 000. Atlas SR, Bratislava. (in Slovak)
23. Ridzoň J. 2018. Why do birds disappear from Slovak fields. Euractiv, Slovakia. https://euractiv.sk/section/ekonomika-a-euro/news/preco-miznu-vtaky-zo-slovenskych-poli/ (in Slovak)
24. Rolling N. 1988. Extension science: Information systems in agricultural development. American Journal of Agricultural Economics. Cambridge University Press, Cambridge.
25. Špulerová J. 2021. How to prepare agriculture for climate change. Euractiv. Slovakia. https://euractiv.sk/section/ekonomika-a-euro/news/ako-pripravit-polnohospodarstvo-na-klimaticke-zmeny/
26. Špulerová J., Dobrovodská M., Stefunková D. 2010. Driving forces, threats and trends related to mosaics in the agricultural landscape in Slovakia. Journal of Landscape Ecology, 3(2), 59–72. DOI: 10.2478/v10285-012-0027-y
27. Urban J. 2020. Ownership and use of agricultural land. Slovakia. Komora pozemkových úprav. Slovakia. http://www.kpu.sk/clanky-nazory/vlastnictvo-uzivanie-polnohospodarskej-pody (in Slovak)
28. Zaman M. 2002. Present status of agricultural information technology system and service in Bangladesh. Bangladesh Agricultural University, Maymensigh.