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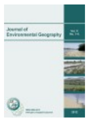

INVESTIGATION OF THE RELATIONSHIP BETWEEN SOIL EROSION, LAND COVER AND HEMEROBY LEVEL IN CSERÉPFALU BY ANALYSING SOIL PROFILES

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Abstract

We can measure the effects of anthropogenic processes to the nature in case of hilly agricultural areas with the rate of soil (water) erosion. There is actual question what kind of connection could be shown between the rate of soil erosion, land cover categories and hemeroby levels? How can the intensity of antropogenic effects influence the rate of soil erosion? We did some research work in the North Hungarian Region, in Cserépfalu in 2014. In Cserépfalu, the northern areas are under nature conservation and belong to the Southern Bükk Mountains while the southern dissected pediment is the extensive agricultural territory. We described the soil types in the southern areas using the soil description method of FAO. We collected data about the rate of soil erosion, the land cover types, slope angle, slope forms, slope aspect and data for the relief conditions too. We could point out the sheet erosion around the 15 investigated soil profiles and we could found 3 strongly eroded, 8 medium eroded and 4 accumulated soil profiles. The land cover categories were given based on FAO category system and topographic map from 1990. Our results showed that land cover categories were changed in time and it caused the change of hemeroby levels as well. The intensity of land cultivation in investigated areas was changed. We could point out in some cases that the stronger soil erosion rate was caused by former land cover system. In summary, some former agricultural areas were changed and became as an abandoned area so that the antropogenic effects were decreased in extensive agricultural areas in Cserépfalu. Our results can be compared with another pediment dissected by valleys where extensive agricultural areas are characteristic in Hungary.

Keywords: soil erosion, land cover categories, hemeroby levels, Cserépfalu

INTRODUCTION

The emergence of anthropogenic influences in landscapes is a very diverse and multifaceted process that can affect all landscape factors (i.e., geological, geomorphological, soil, hydrological, climate factors, plants and animals). At the same time, landscape factors may react differently and to different degrees to human interventions (Szilassi and Bata, 2012). Landscape factors interact with each other, and changes in one factor can trigger changes in other landscape factors. The extent of anthropogenic impacts on landscape and natural ecosystems is studied by assigning hemeroby levels. The concept of „hemeroby" was introduced in the field of landscape ecology in the 1950s. Jalas (1955) used hemeroby categories to measure the degree of human impact, and this category system became a 7- and 10-grade scale system (Bornkamm, 1980; Bastian and Schreiber, 1994; Csorba, 1995; Gabherr et al., 1998; Machado, 2004; Rudisser et al., 2012; Walz and Stein, 2014; Fushita et al., 2017; Csorba et al., 2018). Nowadays, the 7-category hemeroby degree has been applied in Hungary (Kocsis, 2018; Csorba et al., 2018) by designating ahemerobic (almost no human impacts / natural), oligohemerobic (weak human impacts / close-to-natural), mesohemerobic (moderate human impacts / managed, regularly disturbed), β-euhemerobic (moderate–strong human impacts / cultivated), α-euhemerobic (strong human impacts / intensively cultivated), polyhemerobic (very strong human impact / intensively transformed) and metahemerobic (excessively strong human impacts / very intensively transformed) areas. This method combines the extent of anthropogenic influences (disturbance) on relief, water, soil conditions, vegetation and land cover. According to Novák et al. (2019), one of the most commonly used indicators to detect the state and change of landscapes is the rate of land cover. It is possible with analysing of new CORINE Databases (Szilassi, 2003; Csorba and Szabó, 2009; Liska et al., 2017). They draw attention to the fact that at the same time it seems appropriate to examine the state of soils to express the extent of anthropogenic landscape transformation because the influence of 5 landscape factors in the soil is summed up (Novák et al., 2019). Pinczés (1968, 1978, 1980) investigated the effects of linear erosion on Tokaj Hill in 1968, soil erosion research in the Bodrogkeresztúr semi-basin in 1978 and the effects of certain cultivation branches on soil erosion in 1980. More detailed survey of soils was in Hungary in the 1970s and 80s (Stefanovits, 1981). At the same time, the quantitative revolution in physical geography research in the 1980s and 1990s made it possible to study soil erosion processes used for agriculture at erosion measuring stations and to support their sustainable utilization (Pinczés et al., 1978; Kertész, 1984, 1992; Kerényi, 1985). The purpose of the measurements was to study soil erosion and accumulation (Kertész, 1987; Góczán and Kertész, 1990; Kerényi, 1991; Lovász, 2000; Tóth et al., 2001; Jakab et al., 2005; Kitka et al., 2008). Kertész (2004) also investigated the degree of soil erosion in Hungarian landscapes, as well as the types of water and wind erosion. He mentioned types of water erosion as sheet erosion, rill and gully erosion in his studies (Kertész, 2004, 2009). The effects of soil frost on erosion was shown by Pinczés (1979). Huszár (1999) used the EPIC-EROTOP method to determine soil erosion estimation, while Tóth et al. (2001) used the MEDRUSH model to analyse soil degradation. Mészáros and Jakab (2001) applied the Universal Soil Loss Equation in erosion studies. In the 2020s, Manalja et al. (2021) investigated the effects of soil erosion on the spatial distribution of soil characters in vineyards. It can be seen that the extent of soil erosion and disturbance in Hungary has been analysed by numerous studies. Overall, it is the best when we can express the degree of anthropogenic transformation with complex point of view and we can use indicators like land cover, vegetation, soil erosion/compaction and relief conditions (Novák et al., 2019).

The character and changes of hemeroby levels in Hungary have been studied at national scale, macro landscape unit, meso and micro landscape unit and settlement levels so far (Kocsis, 2018; Csorba et al., 2018; Novák et al., 2019; Szilassi and Bata, 2019). Based on the previous research results, we can show what kind of hemeroby level or category change were appeared in the recent study area, in Cserépfalu. Due to its dual micro landscape units' extent (Bükk and Bükkalja micro landscape units), the individual studies mention 2 different categories of hemeroby in connection with the settlement. In the National Atlas of Hungary prepared during the national survey (Kocsis, 2018; Csorba et al., 2018), the northern areas of Cserépfalu protected by Bükk National Park were classified as Mesohemerobic (disturbed), while the southern, extensivelly cultivated areas were classified as α-Euhemerobic (intensively cultivated) level. In case of the micro-landscape survey (Novák et al., 2019), between 1990 and 2018, the proportion of land cover changes with increasing anthropogenic impact was low in the Bükk micro-landscape unit (less than 0,2% of the area of the micro-landscape unit, the national average: 0,7%), while the proportion of land cover changes indicating a weakening anthropogenic effect showed a moderate value (0,4-0,8% of the area of the micro-landscape unit, national average: 1,3%). The proportion of land cover changes with increasing human impact was medium in the micro-landscape unit of Bükkalja (0,4-0,8% of the area of the micro-landscape unit, national average: 0,7%), while the rate of land cover changes indicating weakening anthropogenic effects showed a medium value (0,8-1,7% of the area of the micro-landscape unit, national average: 1,3%). Based on the sudy of Csorba (2021), the Bükk micro-landscape unit, evaluated from the point of view of human strength, was classified into Mesohemerobic, i.e. treated, moderately disturbed category, while the Bükkalja micro-landscape unit was classified into the α-Euhemerobic category, i.e. intensively cultivated agricultural areas. Szilassi and Bata (2019) examined naturalness equivalent to the concept of hemeroby (Hill et al., 2002) using 4 landscape metric indicators. The 4 landscape metric indicators (LPI – Largest Pach Index, NP – Number of Paches, MPS – Main Pach Size, AWMPFD – Area Weighted Mean Patch Fractal Dimension) were calculated using the 1:100 000 scale CORINE Digital Land Cover Database (EEA. 2000) using the Vlate (Vector-based landscape analyses tools) Add-on Panel of ArcGIS software for the years 1990, 2000 and 2006. On their maps, the evaluated areas and settlements can be easily traced at county level as well. Between 1990 and 2000, in Cserépfalu, part of Borsod-Abaúj-Zemplén county, the hemeroby level decreased based on 4 landscape metric indicators, and the sum of changes in landscape metric indices was lower than -50%, which indicated a significant decreasing hemeroby level. Between 2000 and 2006, however, landcape metrics showed uncertainty about changes in hemeroby levels, with changes in landscape metric indices totalling less than -50%, suggesting a significantly declining hemeroby level. *Overall, the level of hemeroby decreased significantly between 1990 and 2006.*

About half a year ago, we studied the changes in historical land use and the changes in hemeroby levels in relation to Cserépfalu in landscape historical and GIS methods (Dobos and Utasi, 2022). At the same time of the First and Second Military Surveys (1763-1787; 1806-1887), *a three-category land use system* emerged in Cserépfalu. The 1990 map was made after change of regime in 1989, but it still basically indicates the legacy of the socialist farming system in the landscape, while the peculiarities of today's post-regime land use system were shown in the CORINE Land Cover 2012 survey. Overall, it can be shown that the original *feudal three-category land use system* (with arable land, forestry and vineyards) (Military Survey I. and II.: 1763-1787; 1806-1887) has changed into a *more diverse, multi-category, mixed land use system* in the case of Cserépfalu over the past 250 years (Dobos and Utasi, 2022). In Cserépfalu, the spread of nature conservation (forests) protected by the Bükk National Park and extensive agricultural areas of mixed farming in Bükkalja can be traced. Based on the hemeroby level, Cserépfalu was characterized by *predominantly natural, semi-natural and semi-natural conditions* in the middle high mountain section in the four periods examined (Military Surveys I and II; 1990; 2012). The ahemerobic level is 9.56% - 2.9% - 12.6% and 12.6%, respectively; β-oligohemerobic levels showed 75.52% - 77% - 64.57% and 63.40% and α-oligohemerobic levels of 1.19% - 5.94% - 7% and 11.05%, respectively. In addition, anthropogenic biological effects appeared in foothill areas due to arable cultivation (α-euhemerobic level: 12.71% - 12.35% - 14.23% and 14.34%, respectively). The growth of the settlement indicates the polyhemerobic level, with a value of 1.61% today.

In this study, our aim is to examine in more detail the part of Cserépfalu that falls within the area of the

Bükkalja micro-landscape unit, as this is more intensively affected by agricultural cultivation. This area is therefore classified as a α-euhemerobic area in terms of human strength (Csorba et al., 2018; Csorba, 2021) and an area classified as medium in terms of soil erosion rate and wind erosion (Kertész, 2004). Based on specific field data on the study area, we intend to explore the relationship among the degree of soil erosion, the type of land cover/land use and the hemeroby level. Our research results represent settlement-level, 1:10,000 scale processing.

STUDY AREA

In 2014, we carried out 1:10,000 scale field soil description in the settlement of Cserépfalu. Our study area is administratively located in Hungary in the North Hungarian Region, in Borsod-Abaúj-Zemplén county, in the Mezőkövesd micro-region (Fig. 1).

Based on the physical geographical landscape classification, our study area lies in the Inner NW Carpathians, in the macro-landscape unit of the North Hungarian Mountains, within that in meso-landscape unit of the Bükk Mountains, in the micro-landscape unit of the Bükk and Bükkalja (Kocsis, 2018; Csorba et al., 2018). The administrative area of the settlement (44.65 km^2) is situated in micro-landscape units of the Bükk and Bükkalja. Based on the land use zone system (Ángyán, 2003), the northern area is under the nature conservation of the South Bükk Mountains, while the southern foothill areas of the Bükkalja belong to extensive agricultural areas.

In Hungary, in the foothill areas of Cserépfalu, the research of landscape ecological features is mainly linked to the name of Zoltán Pinczés and his research group. So far, detailed geomorphological mapping of the settlement (Pinczés et al., 1993; Dobos, 2000, 2002, 2012a), exploration of Quaternary sediments (Pinczés et al., 1998; Dobos, 2000, 2012a), mapping of soil conditions (Kerényi, 1991; Dobos, 2012a, 2017; Dobos et al., 2014), water quality survey (Kerényi and Pásztor, 1994), assessment of its climatic conditions (Kerényi and Justyák, 1987), mapping changes in landscape history and land use (Dobos, 2012b; Dobos and Utasi, 2022), as well as nature conservation research and mapping of unique landscape values (Dobos, 2012b, 2018) were came true. The mapping of geological conditions is related to the names of Balogh (1964) and Pelikán (2002). Our new research results complement this research series. In this study, we seek to answer the question of what relationship can be detected between soil erosion, land cover/land use categories and hemeroby levels in the surroundings of soil profiles excavated in the settlement. Therefore, the aim of our studies is to explore the relationship between the various factors in more detail and on a deeper level, using field data.

METHODS

A total of 15 soil profiles were excavated in the dissected Bükkalja foothill area. We have summarized our field survey results in the Scientific Report (Dobos et al., 2014). The location of the examined soil profiles was determined so that they appear at all geomorphological levels and on different slope parameters and categories with different land cover (Fig. 2). The international soil description methodology makes it possible to map about 30 section identifiers, general soil formation and 37 section description parameters of soil profiles in the field, and to determine the soil type and WRB reference group category of the soil profiles based on the analysis of the data (IUSS Working Group WRB, 2015; Novák, 2013). The data collected included the definition of soil types, the degree of soil erosion, the type of land use (land cover), slope angle, slope shape, slope aspect and altitude data. In the surroundings of the soil profiles, sheet soil erosion was observed in places. The evaluation of actual erosion was given by expressing the thickness of the

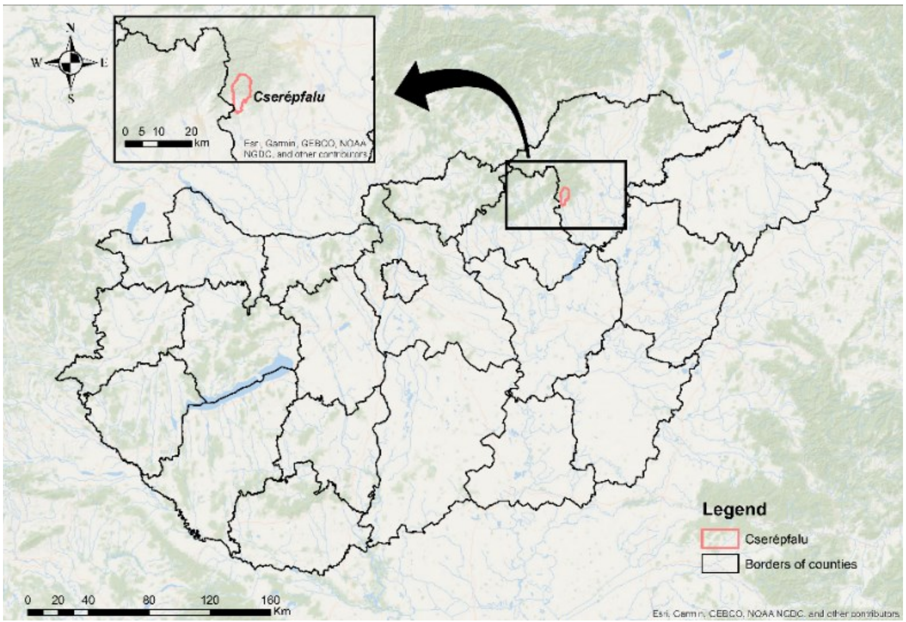

Fig.1 The location of the study area, Cserépfalu

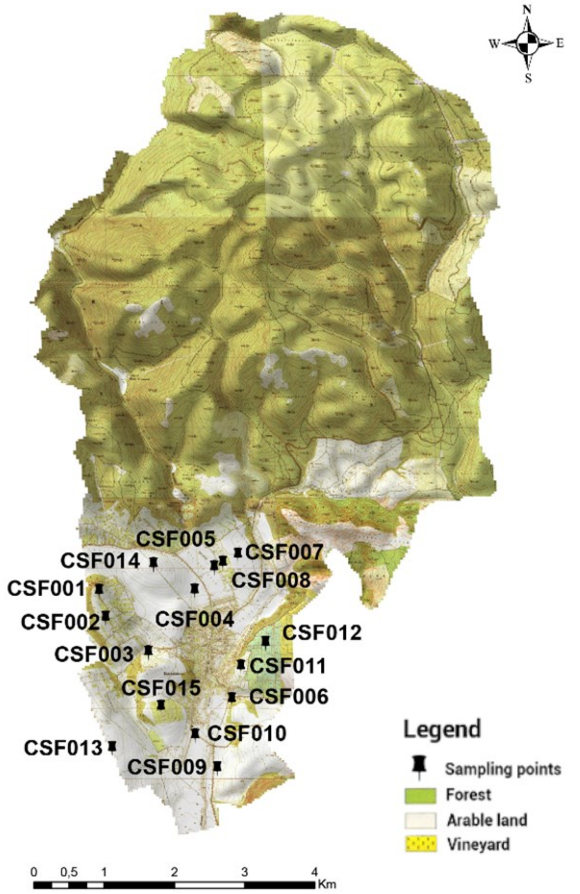

Fig.2 The location of the soil profiles investigated in Cserépfalu

humous soil layer in % relative to the thickness of the investigated soil profile, and by using a table where the category of erosion degree was given (Kerényi, 1991; Kerényi and Martonné, 1994; Novák, 2013). The land cover categories were described on the one hand based on field observations (Novák, 2013) and, on the other hand, the previous conditions were described on the basis of 1:10,000 topographic maps from 1990 (Cartography, 1990). The tabular categories of Karancsi (2001) and Csorba et al. (2018) were used to detect the extent of anthropogenic effects (hemeroby levels). The maps presented in Figure 1 and 2 were created using ArcGIS 10.4.1 for Desktop.

RESULTS

Soil types, morphological and geological data

During our research, the 15 investigated soil profiles were selected in places with diverse morphological, geological and soil conditions in Cserépfalu, taking into account the different appearance of land use types (Fig. 2).

Table 1 shows where 15 soil profiles were excavated in the settlement. The soil profiles examined were located in 40% on hilltops/crest, 13% on middle sections of slopes, 7% on valley bottom, 33% on alluvium and 7% on lower slopes (Table 1). In the hilltop/crest category, older, younger foothill surfaces and fluvial terrace levels also appeared. The bedrock of the soil profiles is 40% rhyolite tuffs (volcanic rock) and 60% clay; clay, gravel, pebble; clay and pebble or clay and gravel (sedimentary rock). The WRB reference group (FAO, 2006) and the definitions of main soil type, soil type and soil subtype based on the Hungarian Soil Classification System (Murányi et al., 1989; Novák, 2013) were summarized in Table 3.

The WRB reference groups for the soil profiles excavated in our study area were varied (Fig. 3). According to the fluvial and hilly character of the area, most soils were classified into the category of Fluvisols and Cambisols category. In addition, the following types were discovered: Leptosols, Umbrisols, Regosols, Antrosols and Luvisols (Dobos et al, 2014). The analyses of WRB reference group and soil types was based on the following characters: depth and name of genetical soil horizons, horizon boundary, soil colour (Munsell), texture, soil structure, pH and $CaCO_3$-content (Table 2).

Taking into account the Hungarian soil classification (Stefanovits, 1981; Novák, 2013) it can be stated that the main soil types indicated Stony soils (20%), casting and Alluvial and Slope soils indicating the legacy of fluvial surface formation (40%), Anthropogenic soils indicating anthropogenic effects (7%) and Brown forest soils (33%) indicating earlier significant forest cover values in the fragmented hilly (foothill) area (Table 3). The classic soil classification system from Stefanovits (1981) did not condider Anthropogenic soils, and here we used Novák's book to define these soils.

At the level of soil types, Rocky soils here were represented by Erubase and ranker soils (20%). Among the Alluvial and Slope soils, Humous alluvial soils (33%) and Slope soils (6%) can be detected in the soil profiles. The soil profile excavated on the built area indicates the presence of Anthropogenic soils (7%) and anthropogenic influences. Among the Brown forest soils, the Brown forest soil with clay illuviation (7%) and the Ramann brown forest soil (27%) appeared in the area. At the level of pedological subtypes, Erubase soils indicate the volcanic origin of rhyolite tuffs. The Meadow humous alluvial soils, the humous alluvial soils and the slope soils of the Forest refer to the relief of the hilly area divided by valleys on the one hand, and the nature of the former land cover on the other. Brown forest soils are represented by Non-podzolic brown forest soils and Ramann brown forest soils with calcareous character.

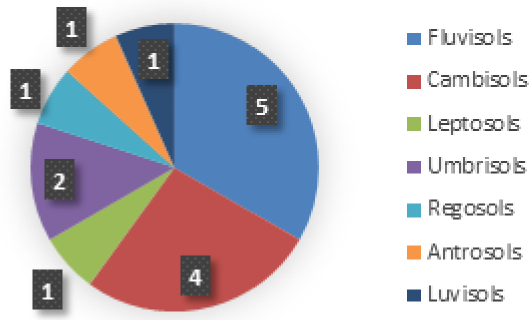

Fig.3 The distribution of WRB reference groups in case of investigated soil profiles in Cserépfalu. The numbers in the figure represent the number of soil types described.

Table 1 Topographical, geological and relief data of investigated soil profiles in Cserépfalu

Code for soil profile	Topographical situation	Relief	Slope category (%)	Baserock	Coordinates
CSF001	the summit of Nyomó Hill	the crest of the hill (older pediment surface)	5-12%	rhyolite tuff	N 47°57'0.96" E 20°31'0.68"
CSF002	Nyomó Hill, the middle southern slope	middle slope	12-17%	rhyolite tuff	N 47°56'49'0.9" E 20°31'4,76"
CSF003	valley bottom between the Nyomó Hill and the Őr Hill	valley bottom	5-12%	weathered rhyolite tuff	N 47°56'34.45" E 20°31'27.82"
CSF004	alluvium of the Hór stream at the southeastern rim of the Kerek Hill	alluvium	5-12%	clay, gravel, pubble	N 47°57'0.85" E 20°31'59.14"
CSF005	the lower part of western slope in the Ispán-szél	lower slope	5-12%	clay	N 47°57'14.77" E 20°32'13.65"
CSF006	the rim of alluvium of the Hór stream, at the southeastern boundary of Cserépfalu	alluvium	0-5%	clay, gravel	N 47°56'10.90" E 20°32'15.13"
CSF007	the area of the summit of Ispán-szél	the crest of the hill (younger pediment)	0-5%	clay, pebble	N 47°57'16.69" E 20°32'19.51"
CSF008	alluvium of the Hór stream, next to the bed channel	alluvium	0-5%	clay, pebble	N 47°57'11.90" E 20°32'10.68"
CSF009	the rim of the Hór stream, Alsó-rét	alluvium	5-12%	clay, gravel	N 47°55'39.86" E 20°32'4.10"
CSF010	the rim of alluvium of the Hór stream, Alsó-rét	alluvium	5-12%	pebble, gravel, silty clay	N 47°55'54.57" E 20°31'52.42"
CSF011	the middle western slope in Galagonyás	the middle slope (younger pediment)	5-12%	sand, weathered rhyolite tuff	N 47°56'30.83" E 20°32'27.69"
CSF012	the summit of the Galagonyás	the crest of the hill (younger pediment)	5-12%	rhyolite tuff	N 47°56'36.16" E 20°32'40.14"
CSF013	the summit of the Gyűr Hill	the crest of the hill	5-12%	clay	N 47°55'46.70" E 20°31'3.04"
CSF014	the summit of the Kerek Hill	the crest of the hill (younger pediment)	0-5%	weathered rhyolite tuff	N 47°57'12.68" E 20°31'36.30"
CSF015	the summit of the Csurdoka	the crest	0-5%	clay	N 47°56'6.95" E 20°31'36.80"

Results of the rate of soil erosion

For the excavated soil profiles, the relationship between slope angle, expected risk of erosion and the degree of soil erosion that can actually be detected was examined (Table 4).

Based on the degree of erosion risk associated with the slope value (Table 4, Fig. 4), it can be shown that 7% of the soil profiles examined are medium or high; 60% have a small to medium risk of erosion. For 33% of soil profiles, there was no detectable risk of erosion.

In fact, sheet erosion can be detected in the surroundings of the 15 investigated soil profiles. Accelerated soil erosion can be caused by improper land use, improper treatment and cultivation techniques, overgrazing or destruction of natural vegetation (Novák, 2013). In addition, soil erosion can be caused by water and wind erosion, sediment accumulation and mass movements. The evaluation of sheet erosion was given by expressing the thickness of the humous soil layer as % of the thickness of the investigated soil profiles (Kerényi, 1991; Kerényi and Martonné, 1994; Novák, 2013). Of the 15 soil profiles, 20% had strongly eroded soils and 53% had moderately eroded soils. However, 27 % of soil profiles showed accumulation trends (Table 3, Fig. 5). If we compare Figures 4 and 5, it can be seen that the actual erosion rate for steeper slopes exceeded the amount of erosion that can occur associated with slope angle. This is especially striking for the category of strongly eroded soils. 60% of the soil profiles examined can be considered inherently small to medium erosion hazards and 33% are erosion-free areas based on only slope angle.

When examining soil erosion, on the one hand, the degree of erosion risk associated with the slope value was given taking into account the slope angle (Várallyay and Fórizs, 1966), and on the other hand, a specific soil erosion rate was calculated for specific soil profiles (Kerényi, 1991; Kerényi and Martonné, 1994; Novák, 2013). Based on our results, the actual erosion rate of steeper slopes exceeded the amount of erosion associated with slope angle. This was particularly marked for the category of heavily eroded soils, with a value of +13%. In reality, the actual erosion rates of moderately eroded and non-eroded soil profiles were lower with values of 7% and 6% in 2014 and 2023.

In the administrative area of Cserépfalu, we can usually find moderately eroded hilltops, in one case (CS014) the summit level was strongly eroded (Table 4). Floodplains show the accumulative tendencies of landforms due to sediment accumulation during the Pleistocene and Holocene period. The soil profiles of CSF003 and CSF004 each show a soil profile in the

Table 2 Results of the soil description in Cserépfalu

Horizon	Depth [cm]	pH	$CaCO_3$ [%]	Soil colour (Munsell)	Horizon	Depth [cm]	pH	$CaCO_3$ [%]	Soil colour (Munsell)
CSF001					CSF002				
A	0-20	7	0	10YR 3/4	A	0-60	6	0-2	10YR 4/3
(C)	20 -			10YR 6/2 - 10YR 5/3	B	60-83	6,5	0	10YR 5/4
					BC	83-100	7	0	10YR 5/6
					C	100 -			
CSF003					CSF004				
A1	0-30	7	0-2	10YR 3/4	A1	0-30	7	0-2	10YR 4/4
A2	30-52	7	0-2	10YR 4/2	A2	30-100	7	0-2	10YR 3/6
B1	52-109	6	0-2	10YR 4/4	B1	100-120	7	0-2	10YR 5/4
B2	109-150	7	0-	10YR 5/4	B2	120-160	7	0-2	10YR 5/4
C	180 -	7	0-2	10YR 5/4 - 10YR 6/4	BC	160-183	6	0-2	10YR 5/4
					C	183 -			
CSF005					CSF006				
A1	0-37	7	0-2	10YR 3/2	A_{gy}	0-15	7	10-25	10YR 4/2
A2	37-55	7	0-2	10YR 3/3	A	15-55	7	10-25	10YR 4/2
B1	55-107	7	0-2	10YR 3/2	B	55-110	7	10-25	10YR 4/2
B2	107-148	7	0-2	10YR 3/4	A	110-148	7	10-25	10YR 4/3
B3	148-181	7	0-2	10YR 2/2	B	148-195	7	2-10	10YR 4/3
B4	181-203	7	0-2	10YR 4/4	B	195 -	6,5	2-10	
CSF007					CSF008				
A_{sz}	0-16	7	0	10YR 3/2	A_{akk1}	0-23	8	10-25	10YR 4/6
A	16-34	7	0-2	10YR 3/3	A_{akk2}	23-60	8	10-25	10YR 4/6
B	34-72	7	0-2	10YR 3/3	A1	60-80	8	2-10	10YR 3/4
BC	72-108	7	0-2	10YR 3/4	A2	80-105	8	2-10	10YR 3/6
					B	105-135	8	2-10	10YR 4/3
					C	135-155	8		10YR 3/4
CSF009					CSF010				
A_{akk}	0-24	6	0-2	10YR 4/2	A_{akk1}	0-27	8		10YR 4/3
A	24-69	6	0-2	10YR 3/3	A_{akk2}	27-45	8		10YR 4/4
AB	69-94	7	0-2	10YR 3/3	A1	45-80	8		10YR 3/2
B	94-120	7	0-2	10YR 3/1	A2	80-122	8		10YR 3/1
BC	120-160	7	0-2	10YR 3/2	B1	122-155	7,5		10YR 2/1
C	160 -	7	0-2	10YR 3/3	B2	155-190	7		10YR 3/3
					C	190 -	7		10YR 3/4
CSF011					CSF012				
A	0-20	4,5	0-2	10YR 4/3	A_p	0-24	7	10-25	10YR 3/4
AB	20-26	7	0-2	10YR 4/3 - 10YR 4/4	tuff-rubble	24-40	7	10-25	10YR 4/3
B1	26-37	7	0-2	10YR 5/3	A	40-60	7	0	10YR 4/2
B2	37-68	7	0-2	10YR 6/3	AC	60-92	7	0	10YR 4/2
B3	68-92	7	0-2	10YR 5/3	C	92 -		0	
B4	92-130	8	0-2	10YR 5/2					
BC	130-166	8	10-25	10YR 4/2					
CSF013					CSF014				
A_p	0-20	7	0	10YR 3/2	A_p	0-22	7	-	10YR 3/3
A1	20-60	7	0-2	10YR 3/3	A	20-60	6	0-2	10YR 3/4
A2	60-120	7	2-10	10YR 3/2	AB	60-120	7	0-2	10YR 3/4
B1	120-150	7	2-10	10YR 4/3	B1	120-150	8	10-25	10YR 5/4
B2	150-175	8	10-25	10YR 5/6	B2	122-146	8	>25	10YR 5/4
C	175-205	8	>25	2.5 YR 4/8, 10 YR 6/3,10 YR 8/2	B3	146-190	8	2-10	10YR 6/2
					C	190 -			
CSF015									
A_p	0-18	8	2-10	10YR 3/2					
A	18-61	8	2-10	10YR 4/2					
B	61-121	8	>25	10 YR 8/1, 10 YR 4/6, 2.5 Y 7/1					
C	121-135	8	>25	2.5 Y 7/1					

vicinity of which strongly or moderately eroded soils can be detected on the valley floor or alluvium. This trend can be explained by earlier cuts in the stream bed and by the higher intensity of stream erosion.

Results of investigated land cover / land use categories

The land use and land cover categories recognizable in the surroundings of the soil profiles were described on the basis of the 1:10,000 topographic map of 1990 and the FAO category system (FAO, 2006) in 2014 and 2023. In 1990, more active land cultivation was typical in the surroundings of the soil profiles. The environment of the soil profiles was characterised mainly by cultivated arable land (80%) and vineyards (20%) (Fig. 6).

During the soil description period (2014) and 2023, we were able to register abandoned areas and arable lands mainly in our study area (Fig. 7). If we compare the data in Figures 6 and 7, we can see that the share of arable land decreased from 80 % to 46 % over 24 years. The share of vineyards has also decreased. Land use became more diverse, but a smaller proportion of areas were under continuous agricultural cultivation. Abandoned areas (40%) and mowed meadows (7%) also appeared. Thus,

Table 3 The classification of genetic soil types based on FAO and Hungarian soil classification systems in case of surveyed soil profiles in Cserépfalu (Dobos et al., 2014.)

Code for soil profile CSERÉPFALU (CSF)	WRB Reference group (FAO, 2006)	Main soil type	Soil type	Soil subtype	The rate of soil erosion (Kerényi, 1991; Kerényi and Martonné, 1994; Novák, 2013)
		based on Hungarian Soil Classification System (Murányi et al., 1989; Novák, 2013)			
CSF001	Leptosols	Stony soils	Erubase and ranker soils	Erubase soil	moderately eroded
CSF002	Umbrisols	Stony soils	Erubase and ranker soils	Erubse soil	moderately eroded
CSF003	Fluvisols	Alluvial and slope soils	Humous alluvial soils	Meadow humous alluvial soils	strongly eroded
CSF004	Fluvisols	Alluvial and slope soils	Humous alluvial soils	Meadow humous alluvial soils	moderately eroded
CSF005	Regosols	Alluvial and slope soils	Slope soils	Forest's slope soils	moderately eroded
CSF006	Antrosols	Anthropogen soils	Anthropogen soils		accumulated
CSF007	Luvisols	Brown forest soils	Brown forest soils with clay illuviation	Non-podzolic brown forest soils with clay illuviation	moderately eroded
CSF008	Fluvisols	Alluvial and slope soils	Humous alluvial soils	Meadow humous alluvial soils	accumulated
CSF009	Fluvisols	Alluvial and slope soils	Humous alluvial soils	Humous alluvial soil	accumulated
CSF010	Fluvisols	Alluvial and slope soils	Humous alluvial soils	Meadow humous alluvial soil	accumulated
CSF011	Cambisols	Brown forest soils	Ramann brown forest soils	Ramann brown forest soil	strongly eroded
CSF012	Umbrisols	Stony soils	Erubase and ranker soils	Erubase soil	moderately eroded
CSF013	Cambisols	Brown forest soils	Ramann brown forest soils	Ramann brown forest soil	moderately eroded
CSF014	Cambisols	Brown forest soils	Ramann brown forest soils	Ramann brown forest soil	strongly eroded
CSF015	Cambisols	Brown forest soils	Ramann brown forest soils	Ramann brown forest soil	moderately eroded

the land cultivation intensity of the examined areas has changed.

The results of the land cover/land use categories in the surroundings of the investigated soil profiles show the emergence of a more diverse and fragmented landscape in 2014 and 2023 compared to 1990. At the same time, it is interesting that the land cultivation intensity of the examined areas has changed, as the share of arable land decreased by 34%, while the share of vineyards decreased by 13%. Today, 47% of the soil profiles examined are abandoned areas or mowing meadows.

Results of investigated hemeroby levels

In the surroundings of the excavated soil profiles, the hemeroby level, i.e. the strength of the landscaping effect of human activity, was determined by Karancsi (2001) and the categories of the National Atlas of Hungary (Csorba et al., 2018; Kocsis, 2018) (Table 5).

In 1990, β-euhemerobic level (cultivated area) can still be detected in the surroundings of 13 soil profiles, while α-euhemerobic level (intensively cultivated area) can be detected in the surroundings of 2 soil profiles (Fig. 8).

By 2014, the situation had changed (Fig. 9). In parallel with the land cover values, it can be observed that in the surroundings of 6 soil profiles previously showing β-euhemerobic level, cultivation was abandoned and abandoned areas were formed, while in 2 cases a category decrease can be registered and in the surroundings of one profile, in addition to the cultivated area (β-euhemerobic level), we were able to detect the intensively cultivated α-euhemerobic level by planting vines. There were no major changes between 2014 and 2023. Overall, by 2014 and 2023, former cultivated areas were abandoned in more places, thus the intensity of anthropogenic influences has decreased in agricultural areas in Cserépfalu (Fig. 9).

DISCUSSION

Previous research results showed that anthropogenic impacts on the landscape have generally increased in Hungary due to the increasing extent of agricultural areas on the one hand and built-up areas on the other (Csorba et al., 2018; Kocsis, 2018). Our research results also showed these tendencies in the field of Cserépfalu in the research based on landscape history. According to the land use results covering the whole area of the settlement, the hemeroby level increased in the Bükkalja micro-landscape unit of the settlement until 2012 compared to previous historical centuries, and the degree of landscape fragmentation also increased (Dobos and Utasi, 2022). The number of landscape patches has also been steadily increasing over the past 250 years.

At the same time, the results of soil profiles analyse comparing several years of data and other landscape factors at settlement level already support the results of Szilassi and Bata (2019), because from 2014 they indicate a decrease in the hemeroby level in the settlement. The

Table 4 The parameters of slope angle, the risk of erosion and the actual soil erosion in excavated soil profiles in Cserépfalu.

Code for soil profile	Slope angle (%)	The rate of soil erosion risk based on slope angles (Várallyay and Fórizs, 1966)	The rate of soil erosion based on actual investigation of soil profile	Relief, slope position
CSF001	5-12%	small, medium	moderately eroded	crest
CSF002	12-17%	medium, high	moderately eroded	middle slope
CSF003	5-12%	small, medium	strongly eroded	valley base
CSF004	5-12%	small, medium	moderately eroded	alluvium
CSF005	5-12%	small, medium	moderately eroded	lower slope
CSF006	0-5%	No	accumulated	alluvium
CSF007	0-5%	No	moderately eroded	crest
CSF008	0-5%	No	accumulated	alluvium
CSF009	5-12%	small, medium	accumulated	alluvium
CSF010	5-12%	small, medium	accumulated	alluvium
CSF011	5-12%	small, medium	strongly eroded	middle slope
CSF012	5-12%	small, medium	moderately eroded	crest
CSF013	5-12%	small, medium	moderately eroded	crest
CSF014	0-5%	No	strongly eroded	crest
CSF015	0-5%	No	moderately eroded	crest

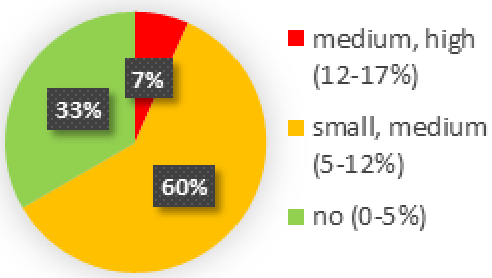

Fig.4 The rate of soil erosion risk based on slope steepness in case of the investigated soil profiles.

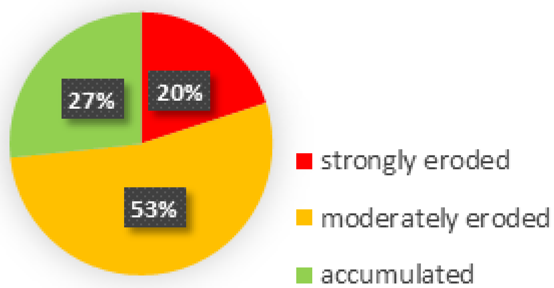

Fig.5 The de facto pointed out soil erosion rate in the investigated soil profiles.

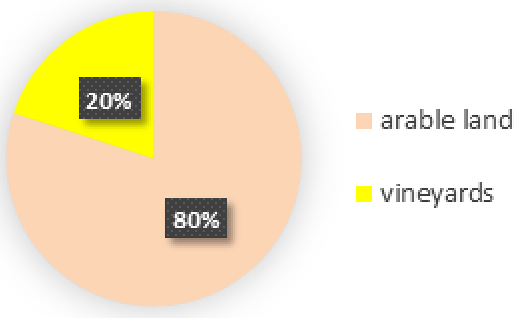

Fig.6 The land cover categories showned by surroundings of investigated soil profiles in Cserépfalun in 1990.

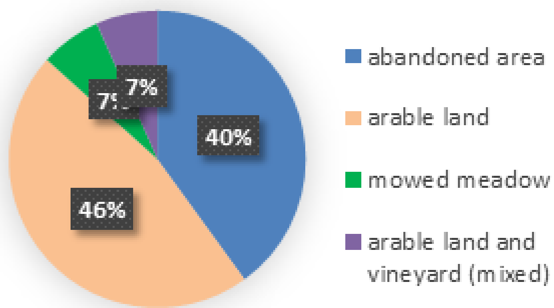

Fig.7 The land cover categories showned by surroundings of investigated soil profiles in Cserépfalun in 2014 and 2023.

differences observed can also be explained by the fact that our designated soil profiles provide data around a given point, and do not examine individual factors based on complete area coverage. We agree that land cover and soil condition (soil erosion) can be good indicators for examining the degree of anthropogenic transformation (Novák and Incze, 2018; Novák et al., 2019).

The degree of hemeroby level detectable on the basis of land cover usually yields results that are well suited for national, large, meso or micro-landscape unit examinations.

Table 5 Determination of genetic soil types in case of investigated soil profiles in Cserépfalu; the former (1990) and actual (2014, 2023) land cover categories and hemeroby levels in surroundings of investigated soil profiles.

Code for soil profile (CSF)	WRB Reference group (FAO, 2006)	Soil Subtype based on Hungarian Soil Classification System (Novák, 2013)	Former land cover category (1990)	Land cover category in 2014 and 2023	Degree of hemeroby – former (1990)	Degree of hemeroby in 2014 and 2023
CSF001	Leptosols	Erubase soil	arable land	abandoned area	β-euhemerobic	-
CSF002	Umbrisols	Erubase soil	vine-yard	arable land, fresh arable land	α-euhemerobic	β-euhemerobic
CSF003	Fluvisols	Meadow humous alluvial soil	arable land	abandoned area	β-euhemerobic	-
CSF004	Fluvisols	Meadow humosu alluvial soil	arable land	arable land (maize)	β-euhemerobic	β-euhemerobic
CSF005	Regosols	Forest soils, Slope soil	arable land	abandoned area	β-euhemerobic	-
CSF006	Antrosols		arable land	abandoned area	β-euhemerobic	-
CSF007	Luvisols	Non-podzolic brown forest soils with clay illuviation	arable land	abandoned area	β-euhemerobic	-
CSF008	Fluvisols	Meadow humuos alluvial soil	arable land	mowed meadow	β-euhemerobic	mezohemerobic
CSF009	Fluvisols	Humous alluvial soil	arable land	arable land (maize)	β-euhemerobic	β-euhemerobic
CSF010	Fluvisols	Meadow humous alluvial soil	arable land	arable land (wheat)	β-euhemerobic	β-euhemerobic
CSF011	Cambisols	Ramann brown forest soil	arable land	abandoned area: shrubs, grassy land	β-euhemerobic	-
CSF012	Umbrisols	Erubase soil	vine-yard	arable land	α-euhemerobic	β-euhemerobic
CSF013	Cambisols	Ramann brown forest soil	arable land	arable land (wheat)	β-euhemerobic	β-euhemerobic
CSF014	Cambisols	Ramann brown forest soil	arable land	arable land (maize)	β-euhemerobic	β-euhemerobic
CSF015	Cambisols	Ramann brown forest soil	vine-yard	arable land: wheat and vineyard	α-euhemerobic	β-euhemerobic and α-euhemerobic

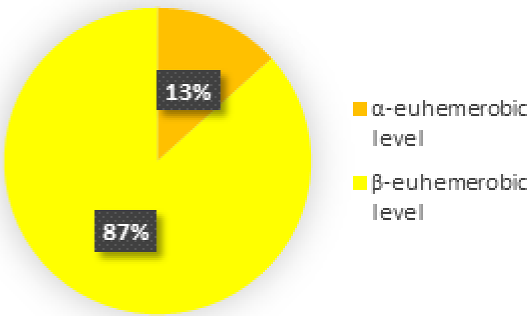

Fig.8 The hemeroby levels pointed out in the surroundings of the investigated soil profiles in Cserépfalu in 1990

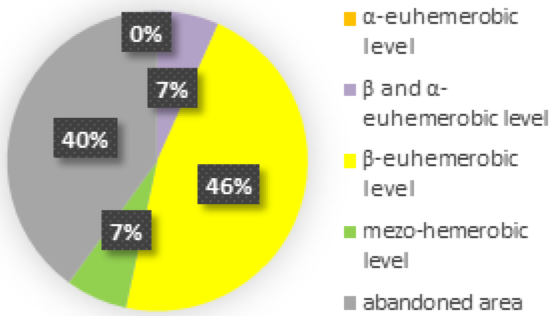

Fig.9 The hemeroby levels pointed out in the surroundings of the investigated soil profiles in Cserépfalu in 2014 and 2023

These studies are generally based on processing the CORINE database. Our research results show that only these data are less applicable at settlement level, even though the basic economic planning level is of settlement character.

Our results reflect that when processing a specific, smaller study area, other local landscape factors have a more significant influence on the research results. In the case of smaller-scale processing, we cannot ignore the mechanism of influence between certain geological, relief and pedological conditions, the farming methods affecting the area and their consequences.

The results of our present study have produced gap-filling results in more detailed, 1:10 000 scale investigations. The practical agricultural soil knowledge map of Cserépfalu was completed in 1961 (Grúz, 1961). The soil description carried out with FAO's international soil description method in the case of Cserépfalu based on the analysis of 15 soil profiles yielded new results and indicated the diverse soil conditions compared to the previously explored Brown forest soils. When presenting soil erosion trends, several geological and topographical parameters were included in the analysis. As we used the new soil description method, we were able to collect data on the spatial distribution of land cover/land use categories and we were able to compare this with the previous conditions from 1990 (Cartography, 1990). In parallel with the land cover values, the hemeroby levels also decreased, on the one hand cultivation was abandoned in the surroundings of several soil profiles showing β-euhemerobic levels, and on the other hand a category decrease could be detected in the surroundings of 2 soil profiles. The intensity of anthropogenic influences has decreased nowadays in agricultural areas in Cserépfalu.

It is difficult to compare our results with other Hungarian settlements, because such results have not yet been obtained using a new soil description method. Our results provide good data for editing hemeroby maps and environmental management maps, which can be used well in regional planning and can improve the practice of landscape design based on local conditions (Csorba, 1995).

CONCLUSIONS

The aim of this article was to examine the relationship between soil erosion, land cover and hemeroby levels in the area of Cserépfalu, a settlement in northern Hungary. During our research, we chose such a method that made it possible to classify 15 soil profiles based on international and national soil classification system, to explore more soil types compared to previous results, and to describe more detailed data about the soil profiles. Anthropogenic soils were also detected in the plot. More detailed results show that the geomorphological position of soil profiles, slope position and past and present land use categories strongly influenced the rate of soil erosion risk. The complete exploration of the soil properties in soil profiles showed that the actual soil erosion rate is usually one half or one category higher than the degree of soil erosion risk adjusted to the slope angle value. We could not show a strong relationship between soil erosion and land cover and hemeroby levels. The greatest soil erosion was detected at valley bottom (CSF 003, 5-12%), younger foothill slope (CSF 011, 5-12%) and at summit level (CSF 014, 0-5%). In the first two cases, abandonment of arable land was recorded, while in the last area arable cultivation was continuous. Moderate soil erosion was shown by abandoned arable land and vineyards. We have seen accumulation in continuous arable and viticultural cultivation, or in abandoned fields. The extent of soil erosion was greatly influenced by previous geomorphological processes and applications of previous land-use categories. However, a closer relationship was found between land cover/land use and hemeroby levels. In continuous arable cultivation, a change in β-euhemerobic level (α - β-euhemerobic level or β-euhemerobic level - mesohemerobic level) can be observed when a vineyards become arable land or mowed meadow. The proportion of abandoned vineyards and arable land was 40%, where a decrease in α and β-euhemerobic levels was detected. Until 2012, the hemeroby level in Cserépfalu was continuously increasing in the settlement, and as you can see, after 2012 the hemeroby level decreased until 2023.

Our research results and method can be applied in foothill areas of similar character, in settlement-level surveys, in extensive or intensive agricultural areas, where soil data are available with the new FAO survey.

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REFERENCES

ArcGIS World Ocean Base (https://www.arcgis.com/home/item.html?id=1e126e7520f9466c9ca28b8f28b5e500) Magyarország topográfiai térképe

Ángyán, J. 2003. The location of the territories in Hungary in Scale of Environmental Sensitivity and Agricultural activity. (Map, M=1:2 000 000) In: Ángyán, J. (ed.): A környezet- és tájgazdálkodás agroökológiai, földhasználati alapozása. (Magyarország integrált földhasználati zónarendszerének kialakítása). MTA Doctoral Thesis, Gödöllő, 58. p. (in Hungarian)

Balogh, K. 1964. Geological formations of the Bükk Mountains. A Magyar Állami Földtani Intézet Évkönyve 48. 2. 245-719. (in Hungarian)

Bastian, O., Schreiber, F. 1994. Analyse und ökologische Bewertung der Landschaft. Fischer, Jena, Stuttgart, 564 p.

Bornkamm, R. 1980. Hemerobie und Landschaftplanung. *Landschaft+Stadt* 12(2), 49–55.

Csorba, P. 1995. Comparison of the landscape ecological structure and geomorphological conditions of Tokaj-Hegyalja. *Földrajzi Értesítő* 64 (1-2), 39–51. (in Hungarian)

Csorba, P. (ed.) 2018. Landscapes. In: Kocsis, K. (ed.) Magyarország Nemzeti Atlasza – Természeti környezet. Magyar Tudományos Akadémia, Csillagászati és Földtudományi Kutatóközpont, Földrajztudományi Intézet, Budapest, 112–129. (in Hungarian)

Csorba, P. 2021. Bükk. Bükkalja. In: Csorba, P. (ed.) Magyarország kistájai. Meridián Táj- és Környezetföldrajzi Alapítvány, Debrecen, 368–371. (in Hungarian)

Csorba, P., Szabó, Sz. 2009. Degree of human transformation of landscapes: a case study from Hungary. *Hungarian Geographical Bulletin* 58(2), 91–99.

Dobos, A. 2000. Development history and landscape analysis of the Hór Valley from a nature conservation point of view. PhD doctoral thesis, Annex. I-II., Debreceni Egyetem, Alkalmazott Tájföldrajzi Tanszék, Debrecen, 119 p. (in Hungarian)

Dobos, A. 2002. A Bükkalja II. Surface morphological description. In: Baráz, Cs. (ed.): A Bükki Nemzeti Park. hegyek, erdők, emberek. Bükki Nemzeti Park Igazgatósága, Eger, 217–228. (in Hungarian)

Dobos, A. 2012a. Reconstruction of Quaternary landscape development with geomorphological mapping and analysing of sediments in the Cserépfalu Basin (the Bükk Mts., Hungary). *Geomorphologica Slovaca et Bohemica* 2012(1), 7-22.

Dobos, A. 2012b. The most significant historical monuments of Cserépfalu, the changes of the land-use system of the settlement from the eighteenth century to the present day. In: Füleky, Gy. (ed.): A táj változásai a Kárpát-medencében: Történelmi emlékek a tájban. IX. Tájtörténeti konferencia kiadványa, Balaton Múzeum, Gödöllő, Környezetkímélő Agrokémiáért Alapítvány, 89–94. (in Hungarian)

Dobos, A., Hegyi, B., Hegyi, P. T., Zelei, Z., Daragó, G., Tari, G. 2014: Soil Science Subproject. Cserépfalu (CSF001 – CSF015). Kutatási Jelentés (Scientific Report), Kézirat, Eszterházy Károly Egyetem, Környezettudományi és Tájökológiai Tanszék, Eger, 224 p. (in Hungarian)

Dobos, A. 2017. Talajok – Soils. In: Dobos, A., Mika, J. (eds.): Természeti és kultúrtörténeti értékek Eger térségében. Natural and Cultural Heritage in the Eger Region. Líceum Kiadó, Eger, 32–37.

Dobos, A. 2018. Examining the role of unique landscape values of natural and cultural history in development plans based on the example of a settlement in Bükkalja. In: Fazekas, I., Kiss, E., Lázár, I. (eds.): Földrajzi Tanulmányok 2018. MTA DAB

Földtudományi Szakbizottság, Debrecen, 275–278. (in Hungarian)

Dobos, A., Utasi, Z. 2022. Landscape use changes of three Bükk Valley settlements (Cserépfalu – Egerszólát – Kerecsend) and the extent of anthropogenic influences between 1763 and 2012. In: Kis, E., Balla, D. (eds.) (2022): Tájökológiai kihívások, adaptációs lehetőségek, MTA DTB Földtudományi Szakbizottság, Debrecen, 138–144. (in Hungarian)

EEA, 2000. CORINE Land Cover Technical Guide. Addendum, EEA, Copenhagen, 105 p.

FAO, 2006. *Guidelines for Soil Description.* Fourth Edition. Food and Agriculture Organization of the United Nations, Rome, 97 p.

Fushita, A.T., dos Santos, J.E., Rocha, Y.T., Zanin, E.M. 2017. Historical Land Use/Cover Changes and the Hemeroby Levels of a Bio-Cultural Landscape: Past, Present and Future. *Journal of Geographic Information System*, 9, 576–590. DOI: https://doi.org/10.4236/jgis.2017.95036

Gabherr, G., Koch, G., Kirchmeier, H. 1998. Hemerobie Hemerobie österreichischer WaldÖkosysteme. Veröff entlichtungen des Österreichischen MaB-Programms, Bd. 17. Universitätsverlag Wagner, Innsbruck, 493 p.

Góczán, L., Kertész, Á. 1990. Results of soil erosion and surface runoff measurements on experimental plots of MTA FKI in Bakonynána. *Földrajzi Értesítő* 39(1-4), 55–69. (in Hungarian)

Grúz, M. 1961. Practical agricultural soil knowledge map of Cserépfalu. M = 1:25 000, Állami mezőgazdasági gépállomás laboratóriuma Vilmány. (in Hungarian)

Hill, M.O., Roy, D.B., Thompson, K. 2002. Hemeroby, urbanity and ruderality: Bioindicators of disturbance and human impact. *Journal of Applied Ecology* 39, 708–720. DOI: https://doi.org/10.1046/j.1365-2664.2002.00746.x

Huszár, T. 1999. Estimation of soil erosion using the EPIC-ERATOPE method. *Földrajzi Értesítő* 68(1-2), 189-198. (in Hungarian)

IUSS Working Group WRB 2015. World Reference Base for Soil Resources 2014, Update 2015. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps. World Soil Resources Reports No. 106, FAO, Rome.

Jakab, G., Kertész, Á., Papp, S. 2005. Investigation of gully erosion in the catchment area of Tetves Stream. *Földrajzi Értesítő*, 54(1-2), 149–165. (in Hungarian)

Jalas, J. 1955. Hemerobe und hemerochore Pflanzenarten. Ein terminologischer Reformversuch. *Acta Societalis – Fauna Flora Fennica* 72, 1–15.

Karancsi, Z. 2001. Assessment of anthropogenic impacts on the natural environment of the Medves region. In: Dormány, G.*, Kovács, F., Péti, M., Rakonczay, J. (eds.): A földrajz eredményei az új évezred küszöbén. Magyar Földrajzi Konferencia,* Szeged, 2001. október 25-27, Szeged, SZTE TTK Természeti Földrajzi Tanszék, 10. p. (in Hungarian)

Kartográfia, 1990. Cserépfalu M = 1:10 000 topographic maps. FÖMI, Budapest.

Kerényi, A. 1985. Field soil erosion experiments in Tokaj-Hegyalja. *Agrokémia és Talajtan*. 34*(*1-2), 367–397. (in Hungarian)

Kerényi, A., Justyák, J. 1987. Gelandeklimatologische Untersuchungen im Raum von Cserépfalu. *Acta Geographica Debrecina Landscape and Environment*, 245–264.

Kerényi, A., Martonné, E. K. 1994. Soil Exercises. KLTE, Debrecen, 90 p. (in Hungarian)

Kerényi A., Pásztor A. 1994. Changes in the area and time of nitrate content in groundwater on the example of the village of Bükkalja. *Földrajzi Közlemények*, 118(42), 113–120. (in Hungarian)

Kerényi, A. 1991. Soil erosion: mapping, laboratory and field experiments. (Talajerózió. Térképezés, laboratóriumi és szabadföldi kísérletek), Akadémiai Kiadó, Budapest, 219 p. (in Hungarian)

Kertész, Á. 1984. The subject and methods of experimental geomorphology. *Földrajzi Értesítő*, *33.* 37–45. (in Hungarian)

Kertész, Á. 1987. Möglichkeiten des Einsatzes von Mikrocomputern zur Erstellung von Landschafts-In-formationssystemen. Wissenschaftliche Mitteilungen, Leipzig, 22. 219–229.

Kertész, Á. 1992. Modern research methods of physical geography at MTA FKI. Experiments, measurements in the field - process studies - modeling, computer methods. *Földrajzi Értesítő* 61(1-4), 83–90. (in Hungarian)

Kertész, Á. 2004. Soil erosion and mass movement processes on the loess covered areas of Hungary. *Geographical Bulletin* 53(1-2), 13–20.

Kertész, Á. 2009. Environmental condition of gully erosion in Hungary. *Hungarian Geographical Bulletin* 58(2), 79–89.

Kitka, G., Farsang, A., Barta, K. 2008. Examining the speed of current soil erosion processes in the light of previous land-use scenarios: a case study in a small catchment under agricultural use. In: Kiss, T., Mezősi, G. (eds.): Recens geomorfológiai folyamatok sebessége Magyarországon. Szegedi Egyetemi Kiadó – Juhász Gyula Felsőoktatási Kiadó, Szeged, 97–109. (in Hungarian)

Kocsis, K. (ed.) 2018. National Atlas of Hungary. Natural Environment. Magyar Tudományos Akadémia, Csillagászati és Földtudományi Kutatóközpont, Földrajztudományi Intézet, Budapest. (in Hungarian)

Liska, Cs.M., Mucsi, L., Henits, L. 2017. Investigation of long-term land cover changes in Csongrád county using time series data, using the Random Forest method. *Földrajzi Közlemények* 141(1), 71–83. (in Hungarian)

Lovász, Gy. 2000. Study of quantitative parameters of anthropogenic accumulation in the South Baranya Hills. *Földrajzi Értesítő* 69(1-2), 5–12. (in Hungarian)

Machado, A. 2004. An index of naturalness. *Journal for Nature Conservation* 12, 95–110. DOI: https://doi.org/10.1016/j.jnc.2003.12.002

Manaljav, S., Farsang, A., Barta, K., Tobak, Z., Juhász, Sz., Balling, P., Babcsányi, I. 2021. The Impact of Soil Erosion on the Spatial Distribution of Soil Characteristics and Potentially Toxic Element Contents in a Sloping Vineyard in Tállya, Ne Hungary. *Journal of Environmental Geography* 14(1-2), 47–57. DOI: https://doi.org/10.2478/jengeo-2021-0005

Marosi, S., Szilárd, J. 1963. On the principle-methodological issues of physical geographical landscape assessment. *Földrajzi Értesítő* 12. 393–417. (in Hungarian)

Mészáros, E., Jakab, G. 2001. Calculation of erodibility values based on soil properties. *Földrajzi Értesítő*, 50(1-4), 137–142. (in Hungarian)

Murányi, A., Rajkai, K., Stefanovits, P., Szűcs, L., Várallyay, Gy., Zilahy., P. 1989. Soil map. In: Pécsi, M. (ed.): *National Atlas of Hungary*. The Geographical Research Institute of the Hungarian Academy of Sciences, Budapest, 78–79.

Novák, T.J., Incze, J. 2018. Estimation of anthropogenic effects in Hungarian soils based on land cover data and WRB diagnostics. *Agrokémia és Talajtan*. 67(2), 179–197. DOI: https://doi.org/10.1556/0088.2018.00014 (in Hungarian)

Novák, T.J., Balogh, Sz., Incze, J. 2019. Spatial differences and changes in the extent of anthropogenic effects in Hungarian landscapes based on land cover and soil diagnostic data. *Földrajzi Közlemények* 143(4), 285–307. (in Hungarian) DOI: https://doi.org/10.32643/fk.143.4.1

Novák, T.J. 2013. Soil Practicality. Field study and classification of soils. Meridián Alapítvány, Debrecen, 188 p. (in Hungarian)

Pelikán, P. 2002. Geological structure, stratigraphic review. In: Baráz, Cs. (ed.): A Bükki Nemzeti Park. Hegyek, erdők, emberek. Bükki Nemzeti Park Igazgatóság, Eger, 23–49. (in Hungarian)

Pinczés, Z. 1968. Linear erosion on the loess of Tokaj Hill. *Földrajzi Közlemények* 16(2), 159–171. (in Hungarian)

Pinczés, Z., Kerényi, A., Martonné Erdős, K. 1978. The destruction of surface soil layer in the Bodrogkeresztúr half-basin. KLTE, *Acta Geogr., Debrecen*, 129., 210–236. (in Hungarian)

Pinczés, Z. 1979. The effect of groundfrost on soil erosion. - Colloque sur l'érosion agricole des sols en milieu tempéré non méditerranéen, Strasbourg-Colmar 20-23 Sept 1978. Strasbourg, 107–112.

Pinczés, Z. 1980. The impact of cultivation branches and methods on soil erosion. *Földrajzi Közlemények* 38(4), 357–374. (in Hungarian)

Pinczés, Z., Martonné, Erdős K., Dobos, A. 1993. Differences and similarities in the Pleistocene evolution of foothill surfaces. *Földrajzi Közlemények* 117, 61(3), 149–162. (in Hungarian)

Pinczés, Z., Martonné, Erdős K., Dobos, A. 1998. About stratified sandy-gravel (grézy litées) slope sediments. *Földrajzi Értesítő (1952-2008)* 47(1), 5–18. (in Hungarian)

Rudisser, J., Tasserc, E., Tappeiner, U. 2012. Distance to nature – A new biodiversity relevant environmental indicator set at the landscape level. *Ecological Indicators*, 15, 208–216. DOI: https://doi.org/10.1016/j.ecolind.2011.09.027

Shuttle Radar Topography Mission (SRTM) Global, Dataset Citation**:** NASA Shuttle Radar Topography Mission (SRTM) 2013. Shuttle Radar Topography Mission (SRTM) Global. Distributed by OpenTopography. DOI: https://doi.org/10.5069/G9445JDF

Stefanovits, P. 1981. Soil Science. Mezőgazdasági Kiadó, Budapest, 379 p. (in Hungarian)

Szilassi, P. 2003. Causes and consequences of land use change on the example of the Káli basin. *Földrajzi Értesítő* 52(3-4), 189–214. (in Hungarian)

Szilassi, P., Bata, T. 2012. Assessment of the naturalness of landscapes using landscape metric methods in Hungary example. In: Farsang, A., Mucsi, L., Keveiné, Bárány I. (eds.): Táj – érték, lépték, változás. SZTE TTIK Földrajzi és Földtani Tanszékcsoport, GeoLitera, Szeged, 75–-83. (in Hungarian)

Tóth, A., Szalai, Z., Jakab, G., Kertész, Á., Bádonyi, K., Mészáros, E. 2001. Modelling of soil degradation using the MEDRUSH model. *Földrajzi Értesítő* 50(1-4), 127–136. (in Hungarian)

Várallyay, Gy., Fórizs, J.-né 1966. Soil descripition on site. In: Szabolcs, I. (ed.): A genetikus üzemi talajtérképezés módszerkönyve. Országos Mezőgazdasági Minőségvizsgáló Intézet, Budapest, 19–160. (in Hungarian)

Walz, U. – Stein, C. 2014. Indicators of hemeroby for the monitoring of landscapes in Germany. *Journal of Nature Conservation*, 22. 279–289. DOI: http://dx.doi.org/10.1016/j.jnc.2014.01.007