Article

Analysis of Ownership Data from Consolidated Land Threatened by Water Erosion in the Vlára Basin, Slovakia

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Abstract: Water erosion is a phenomenon that significantly damages agricultural land. The current land fragmentation in Slovakia and the complete ambiguity of who owns it leads to a lack of responsibility to care for the land in its current condition, which could affect its sustainability in the future. The reason so much soil has eroded is obvious when looking at current land management, with large fields, a lack of windbreaks between them, and no barriers to prevent soil runoff. Land consolidation might be the solution. This paper seeks to evaluate redistributed land and, based on modeling by the Universal Soil Loss Equation (USLE) method, to assess the degree of soil erosion risk. Ownership data provided information on how many owners and what amount of area to consider, while taking into account new conditions regarding water erosion. The results indicate that 2488 plots of 1607 owners which represent 12% of the model area are still endangered by water erosion, even after the completion of the land consolidation project. The results also presented a way of evaluating the territory and aims to trigger a discussion regarding an unambiguous definition of responsibility in the relationship between owner and user.

Keywords: water erosion; erosion threat to the soil; land fragmentation; land consolidation

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1. Introduction

Soil erosion caused by water is one of the most widespread causes of soil degradation, and not just in Europe. Many authors [1,2] have written about the complete stripping of topsoil, what they consider to be a serious environmental, economic, and social problem. Only a few hundredths of a mm of new soil is created each year [3,4] and, in just a few years, all of the soil can be completely eroded away. Because of the very low rate of soil formation, annual losses greater than 1 t per ha can be considered irreversible within 50–100 years [5]. Erosion can be described as the mechanical action of moving water, wind, and other destructive forces removing the soil and transferring it elsewhere [6,7]. Soil erosion impacts all types of landscape. In most European countries, the mean erosion rate for agricultural land is greater than in forests [8].

From an agricultural perspective, soil erosion refers to the stripping of a field's surface layer by the natural physical forces of water and wind, or by forces generated by agricultural activities [5,6]. When the topsoil layer is shallow, all of the natural agricultural land can be lost. But if it is deeper, the loss of topsoil is often not visible, yet nonetheless potentially quite harmful. The main cause of soil erosion is detrimental agricultural practices [9] and ever-expanding development of agricultural land as urban areas grow [10]. Even climate change is accelerating the degradation of soil [11,12].

Universal Soil Loss Equation (USLE) [13] predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern (rainfall erosivity factor “R”), soil type

(soil erodibility factor “K”), crop system (cover management factor “C”), and erosion control practices (effectiveness against erosion factor “P”). Discussions and limitations in topographic factors have led to revision of the equation. The Revised Universal Soil Loss Equation (RUSLE) has become [14] the most common method for estimating mean annual soil loss. RUSLE is better adaptable to disintegration under new conditions and provides more profitable results than USLE [15]. The Erosion Potential Method (EPM) estimates water erosion in hydrographical river basins, taking into account topography, climate, land use, and the type of soil [16]. EPM is applied across the world and, until recently, had been tailored to edaphoclimatic conditions found in Brazil [17,18]. The Modified Universal Soil Loss Equation (MUSLE) is a method commonly used because of the easy availability of data and MUSLE’s production of meaningful results in agricultural land and reservoirs [19,20]. A review of soil erosion modelling can be found in the paper by Alewell et al. [21].

According to Eurostat [22], the annual rate of water erosion in Europe’s agricultural land, forests, and semi-natural areas averaged around 2.5 t per ha in 2016, while the annual mean rate of water erosion in agricultural areas and permanent grasslands in Europe was 3.4 t per ha. Within the European Union (EU), the countries with the highest erosion rates in agricultural areas and natural grasslands are Italy, Portugal, France, Germany, and Sweden [22] (Figure 1).

Figure 1. Estimated mean soil erosion rates in member states of European Union, 2016 [22].

The Soil Science and Conservation Research Institute (SSCRI) estimate that erosion will cost Slovakia annually 39.15% of its current agricultural land or 940,263 ha [23]. This is an enormous amount of land which, in particular, is intensively cultivated on a large scale. The eroded soil usually ends up in rivers and streams and is then transferred to reservoirs, where it settles [24,25]. The solution could be incorporated into a combination of organisational, agro-engineering, biological, and technical measures. Organisational measures include land delimitation, crop dispersion to combat erosion, and a proper determination of the size, shape, and arrangement of the land. Agro-engineering measures include contour farming and protecting the soil through no-till farming, mulching, subsoiling, stubble cleaning, and keeping any agricultural engineering to a minimum. Biological measures are

strip cropping, stabilising the strips, anti-erosion sowing, planting grass, and reforestation to protect the soil. Technical measures are ditches and terrace farming to stop erosion [26].

Act 220/2004 as amended (legislative document defining the limiting values of soil loss due to erosion in the conditions of Slovakia) [27] makes the landowners, or the tenants to whom they lease the land and thereby transfer their obligations, responsible for instituting appropriate and correct agricultural practices. Yet the question remains why visible signs of erosion—furrows, washouts and rivulets—are still encountered despite these clearly defined responsibilities (Figure 2).

Figure 2. Erosion observed in the studied area (a) Orthophoto map and the erosion details with arrows (© Eurosense, s.r.o. and GEODIS Slovakia, s.r.o.); (b) Overlay of orthophoto and land register maps after land reparcelling (ZBGIS).

The entire situation is complicated especially by Slovakia's huge fragmentation of land ownership [28]. Large land users dominate the land management and the possibilities of landowners to influence it towards a more environmentally-friendly ways are limited as well as eventual control and assessment of implementation of required measures. [29]. On average, 11 people own a single plot of land. An owner has a share in 22 land parcels, on average. There are over 100 million registered co-owners [30]. Fragmented land holding is defined as when a landholding or farm consists of a number of spatially distributed, small-area plots irregularly shaped and whose property boundaries are unclear [31]. Such fragmentation is widespread throughout Europe and agriculture takes place on such fragmented useful land. In 2010, the average size of a farm in Europe was 14.1 ha, but in countries such as Denmark and the United Kingdom this figure was over 60 ha. Italy has extensive fragmentation with farms averaging 7.9 ha in size, more than what had been recorded for agricultural land in Slovenia (6.5 ha), Croatia (5.6 ha), Greece (4.8 ha), Romania (3.4 ha), and Cyprus (3.0 ha), the lowest among all 28 EU states [32].

Several European countries have redistributed land in order to eliminate certain types of fragmentation. This was done to a large degree in Austria [33], Poland [34], Estonia [35], Germany [36], Cyprus [37], Slovenia [38], Norway [39], Denmark [40], and Finland [41]. Interest in reparcelling and consolidating land has risen in all countries for the same reasons, such as to redistribute property without changing its ownership so that owners exploit it appropriately [42].

To date, Slovakia has redistributed land in 431 of the country's 3559 cadastral districts. Currently, there are 3103 cadastral districts remaining where land needs to be consolidated and the government should be embarking over a 30-year period to reparcel each year the land in 120 cadastral districts [43]. The land redistribution projects do not only serve to consolidate fragmented land ownership, but their purpose is to create a proposal for a system of measures, including preventing soil degradation. In this article, the authors try to link the fragmentation of land with the soil erosion problem. This contribution also attempts to point out the need to evaluate the feedback on the effectiveness of the proposed measures in land consolidation projects, as this has been ignored by Slovakia up till now.

Because the land in the modelled area has already been consolidated, it is reasonable to assume that a minimum area would have been defined as endangered.

This paper attempts to assess erosion control measures in a land consolidation based on comparing soil erosion state before and after a project by classifying the plots into endangerment categories and by their ownership thus providing material for a discussion on position of land owner and tenant, role of the legislation, and the land ownership fragmentation in environmentally sensible land management.

2. Materials and Methods

2.1. Characteristics of the Geographical Location

The modelled area is the Vlára water catchment area (Figure 3), a tributary of the Váh River flowing from the Czech Republic whose source is below Klášťov Mountain (752.9 m) in the Vizovice Highlands. The Vlára runs in a southwest direction through the Vlára pass in the White Carpathian Mountains into Slovakia. The entire area is drained by the river and its tributary streams, the Vlárka, Branný, Čakanovský, Bradelský, Sietne, Hornosrniansky, and Kremnica. The Vlára passes through the cadastral district of Horné Srnie and empties into the Váh about one km from the village of Nemšová [44].

Figure 3. Broader relationships.

As of 31 December 2018, the Nemšová cadastral district's population stood at 6384. The modelled area covers 389.60 ha out of a total of 3344 and is situated in the north-western part of Trenčín Region bordering the District of Ilava. It is located at the border of Moravia and Slovakia within the Váh River valley at the confluence with the Vlára and the Váh. Nemšová is divided into the former villages and new neighbourhoods of Nová Nemšová, Luborča (the modelled area extends 18.06 ha therein), Kľúčové, and Trenčianska Závada.

It is bordered to the north by the village of Horné Srnie, with an area of 2726 ha (the modelled area covers also 2555.96 ha thereof) and a population of 2750 as of 31 December 2018 [45]. It lies on the Slovakian side of the White Carpathians, at the mouth of the Vlára Pass in the central Považie (Váh Valley) region. The catchment area is located within the geomorphologic Považské Podolie around the White Carpathians (Biele Karpaty) and also belongs to the Ilavská Kotlina and Bielokarpatské Podhorie. In terms of relief, the area is mostly rugged mountainous terrain, although the south is composed of the negative morphostructures found in the Pannonian Basin, i.e., relatively young, declining morphostructures with aggradation. There are fluvial and slope processes in the area, with both fluvial and deep erosion quite strong. The geological structure of the wider area is composed of Mesozoic, Neogene, and Quaternary soils. The rocks of the Klippen zone above the area feature a varied development of limestone, sandstones, claystones, and shale. The soil in the area is mainly composed of fluvizols, luvisols, stagnosols, and cambisols. Soil permeability is medium and soil retention capacity is medium to high. In terms of granularity, the soil is predominately sandy-loamy to loamy and characterised as slightly moist [46].

Land consolidation has taken place in the cadastral districts of Nemšová and Horné Srnie. Land in Ľuborča was consolidated between 12 May 1993 and 14 September 2010, in Horné Srnie between 2 August 1993 and 14 February 2011, and in Nemšová itself between 20 August 1993 and 20 September 2010.

2.2. Data Collection and Analysis

The area was defined and the intensity of water erosion for the Vlára catchment area calculated from data in the updated map of certified soil-ecological units (in Slovak “BPEJ” for bonitované pôdno-ekologické jednotky) and the cadastral map for use of the area after the reparcelling and land improvement was registered (Figure 3).

It incorporates new communicating paths, anti-erosion barriers, and other environmental action taken (whose legal status has been registered without them having been necessarily implemented). Land consolidation design in the model area included just measures for construction of a road infrastructure needed to make the plots of land accessible, i.e., forest roads with total length of 6.61 km and field roads with total length of 36.27 km.

The boundaries of the Vlára catchment area were defined from a digital elevation model (DEM) of the contour map at a scale of 1:10,000. To create the DEM (Figure 4a), the Topo to Raster interpolation method was used, with a resolution to two m. Soil loss has been quantified by the universal soil loss equation, USLE, as adapted and required in Methodology no. 5/1992: Protection of agricultural soil against erosion [47] and modified for the geographic information system (GIS) environment in 2012 [48]. The USLE methodology is required by the Slovak legislation in the Decree no. 59/2013 Coll. [49] and the central portal on soil characteristics of the authoritative pedological institution in Slovakia—Soil Science and Conservation Research Institute (SSCRI) in Bratislava quantifies the loss of soil by water erosion using the USLE model (<http://www.podnemapy.sk/portal/verejnost/erozia/vod/vod.aspx>). The USLE, which contains six underlying factors, was used to analyse the threat of water erosion [13]. The rainfall factor (R) of 14.21 was determined from ombrograph records [50] kept at the nearest station in Trenčín, which is located about 20 km from the observed area. The soil erodibility factor (K) was derived from the BPEJ for individual soil types, expressed in a seven-digit BPEJ code with three- and four-digit codes for the main soil unit (HPJ for hlavná pôdna jednotka). K fluctuates between 0.20 and 0.70 (Figure 5a). The topographic factor “(LS)” is based on the incline and length of the slope [51]. It expresses the ratio of land loss per unit slope area to land loss per unit plot. The factor was calculated from relation (1)

$$LS = I_d^{0.5} \cdot (0.0138 + 0.0097 \cdot s + 0.00138 \cdot s^2) \quad (1)$$

where:

I_d —uninterrupted slope length [m]

s—slope gradient [%].

Figure 4. (a) Digital relief model; (b) current use of the landscape.

Figure 5. (a) Factor K, (b) Factor LS, (c) Factor C.

Barriers already existing to transform surface runoff to subsurface runoff were also taken into account to calculate LS. The topographic factor fluctuates at a range between 0 and 298 (Figure 5b). The crop management factor (C) for the landscape's different elements of land use after reparcelling and any improvement (Figure 5c) was simplified for the type of land that was processed [52]. These values were determined to be 0.29 for arable land, 0.005 for grassland, 0.45 for non-forest woody vegetation, 0.5 for ordinary gardens, 0.8 for hop gardens, and 0.45 for orchards (Figure 4b). A value of 1 was chosen for erosion control practices (P) because detailed information about anti-erosion action taken in the area was not available (land users are not legally obliged to keep consistent records of erosion control practices on the land they manage).

Permissible soil erosion limits for water erosion were defined in accordance with either Act 220/2004 [27] or STN 75 4501 [53]. In both methods, the depth of the soil is critical for determining permissible soil erosion. The standard's stricter, more stringent categories were used. The permissible values for different soil depth categories were shallow soil (to 30 cm): one tonne per ha annually ($1 \text{ t} \cdot \text{ha}^{-1} \cdot \text{year}^{-1}$); medium-deep soil (30–60 cm): four t per ha annually ($4 \text{ t} \cdot \text{ha}^{-1} \cdot \text{year}^{-1}$); and deep soil (over 60 cm): ten t per ha annually ($10 \text{ t} \cdot \text{ha}^{-1} \cdot \text{year}^{-1}$). The ratio between calculated actual intensity (with the C factor) and potential intensity (omitted C factor) and permissible erosion expresses the degree of soil erosion risk (SER) in five classes: not endangered or slightly endangered (under 1.00), moderately endangered (1.01–2.00), significantly endangered (2.01–7.00), very significantly endangered (7.01–28.00), and catastrophically endangered (over 28.00) (Table 1). SER was determined from calculated actual water erosion intensity in relation to permissible erosion expressed according to the stricter standards given in the STN 75 4501 [53].

Table 1. Degree of soil endangered by erosion.

Soil Erosion Risk (SER)	Name of Soil Endangered by Erosion	Land Area (ha)	Land Area (%)
<1.00	Unaffected or slightly endangered	592.03	87.50
1.01–2.00	Moderately endangered	18.57	2.74
2.01–7.00	Significantly endangered	24.36	3.60
7.01–28.00	Very significantly endangered	35.65	5.27
>28.01	Catastrophically endangered	5.92	0.88

The USLE was then integrated into a geographic information system (GIS). The factors influencing water erosion are expressed in maps created from an existing database. Landowner data (map and description) were obtained from ZBGIS [54], (available at <https://zbgis.skgeodesy.sk/>, retrieved on 15 January 2020), where an analysis was made of ownership type (state, municipal, church, private), plot area in ha and the number of owners. Each owner has its own identification number in the Land Register's descriptive data. If the same person or entity owns more than one plot, then the identification number is repeated.

Property can be owned by a single person or entity or jointly owned with others. The geometric parameters of the property boundaries were overlaid in the ArcGIS 10.2.2 (www.esri.com) software environment, using the Zonal Statistic function with the degree of soil erosion risk. The result was a layer (Figure 6) that included data about the owners, the soil erosion risk by the selected category (indicated as 1–5 from least endangered to most endangered) and the area in ha. The data were divided into five categories based on the degree of erosion risk, while the holdings were classified by land area into categories, too.

Figure 6. (a) SER, (b) Landowners, (c) SER Overlap + Property Boundaries.

3. Results

The current land use map indicates that forest land is the most common land use with 72% of the modelled area. The remaining percentages are permanent grassland—13%, arable land—7%, built-up land—3%, other lands and gardens—2%, water, orchards, and hop gardens—1%. The USLE was used to determine potential and calculated real erosion runoff (Figure 7). Soil erosion was classified into four categories: less than 10; 101–150; 151–200; greater than 200 ($\text{t. ha}^{-1} \cdot \text{year}^{-1}$).

Table 2. Calculated water erosion intensity in the modelled catchment area.

Category Soil Endangered	Mean Value Loss of Soil ($\text{t. ha}^{-1} \cdot \text{Year}^{-1}$)	Land Area (ha)	Calculated Loss of Soil (t. Year^{-1})	Calculated Loss of Soil (%)
<1.00	1.03	592.03	609.65	36.13
1.01–2.00	8.03	18.57	149.06	8.83
2.01–7.00	7.08	24.36	172.46	10.22
7.01–28.00	14.25	35.65	508.13	30.12
>28.01	41.87	5.92	247.89	14.69
Together			1687.18	100

There were 3696 holdings in the areas where the degree of soil endangered by erosion was determined.

Table 3 shows land is predominately in state hands followed by private hands. The total area is spread among 14 groups according to ownership (private, state, municipal, Vlára Agricultural Cooperative, church, Slovenská správa ciest (Slovak Road Authority), Spoločenstvo bývalých urbárikov a lesomajiteľov (Community of Former Landowners and Foresters), SPP—distribúcia, a.s., Lesy České republiky (Czech Republic Forests), Lesy Slovenskej republiky (Slovak Republic Forests), Občianska záložňa v Brumove

(Brumov Civic Reservation), Pastevní Družstvo Sidónie (Sidónie Pasture Cooperative), RST GLOB s.r.o., and Slovenský vodohospodársky podnik, š. p.).

Figure 7. (Water erosion intensity: a) potential intensity; (b) calculated actual intensity, (c) degree of soil erosion risk (shown in detail with property boundaries).

Table 3. Summarised areas by ownership type on erosion endangered soil.

Ownership	Nemšová		Ľuborča		Horné Srnie	
	ha	%	ha	%	ha	%
Municipal	17.21	6.35	0.57	5.45	27.90	2.14
State	35.19	12.98	2.93	28.01	584.50	44.83
Church	9.45	3.49	1.07	10.23	3.85	0.29
Private	127.21	46.94	1.24	11.85	461.37	35.39
Vlára Agricultural Cooperative	1.30	0.48	-	-	0.74	0.06
Slovak Road Authority	0.44	0.16	-	-	-	-
Community of Former Landowners and Foresters	41.37	15.26	-	-	-	-
SPP—distribúcia, a. s.	0.06	0.02	-	-	-	-
Západoslovenská distribúcia, a. s.	0.01	0.005	-	-	-	-
Czech Republic Forests	-	-	-	-	19.61	1.50
Slovak Republic Forests	-	-	-	-	0.01	0.001
Brumov Civic Reservation	-	-	-	-	6.12	0.47
Sidónie Pasture Cooperative	-	-	-	-	0.40	0.03
RST GLOB s. r. o.	-	-	-	-	1.14	0.09
Slovenský vodohospodársky podnik, š. p.	1.84	0.68	-	-	-	-

Ownership was divided into three groups covering the number of owners, land area, and number of plots (Table 4). These ownership groups are classified into categories based on the five SER classes. Private ownership is the most common type, with 1607 holdings on 589.82 ha covering 2488 plots. Other ownership types are state-owned and municipally-owned land. All five SER categories can be found in the area, with the most, 1022.05 ha or 64.48% of the total area, classified in the first, lowest category (unaffected or slightly

endangered); 192.61 ha or 12.15% of the total studied area fall into SER Category 4 (very significantly endangered) or Category 5 (catastrophically endangered). All of the Ľuborča cadastral district's soil is classified in SER Categories 1 or 2, while no soil in the cadastral district of Nemšová was placed in SER Category 5. The most endangered parcels (16 plots) are found in the cadastral district of Horné Srnie, all of which are in Category 5. The steep sloping and rugged terrain here is the reason all the catastrophically endangered soil is situated at a single area, while the cadastral districts of Nemšová and Ľuborča lie on flatter terrain along the Vlára River.

Table 4. Overview of ownership by SER in the cadastral districts of Nemšová, Ľuborča and Horné Srnie.

NEMŠOVÁ																
		Owners					Land Area (ha)					Number of Plots				
Category SER		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
State	Private	477	39	24	11	-	112.20	7.33	5.41	2.27	-	648	40	28	16	-
	Unknow owners	130	7	2	-	-	28.47	0.80	0.45	-	-	145	7	2	-	-
	Slovak Republic (SR)	1	1	-	-	-	0.11	5.36	-	-	-	10	1	-	-	-
	Municipal	1	1	-	1	-	16.52	0.64	-	0.05	-	62	4	-	2	-
	Vlára Agricultural Cooperative	1	1	-	-	-	1.30	0.56	-	-	-	6	2	-	-	-
	Church	1	-	1	1	-	5.28	-	4.08	0.09	-	5	-	1	2	-
	Slovak Road Authority	1	-	-	-	-	0.44	-	-	-	-	9	-	-	-	-
	Community of Former Landowners and Foresters	1	-	-	-	-	41.37	-	-	-	-	27	-	-	-	-
	SPP—distribúcia, a. s.	1	-	-	-	-	0.06	-	-	-	-	2	-	-	-	-
Západoslovenská distribúcia, a. s.	1	-	-	-	-	0.01	-	-	-	-	6	-	-	-	-	
ĽUBORČA																
		Owners					Land Area (ha)					Number of Plots				
Category SER		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
State	Private	2	1	-	-	-	1.18	0.06	-	-	-	2	1	-	-	-
	Unknow owners	1	-	-	-	-	2.93	-	-	-	-	8	-	-	-	-
	SR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Municipal	1	1	-	-	-	0.51	0.06	-	-	-	1	1	-	-	-
	Slovenský vodohospodársky podnik	1	1	-	-	-	1.53	0.31	-	-	-	1	1	-	-	-
	Church	1	-	-	-	-	1.07	-	-	-	-	4	-	-	-	-
HORNÉ SRNIE																
		Owners					Land Area (ha)					Number of Plots				
Category SER		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
State	Private	654	87	138	163	11	324.53	60.52	23.15	52.17	1.00	1288	94	155	204	12
	Unknow owners	398	29	37	37	2	80.71	3.95	6.39	5.70	0.31	501	29	38	38	2
	SR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Unknow owners	1	-	-	-	-	1.60	-	-	-	-	3	-	-	-	-
	Czech (CZ)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SR	1	1	1	1	-	350.15	8.27	2.59	126.43	-	82	4	6	6	-
	Municipal	1	1	1	1	1	20.88	0.31	2.46	3.98	0.27	94	3	15	19	2
	Czech Republic Forests	1	-	-	-	-	19.61	-	-	-	-	6	-	-	-	-
	Slovak Republic Forests	1	-	1	1	-	0.01	-	-	-	-	1	-	-	-	-
	Brumov Civic Reservation	1	-	-	-	-	0.07	-	-	-	-	1	-	-	-	-
	Sidónie Pasture	1	-	-	-	-	6.12	-	-	-	-	4	-	-	2	-
	Cooperative	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vlára Agricultural Cooperative	1	-	-	1	-	0.40	-	-	0.34	-	3	-	-	2	-
Church	1	-	-	-	-	3.85	-	-	-	-	8	-	-	-	-	
RST GLOB s. r. o.	1	-	-	-	-	1.14	-	-	-	-	1	-	-	-	-	

It is clear from Table 5 that 229 holdings out of the total number in the area have soil significantly or catastrophically endangered by water erosion. There are 14 holdings in the cadastral district of Horné Srnie whose soil is catastrophically in danger of water erosion.

Table 5. Number of owners falling into the categories of erosion endangered soil.

SER	Nemšová	Ľuborča	Horné Srnie
Unaffected or slightly endangered	615	12	1062
Moderately endangered	49	13	118
Significantly endangered	27		177
Very significantly endangered	13		202
Catastrophically endangered			14

From the example of the model area, it is unfortunately clear that the new reorganization did not achieve the expected benefits of land consolidation related to the protection of the landscape from water erosion. Despite taking 42.88 ha of land for improvement measures, 12% of the area remained unresolved with regard to a significant erosion risk.

4. Discussion

The new road network project for the model area providing accessibility to land was designed incorrectly. Unfortunately, it did not take into account the erosion protection of the area in most cases. The placement of roads has been suboptimal; incorrect location on the slopes did not interrupt the slope length, which should create, together with the anti-erosion ditch, a barrier to surface runoff. The state of endangered sites is mostly identical before and after land consolidation.

Two main problems have been identified:

- Errors, underestimation of land consolidation design and neglecting analytical work, which seems to be a serious problem in several projects analysed by the authors, plus weak, often none/neglected control by a state authority. This problem is easy to solve. Thorough control of the entire landscaping project and subsequent implementation of measures can be achieved by the country adopting a proper framework of functional land use according to the new plan of common measures and facilities for the protection and use of the territory.
- A more serious problem is that even in the cases of correct optimization of the area in the land consolidation project, practically (in terms of land management) nothing will change, many times. Most of the landlords, as a rule, leave their land in use by the original tenants, who continue to handle the area in the usual way, disregarding the environmental measures. They manage small plots of individual owners in merged land blocks, which is the reason for the continuation of degradation processes.

This study also tries to point out that land consolidation could be a significant impulse to a change in the management of countryside towards limiting the consequences of degradation processes. According to authors as [55], the quantity and quality of green spaces examined on the basis of land-use change has shown a declining trend over the last forty years. Soil degradation increases [56] and according to Sumfleth et al. [57] it is necessary to start a complex debate around land use change associated with a growing demand for biomass. Reducing crop diversity and homogenizing land use is a cause of increasing soil degradation [58]. The tolerated rate of erosion is defined by the sustainability of natural resources, and the soil lost has to be lower than what is naturally formed. [59] The most significant problem not discussed in the literature is the soil that is carried away from property holdings registered to one owner to another's land. The soil elements move onward from one landholding to another until they finally reach the river. The soil elements transported in this way end up in water areas, turn into sediments, and reduce the permeability of watercourses and the volume capacity of water reservoirs. With correctly

designed soil erosion management, there would be no washing of soil elements to the land of other owners or those would get trapped in buffer zones, eventually. Therefore, ownership of the drifting soil is not resolved. Soil ownership is based on the parcels geometrically drawn on the cadastre map and nothing changes on paper even after the soil erodes elsewhere. Opinion is shared that pricing topsoil is quite complicated [60]. The price of topsoil stripped from construction sites has been calculated at between €8 and €15 euros per cubic m (where the mean specific weight of the soil is 1450 kg). In the modelled area, the average price of soil lost to erosion amounted to €11.50 per cubic m or, at 1687.18 t of soil lost per year, to a cost of €13,381.11.

According to Schwilch et al. [61], the land management affects ecological processes, which in turn affect the kinds of benefits that people derive from land. The Food and Agriculture Organisation of the United Nations (FAO) [62] sees land ownership systems, as well as tenure and business, to have the most significance in protecting soil. Soil degradation has increased especially when users consider the soil just a source of income and livelihood, or when there are inequalities in who owns the soil. This is often the case in countries where land protection laws are not well-developed. According to the authors Rapsomanikis [63], land degradation in Slovakia is the result of incorrectly set agricultural legislation. Landowners could be allowed to charge a sufficiently high rent to compensate for the soil and nutrients therein that are lost, unless the lease mentions the condition of the farm when it ceases to operate [64]. Legal documents on leases with a precise definition of the principles of soil protection against degradation could be the solution. In the conditions of Slovakia, the lease agreement does not usually mention the clause on a careful management of land. Soil protection is given by legislation, which is, however, often set very benevolently, e.g., the water erosion limits. Relevant studies, e.g., [65], show that land management is also in the hands of legislators in order to promote land rights and land use policies. Results of [65], according to which tenure insecurity may lead to degradation of soils, are supported by our experience. In countries with a high ratio of rented land, it is therefore particularly desirable to promote long-term leases as opposed to the short-term ones, and set agro environmental standards. The study of Azadi et al. [64] suggest that one possible approach to mitigate the land degradation is collection/evaluation of feedback on effects of soil protection practices and related incentives before implementing new policies. An interesting insight reported by Uchiyama and Kohsaka [66] claims that the protection of the landscape, in a time of pandemic, is beginning to influence national policies that need to further address green areas (including agricultural lands) and healthy landscapes. Degraded landscapes endanger the sustainability of a territory and are also detrimental to health and well-being.

The problem in the solution based on a stricter setting of environmental measures in lease agreements lies in the current position of the owner of agricultural land in the conditions of Slovakia. Long term unresolved fragmented land ownership and lease agreements result in continuing formation of passive owners. Owners know what they own, but they do not know exactly where [31]. As a rule, they let their small shares scattered throughout the cadastral area to be used by tenants and are content with any fee provided. Only an owner with unambiguous and consolidated ownership on the map and in the field has the potential to go look at the land and evaluate its condition.

Mediation and education is needed to ensure effective and sustainable use of land that is not detrimental to those least able to make changes. Tenant farmers might not always farm in the best interests of the soil; however, it is still in their interest that they can continue to farm an area, albeit being handicapped by the short-term leases mentioned earlier.

5. Conclusions

The main benefit of land consolidation and reparcelling projects is to make the area optimally functional. The design of a multifunctional system for communications, environmental action, and to combat erosion is a condition for such projects to be successful. The outcome should be a landscape organised so new plots of land created from the reor-

ganisation are accessible from roads and the soil is in no danger of erosion. The impact upon owners of whatever the project proposes is not examined here in greater detail. Even when a minimum number of owners start to exploit their own soil after the reparcelling of the land causes no sufficient need for the owners to have an interest in it. It remains in use by large agricultural holdings even after the land has been consolidated and rules govern such use, as was the case before land consolidation took place. The soil will continue to be degraded unless action is taken. Using the USLE method, 3696 holdings in the Vlára model basin have been evaluated for danger of erosion. The owner groups have been classified into five classes (SEOP). Privately owned land by 1607 people on 589.82 ha in 2488 plots, even after completion of the land consolidation project, on a total of 12% of the modeled area, still had signs of soil endangered by water erosion.

A land consolidation project has the potential to optimize the landscape, including incorporating a system of accumulation and collection measures for erosion control. But, agricultural holdings keep managing the land even after land consolidation in most cases and apply methods associated with a growing demand for biomass. Land ownership defragmentation with more environmentally conceived long-term tenure might be a very important factor in land degradation reduction if land-owners are not going to farm the land themselves.

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