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Priority Areas for Initiating Land Consolidations Related to Erosion and Water Retention in the Landscape, Czech Republic

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ABSTRACT

Land consolidations represent a unique tool for managing the problems of the rural space. They help to settle the land property rights and meet the current requirements associated with the protection and formation of a stable, permanently sustainable rural landscape. In the Czech Republic, complex land consolidations have been completed in 1,965 cadastral areas out of the total 13,100, and in 2,134 more they are in the preparation phase (up to 1st September 2015). It means that about 60% of cadastral areas in CR still await land consolidation. Our study aimed to localize the priority localities (cadastral areas and regions) for preferential implementation of land consolidation. The authors selected three thematic factors to determine the risk of their occurrence in particular localities and, consequently, the need to initiate the land consolidation. The analysis is based on the assumption that the cadastral areas where land consolidations have been completed or are under way have already dealt with the above-mentioned risk factors or will do so soon. Therefore, such areas have not been included into our study. The key selected thematic factors relevant for the preferential implementation of land consolidation include: the risk of water and wind erosion in arable land, water management, and water retention in the landscape. For each of these three factors, a map of preferential localities (based on the degree of risk/suitability) was processed for initiation of land consolidation. At the same time, a simple multi-criteria analysis of the extent of the Czech Republic's erosion (water and wind) has been prepared. The result of this analysis is the ranking of regions according to the degree of risk of erosion. The most vulnerable regions of the Czech Republic include Jihomoravský (South Moravian Region), Středočeský (Central Bohemia) and Pardubice.

Keywords: land consolidation; rural areas; water erosion; wind erosion; water retention; GIS

INTRODUCTION

Land consolidation is a tool for creation of sustainable rural areas and improving the effectiveness of land cultivation as well as supporting the rural development in different countries, including the Czech Republic (CR) (Sklenička, 2006; Pašakarnis and Maliene 2010). Land consolidation can be also defined as a comprehensive reallocation procedure in the rural area consisting of fragmented agricultural holding, or their parts Vitikainen (2004).

In the countries of the former Eastern Bloc, the land consolidation brings about land reform or de-collectivisation in response to a long period of suppression of the land use and ownership (Podhrázská et al., 2015).

Similarly as in other Central and Eastern European countries, land ownership fragmentation, when the non-contiguous plots of individual owners are scattered around the area of one or more cadastres, is an important issue for farmers in the Czech Republic. After forty years of interrupted farming based on land ownership, a significant number of plots are not accessible by field roads. Additionally, the plot shapes and sizes are not suitable because they reflect the conditions in the first half of the 20th century. These factors, together with other driving forces, primarily the massive exodus of workers from agriculture to

industry between 1950 and 1990, and the present-day mismatch between the small holding size and the large scale agricultural machinery, drainage and irrigation systems, are at the root of the sharp distinction between the land ownership and land use (Sklenička et al., 2006).

Land consolidation not only deals with land redistribution, but also arranges the optimal shape and size of plots (Leń, Noga, 2018). At the same time, the environmental conditions, soil protection, water management and ecological stability of the landscape (in particular flood and erosion control measures or systems of ecological stability of landscape) are improved through the application of the land consolidation process.

The land consolidation programme is not a specific Czech project. Land consolidations are applied in various forms all over the world. Sky (2015) reports that the land consolidation processes are similar between countries. Depending on the political, socio-economic and environmental demands of the particular countries or regions, the land consolidation process places stress on land reclamation, nature and landscape conservation (Nikodemus et al. 2005), or possibly it constitutes a remedial platform for the social and economic development of the countryside (Miranda et al. 2006; Sklenička et al. 2006). The basic idea of land consolidations in advanced countries in EU remains the same, i.e. to preserve and improve the rural space in such a way as to make it stable and permanently sustainable for further generations (Podhrázská et al., 2015).

The majority of current land consolidations in CR deal with insensitive human interventions into the landscape in the second half of the 20th century. The main efforts of the Socialist regime were focused on intensifying the agricultural production. The agricultural production was collectivized and large agricultural cooperation was established. The landscape was subjected to extensive devastation of natural eco-stabilizing elements, destruction of spinneys, balks, drainage of river floodplains and wetlands. Large land blocks of hundreds of hectares in size were created, destroying the field roads. The landscape became impassable. These factors led to a massive development of wind and water erosion and to the problems connected with low water retention in the landscape, as well as flash floods from heavy rainfalls. The communist era showed to be problematic and in some aspects, the sustainable development of rural areas was impossible (Thomas, 2006; Hartvigsen, 2014).

The process of land consolidation in the Czech Republic, as it is known today, has been occurring since 1991 and currently is controlled by the State Land Office (SLO). Land consolidations are regulated by Act No. 139/2002 Coll. The law stipulates that land consolidations create the conditions for rational management by landowners, improve the environmental protection and water management. It is a long-lasting process.

The project and design phase of a land consolidation takes 4–5 years on average, according to the size and difficulty of the project implementation (SLO, 2015). The gradual execution of the shared facilities proceeds after agreement with the owners, depending on the financial support from the state budget and possible EU support at different time periods (Podhrázská et al., 2015). In isolated cases, the duration of the land consolidation may even exceed double average length (6 years or more).

At present, designers of land consolidations are bound by several methodological guidelines existing in CR. These methodological guidelines are recommended for use by the State Land Office. They include the methodologies for evaluation of water erosion (Janeček et al., 2012), wind erosion (Podhrázská et al., 2011), design of land consolidations (SLO, 2016), evaluation of the landscape (Tlapáková et al., 2013), assessment of the effectiveness and benefits of implemented land consolidations (Konečná et al., 2014), and other.

The design and application of a land consolidation represents a rather demanding process, involving both the restoration of the cadastral map and reorganization of land parcels, including a proposal of the measures aimed at the recovery of a stable agricultural landscape. According to the statistics of the State Land Office (SLO, 2015), land consolidations have as yet been completed in 1,965 cadastral areas (data of September 1, 2015). This figure represents about 15% cadastral areas in CR. In 16% cadastral areas, the land consolidations are in the initiation phase or under way. That leaves about 60% cadastral areas in CR still awaiting land consolidations.

In 2015, the State Land Office issued the "Concept of Land Consolidations in CR for the period 2016 – 2020" (SLO, 2015). This material assumes the application of 200 land consolidations per year. In the current situation, with land consolidations still lacking in about 9 thousands cadastral areas, this would represent a time horizon of 50 years. From the long-term point of

view, this means that in order to meet the needs of nature and landscape protection, we must establish priority localities for preferential initiation of land consolidations. In CR, the major environmental problems are the risk of water and wind erosion, as well as inadequate water retention in the landscape.

Soil erosion is a natural process, which is accelerated by insensitive interventions of man into the natural environment and landscape and by intensive management of the agricultural land. In CR, water erosion potentially threatens almost 50% of agricultural land, 18% of which is at extreme or high risk; about 20% is at risk of wind erosion, almost 5% of which – at extreme or high risk (Ministry of Agriculture of CR, 2015). At present, the maximum soil loss in CR is estimated to be approximately 21 million tons of arable land per year, which may be expressed as an economic loss of CZK 4.3 billion per year. According to the Situation and Prospective Report of the Ministry of Agriculture CR (Ministry of Agriculture of CR, 2015), about 40% of soil in CR has above-average productivity. Due to the land degradation processes, namely erosion, these most productive regions gradually depreciate (Podhrázská et al., 2015).

The issue of soil degradation and the need of soil conservation have been among intensively debated topics for decades. One of the ways to improve the present situation may be the process of land consolidation, because land consolidations include the erosion and flood control measures together with the limitation of soil erosion in particular districts.

Protection of soil and water resources should be one of the state's priorities. The conservation of natural resources is one the main prerequisites for permanently sustainable development and healthy population. The loss of high-quality agricultural land is perceived worldwide as an extensive problem touching not only the developing countries. The main threat to the environment and agriculture is water erosion. This phenomenon is defined as a process of release, transport and deposit of soil particles by flowing water. Soil erosion leads to the loss of soil fertility, reduction of depth of the rooting zone, and loss of nutrients and moisture. The direct consequence is the fall in prices of agricultural land due to the loss of its quality and fertility (Podhrázská et al., 2015). Long-term economic analyses have shown that prevention of the negative effects of soil and water degradation is more advantageous than solving their consequences (Konečná et al., 2014).

The potential negative impacts of the continuing climatic changes on water sources attract attention of both scientists and policy makers worldwide. Their manifestation in the territory of CR is twofold – the growing occurrence and intensity of extreme precipitation brings about the damage to the soil by water erosion. The data from the monitoring of the Czech Hydrometeorological Institute, along with model calcula-

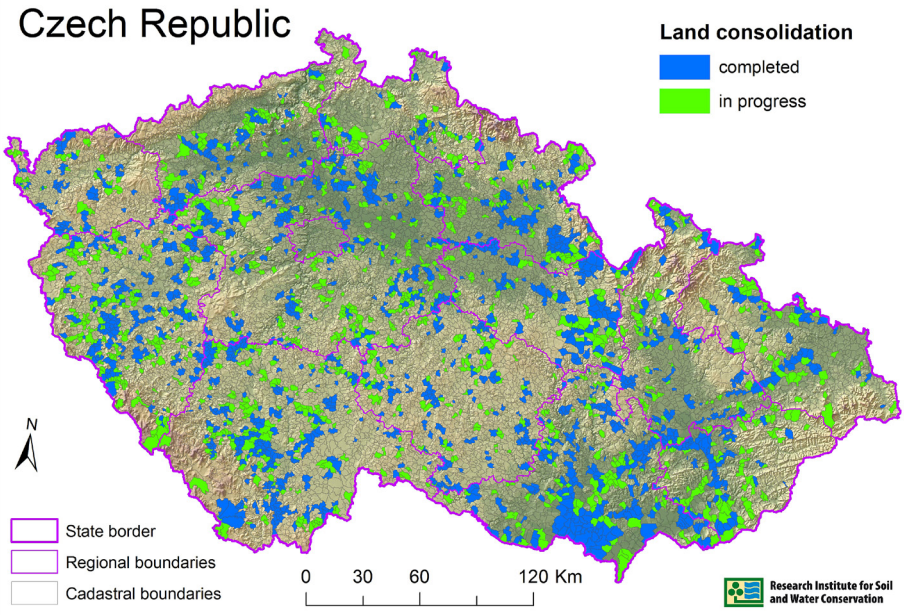

Fig. 1. State of land consolidations in CR (1st September 2015)

tions, show that due to the climatic changes, the territory of CR will probably experience more frequent droughts, both as a consequence of the precipitation deficit and the constant rise in the air temperature and evaporation (Rožnovský et al., 2010). The risk of drought requires the elevation of rainfall water retention in the landscape.

Land consolidations represent a unique tool for designing the landscape in many aspects. A plan of priority localities for initiating land consolidations should come into existence. Particularly in these localities, information should be disseminated about the land consolidations, their course and benefits. On the basis of a questionnaire campaign, a study by Karásek et al. (2014) has shown that a large part of the population still lacks the adequate information on the land consolidations.

METHODOLOGY AND DATA

In our research, we focused on the water and wind erosion and water retention in a landscape. The reason was that the erosion control and water management are key issues which are important under the conditions of the Czech Republic and subsequently they are widely employed in the frame of land consolidations. The methods were applied using the geographical information system (GIS) in the following subsequent steps:

- collection of input geodata (information on land use, pedological characteristics of the land, morphological characteristics, statistical data on demography, data on land consolidation in CR),
- processing of input data into a unified GIS geodatabase,
- creating criterions for evaluation of the obtained values,
- creating information layers (land consolidation, water and wind erosion, soil suitable for construction of retention reservoirs and wetlands),
- processing of simple multi-criteria analysis of the region erosion risk evaluation of the information layers
- processing map outputs and evaluation.

The evaluation of the priority localities for the initiation of land consolidations was done in individual regions of CR (Fig. 2).

Vulnerability of soil by water erosion

The analysis of soil vulnerability by water erosion was based on the method published in the methodological manual "Protection of Agricultural Land against Erosion" (Janeček et al., 2012). The calculation was done using the USLE 2D method (Janeček et al. 2012). The input data were taken from the valid pedological database for CR (Ministry of Agriculture, 2015), the DMT created

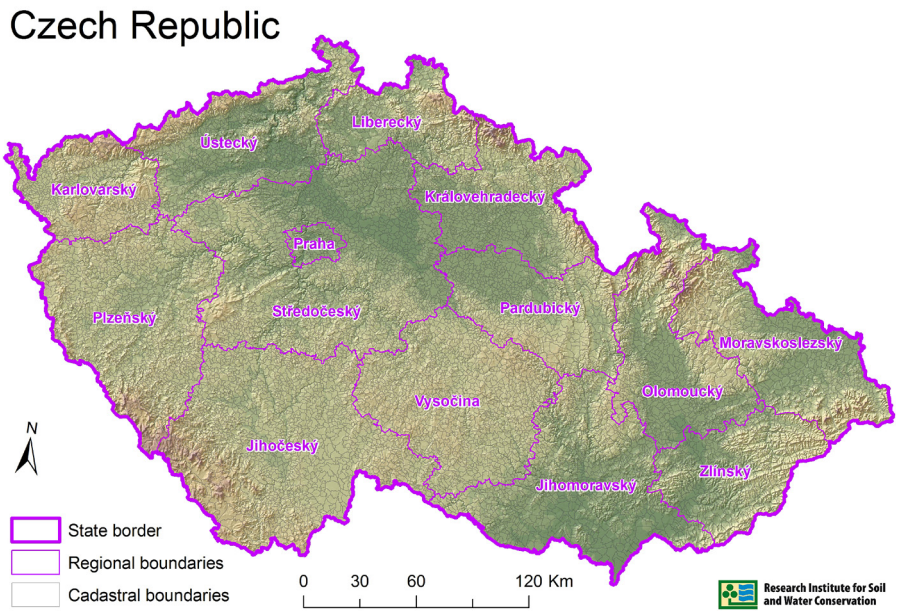

Fig. 2. Regional boundaries in CR

from the main base of geographical data (ZABAGED 2015 – Czech Geographical and Cadastral Office), the database of land blocks and their use (LPIS, Ministry of Agriculture, 2015), and the data on water courses and water surfaces from the valid database for CR (DIBAVOD). Subsequently, the value of average long term soil loss was calculated and the output layer of erosion threat was created. According to the valid guidelines of the State Land Office and the methodology of erosion control (Janeček et al., 2012), the permissible soil loss by water erosion is 4 t/ha/year. Any higher calculated value is considered as an excessive loss. Any locality with erosive loss exceeding this permissible limit requires the application of appropriate erosion control measures. Each cadastral area in CR has a calculated acreage of agriculturally exploited land. We compared this acreage with the acreage of the land susceptible to erosion (land with calculated erosion risk higher than the appropriate permissible limit). Then, for each cadastral area with incomplete or not yet initiated land consolidation we calculated the value (percentage) of agriculturally exploited land in which the erosion risk was assessed as higher than the appropriate permissible erosive wash out. The results were expressed in the map "Vulnerability of soil by water erosion". This map classifies the cadastral areas into five categories, according to the water erosion risk of agriculturally exploited land. These categories are: 0–20; 20–40; 40–60; 60–80; 80–100% of agricultural land with excessive erosive wash.

Vulnerability of soil to wind erosion

The analysis of land potentially vulnerable to wind erosion was based on the method published in the methodological manual "Optimization of Windbreak Functions in Agricultural Landscape" (Podhrázská et al., 2008). The method assesses the localities according to the climatic and pedological characteristics. Dry and warm localities are at the highest potential risk, similarly to light, sandy soil areas. The calculation was done using the GIS method, with resulting weighted means of the potential erosion risk for individual land blocks in the model localities. For each cadastral area with incomplete or not yet initiated land consolidation, we established the average value of the wind erosion risk. The resulting map "Vulnerability of soil by wind erosion" was classified into five categories according to the risk degree, ranging from low risk to high risk.

Suitable locations for construction of retention reservoirs or wetlands

The map was processed based on the evaluation of soil characteristics according to valued pedological-ecological units (BPEJ) obtained during the research projects by Novák et al., 2003. We selected the soil types characterizing extensively waterlogged, very heavy land, difficult to drain, with a high underground water level, in favourable relief organization, in particular: Modal Stagnogleys, Modal Gleys, Aqui-gleysols, Gleyed Fluvisols.

These soil types are not suitable for further agricultural management due to their overall incapacity and ineffectiveness. They can be further used for the construction of retention reservoirs, ponds, and wetlands. The selection of these soil types was done in the cadastral areas where land consolidations have not yet been completed or developed. For each cadastral area, we calculated the total acreage of these localities suitable for increasing the water retention in the landscape. The resulting map "The surface area (ha) of suitable localities for construction of retention reservoirs or wetlands" classifies the cadastral areas into five categories (0; 0.1–10; 10–100; 100–200; >200 ha) according to the acreage of these localities.

Priority localities for initiation of land consolidation due to the risk of water and wind erosion in the Czech Republic

For the purpose of identifying the regions in the Czech Republic which are most threatened by erosion (priority for the start of land consolidation due to protection of agricultural land against erosion), a simple multi-criterion analysis was conducted. The water and wind erosion vulnerability analyses did not include the areas where the land consolidation had already been processed. The multicriterial analysis consisted in assessing the vulnerability of the Czech Republic to water erosion and threatened regions of the Czech Republic by wind erosion. The map outputs and analyses processed within this article were used. It consisted of determining the order of individual regions (depending on the risk of water and wind erosion). The order is determined from 1 (highest erosion risk) to 14 (lowest erosion risk). Subsequently, the sum of both orders is made and the erosion risk for each region is evaluated.

On the basis of this evaluation, a table and a map showing the overall vulnerability of the re-

gions of the Czech Republic by erosion (a region without land treatment) were created.

RESULTS AND DISCUSSION

Priority localities for initiation of land consolidation due to the risk of water erosion

The cadastral areas in CR are threatened by water erosion to various degrees. The results of our evaluation pertaining to the average long term soil loss evocated with water erosion are given in Table 1 and Figure 3. The table contains the numbers of cadastral areas without land consolidation for each CR region in individual categories of risk of water erosion. The risk of water erosion is expressed as the percentage of agriculturally exploited land with erosive loss higher than the permissible limit (4 t/ha/year). In 4,150 cadastral areas (42% of cadastres), the risk was assessed as mild, with the permissible loss exceeded in up to 20% of agricultural land acreage.

These areas do not represent priority localities for initiating land consolidations due to water erosion. The remaining 5,545 cadastral areas (56.4 of cadastres) are at high risk of water erosion according to the analysis (more than 20% agricultural land at risk of excessive erosive loss), while 803 cadastral areas (8.2%) were classified into the category of 60–80 % agricultural land with excessive erosive loss and 157 (1.6%) even into the category of 80–100% agricultural land with excessive erosive loss. These localities were assessed as highly suitable for initiation of land consolidation, with high need of managing the water erosion problems.

The highest number of strongly vulnerable cadastral areas is found in the regions of Jihomoravský, Vysočina, and Středočeský. These most vulnerable regions are shown in red in Figure 4. In the Jihomoravský region, 79% of cadastral areas without completed or developed land consolidation are at high risk of water erosion (more than 20% of agricultural land displays erosion vulnerability higher than the permissible soil loss). In the Vysočina region, this concerns 81% of cadastral areas, and in Středočeský 69%. These regions are intensively exploited agriculturally, with large blocks of arable land. The land parcels often exceed 100 ha and are managed by large agricultural cooperatives. In contrast, the lowest numbers of cadastral areas with excessive erosion vulnerability (more than 20% of agricultural land acreage within the cadastre) are situated in the regions of Karlovarský (20% – green colour, lowest risk), Liberecký (36%), and Ústecký (41%).

The risk of water erosion is a frequent and current topic of debate in CR. A number of studies and research activities are related to the issue of soil degradation by water erosion and its subsequent sedimentation in the river beds and water bodies (Krása et al. 2013, Uhlířová et al, 2009). Novák, Batysta and Havelková (2013) refer to

Table 1. Number of cadastral areas in CR threatened by the water erosion

Region	Number of cadastral areas without land consolidation threatened by water erosion						
	not rated	Expressed as % of agricultural land in the cadastral areas with G > 4 t/ha/year					Total
		0 – 20	20 – 40	40 – 60	60 – 80	80 – 100	
Praha	30	26	26	14	5	7	78
Jihočeský	4	627	353	152	20	0	1152
Jihomoravský	18	101	144	153	107	54	559
Karlovarský	9	358	61	24	3	2	448
Vysočina		192	515	287	32	0	1026
Královehradecký	4	328	191	139	54	5	717
Liberecký	9	256	98	45	7	1	407
Moravskoslezský	10	240	114	107	35	5	501
Olomocký	5	288	83	96	86	17	570
Pardubický	3	261	158	135	46	3	603
Plzeňský	6	383	234	231	100	5	953
Středočeský	4	470	440	425	193	13	1541
Ústecký	31	485	154	131	65	11	846
Zlínský	2	135	33	42	50	34	294
Total	**135**	**4150**	**2604**	**1981**	**803**	**157**	**9695**

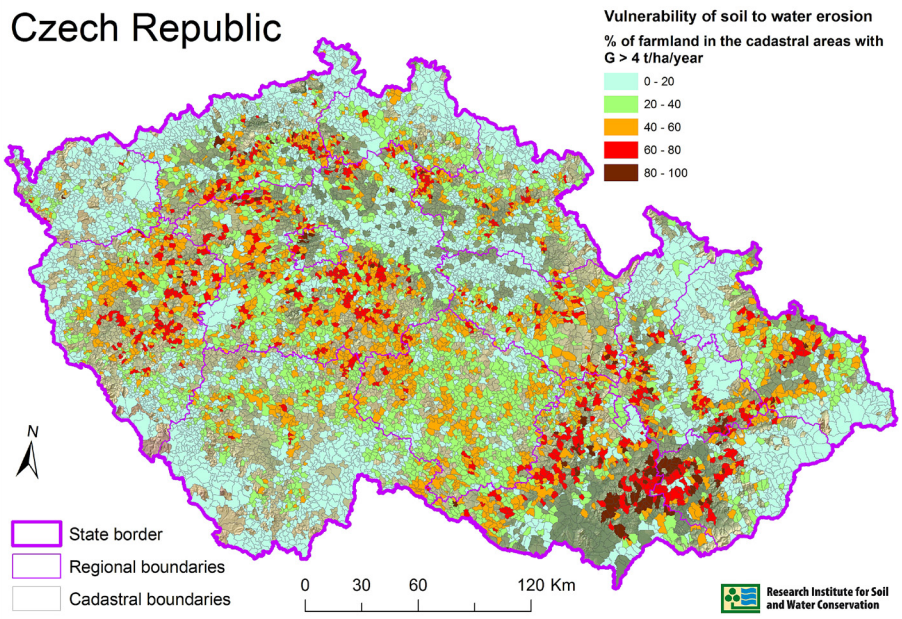

Fig. 3. Vulnerability of soil to water erosion in the cadastral areas without land consolidation

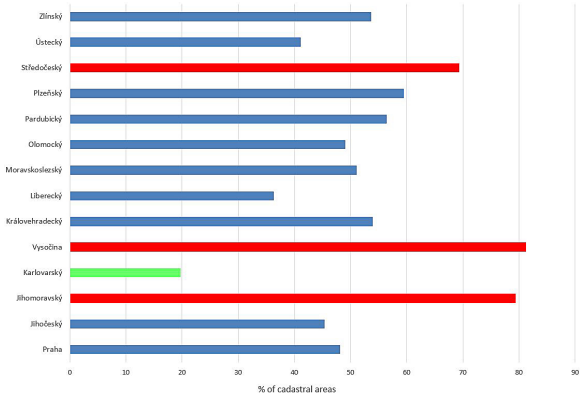

Fig. 4. Percentage of cadastral areas (without land consolidation) threatened by water erosion in individual regions of CR

the extreme threat of water erosion in some regions in CR. They found out that the erosion in Southern Moravia (Jihomoravský region) leads to the degradation of soil profiles and changes of soil types. The negative effects of water erosion were documented by Konečná et al. (2011) in the Vysočina region.

Priority localities for initiation of land consolidation due to the risk of wind erosion

We found out that out of 9,830 cadastral areas without land consolidation, 18% are vulnerable to the effects of wind erosion (ca 1,774). The degree of risk is given in Table 2 and documented in Figure 5.

Table 2 shows the numbers of cadastral areas without land consolidation for each CR region in individual categories of risk of wind erosion. From all considered cadastres, 12.5% (1,231) are classified as being at low or moderate risk. The wind erosion vulnerability in these areas is mild and so they do not represent priority localities for initiation of land consolidations due to the wind erosion risk.

The remaining 5.5% of cadastral areas (total 543) have been assessed as being at medium risk (378), high risk (126) and very high risk (39). In these areas, wind erosion should be managed by appropriate erosion control measures. Therefore, they should be considered as priority localities for initiation of land consolidations.

The vulnerability to wind erosion represents a frequently underestimated risk of soil degradation. In CR, wind erosion threatens 26% of agricultural land. The assessment of vulnerability to wind erosion is a standard element of land consolidation, forming an integral part in the form of proposed measures to be adopted against the wind erosion effects. Appropriate erosion control measures are given in Podhrázská et al., 2008, Janeček, et al., 2012.

The highest number of cadastral areas with a significant risk of wind erosion (medium, high, very high risk categories) is situated in the region of Jihomoravský. In total, they encompass 102 cadastres (18% of all cadastres without land consolidation in the region). In the region of Ústecký, this concerns 17% of cadastral areas, and in

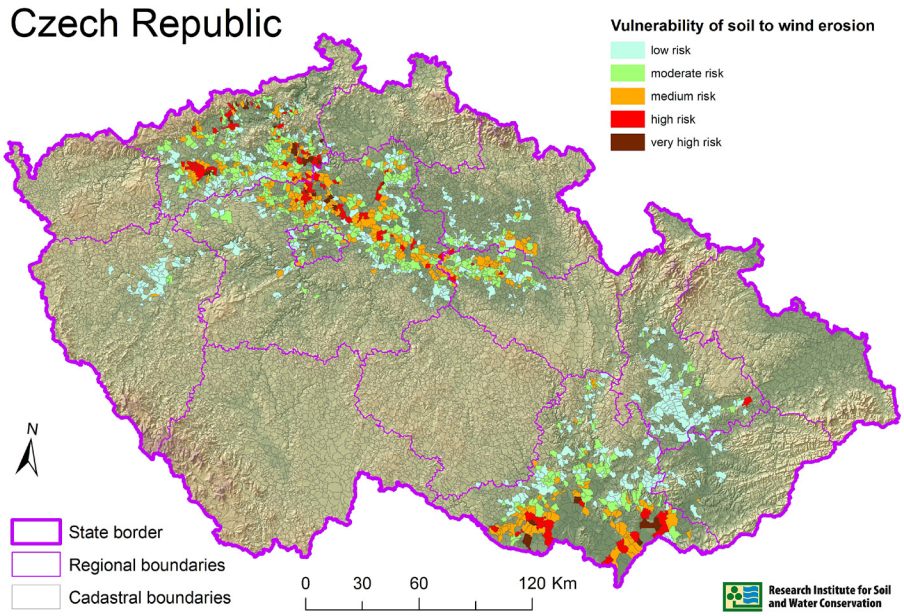

Fig. 5. Vulnerability of soil to wind erosion in cadastral areas without land consolidation

Table 2. Number of cadastral areas in CR threatened by wind erosion

Region	Number of cadastral areas without land consolidation threatened by wind erosion					Total
	low risk	moderate risk	medium risk	high risk	very high risk	
Praha	15	32	7	0	0	54
Jihočeský	0	0	0	0	0	0
Jihomoravský	99	80	74	19	9	281
Karlovarský	1	0	0	0	0	1
Vysočina	4	0	1	0	0	5
Královehradecký	64	25	19	1	0	109
Liberecký	2	1	0	0	1	4
Moravskoslezský	0	0	0	0	0	0
Olomocký	129	15	1	1	0	146
Pardubický	38	62	46	9	0	155
Plzeňský	44	6	2	0	0	52
Středočeský	154	187	151	43	7	542
Ústecký	108	130	75	53	22	388
Zlínský	33	2	2	0	0	37
Total	691	540	378	126	39	1774

Středočeský – 13%. These 3 most vulnerable regions are shown in red in Figure 6.

Wind erosion is one of serious degradation factors, particularly in the localities with most fertile soils (southern Moravia, the Elbe valley). Its harmful effects are reflected in the loss of arable land, deterioration of both physical and chemical soil properties, decrease of hectare yields, and increase of dust pollution in the environment (Podhrázská et al., 2015). The regions of CR not directly threatened by wind erosion are: Jihočeský, Karlovarský, Liberecký, Moravskoslezský, Olomocký, Plzeňský, Zlínský, Vysočina (shown in green colour in Fig. 6).

Priority localities for initiation of land consolidation due to the risk of water and wind erosion

A simple multicriterial analysis was developed to determine the vulnerability of the regions of the Czech Republic to erosion (both water and wind). It consisted of determining the order of individual regions (depending on the risk of wa-

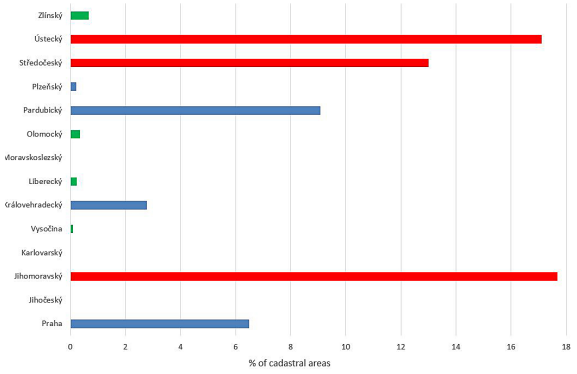

Fig. 6. Percentage of cadastral areas without land consolidation threatened by wind erosion in individual regions of CR

ter and wind erosion). The order is determined from 1 (highest erosion risk) to 14 (lowest erosion risk). Subsequently, the sum of both orders is made and the erosion risk (total order) for each region is evaluated (Table 3, Fig. 7).

The most vulnerable areas of erosion in the Czech Republic is Jihomoravský kraj (South Moravian Region). Then, the region of Středočeský (Central Bohemia) and Pardubice follow. In these areas priority should be given to the erosion control through the state policy instruments. The regions Karlovarský, Jihočeský, Liberecký are at the other end of the ranking of erosion threat, being least vulnerable to erosion.

Table 3. Analysis of vulnerability of the Czech Republic regions by erosion

Region of Czech Republic	The order of the regions of the Czech Republic by erosion threat (1 – highest risk; 14 – lowest risk)		Summary	Overall order of regions
	Water erosion threat	Wind erosion threat	Water erosion threat + Wind erosion threat	1 – the highest risk of erosion; 14 – the lowest risk of erosion
Jihomoravský	2	1	3	1
Středočeský	3	3	6	2
Pardubický	5	4	9	3
Královehradecký	6	6	12	4
Vysočina	1	11	12	4
Plzeňský	4	10	14	6
Ústecký	12	2	14	6
Zlínský	7	7	14	6
Praha	10	5	15	9
Olomocký	9	8	17	10
Moravskoslezský	8	12	20	11
Liberecký	13	9	22	12
Jihočeský	11	12	23	13
Karlovarský	14	12	26	14

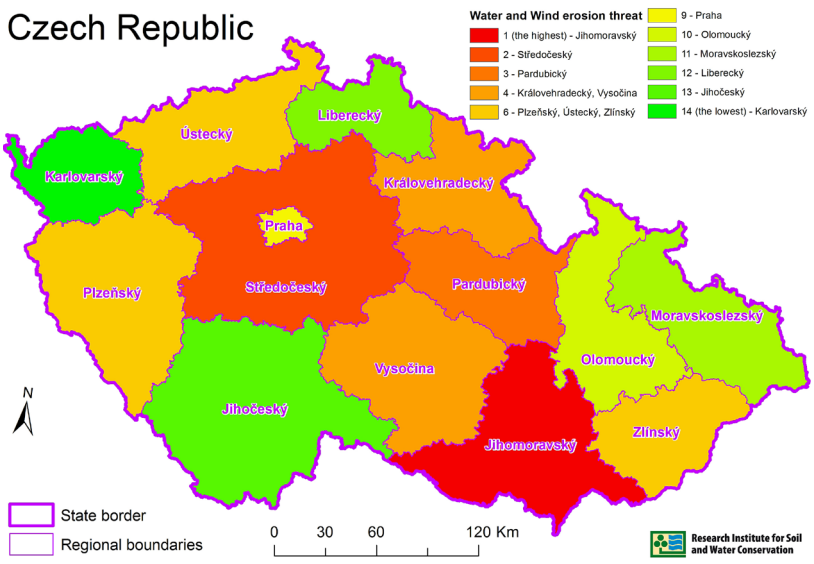

Fig. 7. The threat to the regions of the Czech Republic by erosion (water and wind)

Priority localities for initiation of land consolidations aimed at increasing water retention in the landscape

The analyses presented above assessed the landscape of CR from the aspect of land degradation by water and wind erosion. Additional consequences of the climatic changes that we have to face are drought impacts and growing risk of occurrence of dry periods in the course of the year (Kyselý, Beranová, 2009). During the second half of the 20th century, CR experienced intensive drainage of agricultural land at almost 26% surface (1.1 mil. ha) (Kulhavý et al., 2007). Drainage and fertilization were frequently applied in unsuitable localities, resulting in profound changes in the landscape (Langhammer et al., 2008; Karásek et al., 2015). Both the drainage and land degradation due to water and wind erosion negatively impact the water retention in the landscape. Our analysis was aimed at locating potentially suitable localities (inappropriate for agricultural production) that could be used for increasing the water retention in the landscape by construction of retention reservoirs and wetlands. The analysis has shown that 67% of cadastral areas in CR without land consolidation contain such potentially suitable localities.

Table 4 shows the number of cadastral areas without land consolidation classified into categories according to the acreage of potentially suitable localities for the construction of retention reservoirs and wetlands for all regions of CR. These localities can be found in 6,621 of cadastral areas (67% of all cadastres without land consolidation). In 2,500 cadastral areas (25%), the acreage of these suitable localities ranges between 0.01–10 ha (in each cadastre). In theory, some potentially suitable surfaces exist in these areas, but they are not numerous. In contrast, in 3,906 of cadastral areas (40%), the acreage reaches 10–100 ha. The highest category includes 165 of cadastral areas (2%) with suitable localities of 100–200 ha and 46 of cadastral areas (0.5%) in the category over 200 ha. The growing need of increasing the water retention in the landscape predetermines the required land consolidations to be initiated in these localities.

The highest surface area of potentially suitable localities for the construction of retention reservoirs and wetlands was found in the region of Jihočeský (350 km^2). Historically, this region is a place of numerous fish ponds and artificial reservoirs (Pavelková et al., 2017). In the region of Vysočina, this surface area is 266 km^2, in the Plzeňský region 223 km^2, in Středočeský 176 km^2 (green colour in Fig. 9). In contrast, in the region of Ústecký, these surfaces are markedly smaller (46 km^2), and in the region of Zlínský they encompass 57 km^2. Figure 10 presents the order of regions of the Czech Republic according to the area of potentially suitable sites for the construction of retention reservoirs and wetlands.

Table 4. Number of cadastral areas in CR with suitable localities for construction of retention reservoirs or wetlands

Region	Number of cadastral areas (without land consolidation) with suitable locations for construction of retention reservoirs or wetlands (ha)				Total
	0,01 – 10	10 – 100	100 – 200	> 200 ha	
Praha	20	11	0	0	31
Jihočeský	250	770	45	7	1072
Jihomoravský	139	111	7	10	267
Karlovarský	146	222	14	0	382
Vysočina	266	676	24	2	968
Královehradecký	227	220	5	0	452
Liberecký	112	122	7	2	243
Moravskoslezský	121	145	17	5	288
Olomocký	139	127	16	8	290
Pardubický	199	162	7	0	368
Plzeňský	256	578	13	4	851
Středočeský	381	539	5	0	925
Ústecký	183	148	1	0	332
Zlínský	65	75	4	8	152
Total	2504	3906	165	46	6621

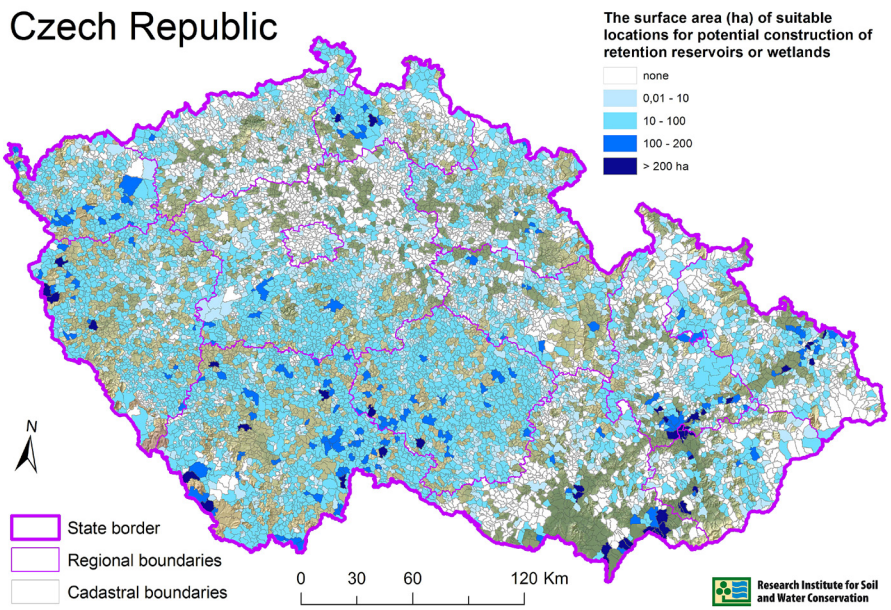

Fig. 8. The surface area of suitable locations for potential construction of retention reservoirs or wetlands in the cadastral areas without land consolidation

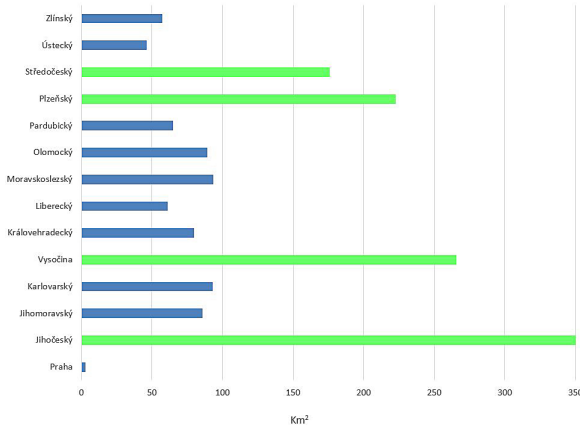

Fig. 9. The surface area of agriculturally exploited areas potentially suitable for construction of retention reservoirs or wetlands in cadastral areas without land consolidation

CONCLUSION

The process of land consolidation represents a unique tool of state policy for the promotion and application of protective erosion control and water management measures in CR. Since land consolidations have not yet been started in 60% of the CR territory, suitable localities (cadastral areas) for their preferential initiation should be defined. Land consolidations deal with a large spectrum of issues, and virtually any land consolidation is unique because it reflects the current and local needs of the area. In this study we selected three thematic factors according to which we analysed the degree of risk/suitability for initiation of land consolidation in the cadastral areas of CR. The first two factors represented the vulnerability of land to water and wind erosion. Every year, these processes result in massive degradation and loss of high-quality arable land. The third selected factor was related to the water retention in the landscape, which should be solved by finding potentially suitable localities for construction of retention reservoirs and wetlands.

The results of our analyses confirmed that CR is strongly threatened by water erosion. This fact was also confirmed at a local level by Podhrázská et al. 2015 who analysed the degradation of soil characteristics in the period 1978–2013 in a land block of 100 ha in southern Moravia and found that erosion resulted in a soil loss of 70,000 t.

Out of 9,830 cadastral areas without land consolidation, 56 % have exceeded the permissible erosive loss of 4 t/ha/year in more than 20% of agricultural land. The regions at the highest risk are Jihomoravský, Středočeský and Vysočina. Wind erosion threatens 18% of the cadastral areas without land consolidation, i.e. 1,174 of them. Manifestations of wind erosion are not as evident those of water erosion. However, the consequences represented by the loss of the upper layer of fertile soil by wind are serious. In the future, attention must be drawn this issue as well, and proper measures must be adopted. As reported by Podhrázská et al. (2008), land consolidations propose networks of wind breakers as appropriate

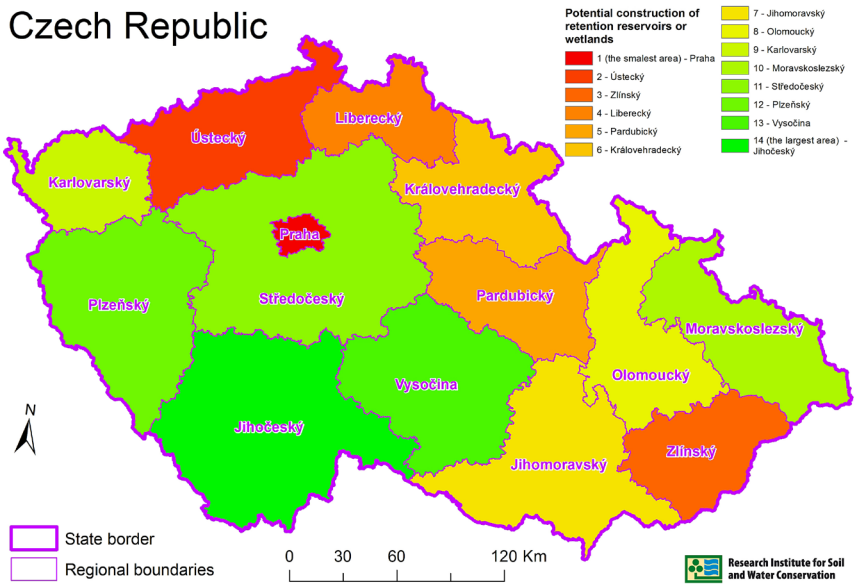

Fig. 10. Potentially suitable sites for the construction of retention reservoirs and wetlands

control of wind erosion. The localities at highest risk of wind erosion in CR are situated in the regions of Jihomoravský, Ústecký and Středočeský.

On the basis of the elaborated multicriteriaal analysis of the Czech Republic's vulnerability to water and wind erosion, the ranking of regions was evaluated according to the risk of erosion risk. In this way, the priority regions were identified as suitable for the intensive solution of the problem of protection against erosion through land consolidations. The regions of Jihomoravský, Středočeský and Pardubický are evidently the regions that are most vulnerable to water and wind erosion in CR. In these regions, the process of land consolidation should be accelerated and the erosion risk should be managed preferentially.

The pressing problems associated with the climatic changes and droughts have emerged in CR in recent years. Both 2015 and 2016 were exceptionally dry. Drought and the need of increasing water retention in the landscape have become the main question of debate at the level of government and state strategy (Ministry of Agriculture of CR, 2016). Identification of the localities which are unsuitable for agricultural production but potentially favourable for the construction of retention reservoirs and wetlands is now a hot topic. Such localities, pedologically unsuitable for agricultural production, are numerous in CR. These potentially suitable surfaces of 10–100 ha can be found in 40% of the cadastral areas without land consolidation. Most of them are situated in the regions of Jihočeský, Vysočina, Plzeňský, and Středočeský.

The thematic issues that could serve as a basis for initiating land consolidation are numerous. It is due to the variability of land consolidations, which comprise the rural space and landscape as a whole, as an integrated functional system. Our study is a partial contribution to solve the most relevant and urgent tasks in the rural landscape of CR.

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