SETOF Soil Erosion and TOrrential Flood
Prevention: Curriculum Development at the Universities of Western Balkan Countries

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WP1

Analysis of soil erosion state and torrential floods in Western Balkan Countries

Lead Organisations of WP1**: UNSCM; UB**
Participating Organisation: UNS; UNI; UBL; UNSA; INSZASUM; BOKU; UNIRC; FRI-BAS

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2. Analysis state of soil degradation/soil erosion in Serbia

Introduction

Serbia is located in the central part of the Balkan Peninsula and covers 88,361 km^2. The territory consists of two different regions: the large Vojvodina plain to the north and the hilly and mountainous area to the south, with the Danube and Sava rivers marking the border between them. Elevation in Serbia ranges from 17 m (near Danube River at Prahovo) up to the 2,169 meters (Midžor peak).
According to the results of the 2011 Census of population, released by the Republic Statistical Office, 7,186,862 inhabitants, or 92 inhabitants per km^2 live in Serbia. Serbia is classed as a medium populated European country. During the last decade, Serbia was characterised by a decrease in population rate, a decline in the birth rate and a concentration of population in urban areas. Based on the results of the 2011 Census, the population in Serbia decreased by 4% compared to 2002.

Status of the soil

The share of agricultural land in the territory of the Republic of Serbia is 60.2% and in the territory of Vojvodina, 82%. The structure of agricultural land, by category of use, has a high share of arable land (83%). Over the past fifteen years, the share of agricultural land has reduced by 10.6%, while the share of arable land has reduced by 10%. In terms of the purpose of use of agricultural land, the disappearance was greatest in terms of vineyards (20.7%) and least in terms of fisheries, reeds and marshes (2.5%). In terms of area, 179,036 hectares or 18% of pastures disappeared over the past fifteen years. It is important to note that ploughed fields and gardens in Serbia cover 3,355,000 hectares, which make up 79% of the total arable land. This is complemented by additional about 312,000 hectares of orchards and vineyards and about 587,000 hectares of meadows. The area that is not cultivated is about 855,000 hectares (pastures, reeds, marshes and fisheries).

The land cover of the Republic of Serbia is characterized by a large number of systematic units, which have arisen as a result of a variety of conditions and development of land. Soil genesis and evolution in Serbia have been crucially influenced by the land relief and its variable petrographic composition. A wide diversity of soils form through the long and complex process in a variety of geological, climate, water, and vegetation conditions.

Soil genesis and evaluation in Serbia have been influenced by geomorphological structure of the terrain and its variable petrographic conditions (Hadžić et al. 2002). The soils range from naturally fertile such as a carbonate chernozems on loess to the totally economically invaluably and unfavorable for formation of natural vegetation, such as solontchak and solonetz (Pavlović et al. 2017).

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According to the Pavlović et al. (2017) most frequent soil types in the Republic of Serbia are as follows:
(1) lithosol (WRB, Leptosol), an undeveloped soil composed of weathered rocks belonging to soil productivity class 8;
(2) arenosol, an undeveloped sandy soil, which is not suitable for crop production and also belongsto soil productivity class 8;
(3) kalkomelanosol (WRB, Lep tosol) and kalkocambisol (WRB, no adequate WRB name) are categorized in productivity class 7 and are used mainly as natural pastures or are forested with only small areas used for cultivation;
(4) ranker (WRB, Leptosol, eutric) is mainly used for pastures and meadows with smaller areas used for the cultivation of potatoes, barley and oats. Rankers belong to soil productivity class 7, meaning they are not suitable for intensive plant cultivation;
(5) chernozem is mainly found in Vojvodina where it accounts for approximately 1,000,000 ha, with only 200,000ha in other parts of Serbia. It is categorized in soil productivity class 1, which in conditions of optimal irrigation produces high, stable yields of cultivated crops;
(6) vertisol is a soil type which belongs to productivity class 3. It has an unfavorable water, air and temperature regime, but has favorable chemical characteristics;
(7) eutric cambisol belongs to soil productivity class 2. It is a medium heavy soil which has a very favourable water and air regime. It is suitable for crop, vegetable, fruit and viticulture production;
(8) dystric cambisol belongs to productivity class 5 or 6, depending on the gradient of the terrain on which it is formed and solum thickness. In nature, this soil is covered with forest vegetation and small areas are used for fruit, crop and vegetable cultivation. Satisfactory yields can be obtained when growing potatoes, rye, oats and barley;
(9) ranker (WRB, Leptosol, eutric) and eutric cambisol are characterized by unfavourable physical and chemical properties and are mainly used as pastures and meadows. Due to their significant limitations for plant cultivation, they belong to productivity class 7;
(10) pseudogley (WRB, Stagnosol) is soil which is characterized by an unfavorable water, air and temperature regime and belongs to productivity class 4. More intensive use of pseudogley for plant cultivation is possible if accompanied by complex ameliorative measures;
(11) fluvisol and humogley (WRB, Gleysol, humic) belong to productivity class 3, which comprises soils that are used for plant production, but with certain limitations. Due to the additional water content ofthe solum from flood and/or underground water and the mechanical composition, fluvisols and humogleys (WRB, Gleysol, humic) are characterized by an unfavourable water, air and temperature regime;
(12) solontchak and solonetz are used as natural, quite barren pastures due to their unfavourable chemical and physical properties. In terms of their suitability for plant production, solontchak and solonetz belong to productivity class 7.

The Soil Map of Serbia represents a rich assemblage of numerous soil types that are presented in the Figure 1.

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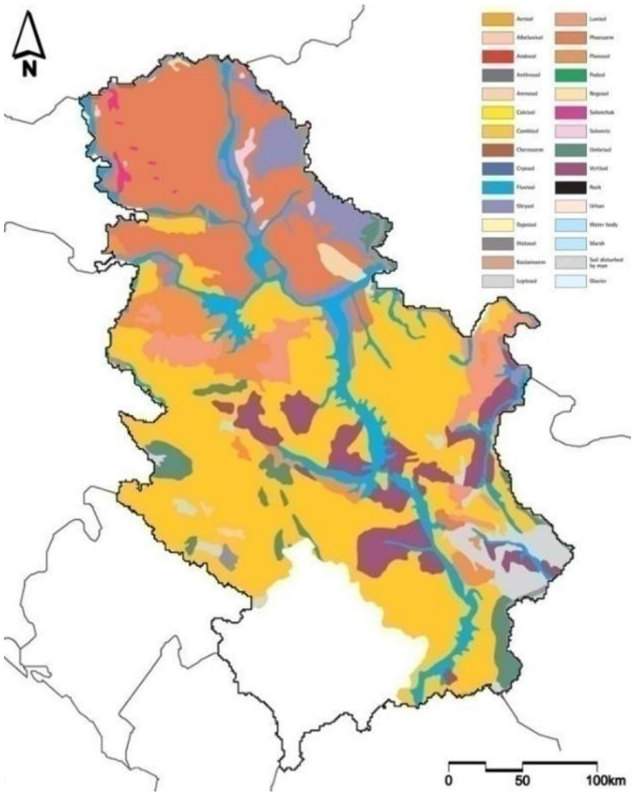

Fig.1. Soil map of Serbia (modified map from Soil Atlas of Europe, 2005); Source: Ristić et al. (2017)

Soil degradation

Nowadays, all types of soil degradation are present in Serbia such as degradation of soil physical properties (compaction, loss of the structural stability), chemical (salinisation, acidification, and nutrient depletion), biological degradation and soil loss (due to soil erosion and landslides).
The factors of degradation of soil in Serbia include: permanent loss of agricultural land (mostly due to the following reasons: growth of settlements, industrial, mining, power generating and transport developments, water erosion, wind erosion, salinisation of soil, loss of nutrients, chemical pollution from bio-industrial sources, mechanical compaction of soil under the impact of heavy machinery, turning of soil into marshes, floods, loss of soil fertility, etc.).

Indicators for assessing the risk of land degradation

According to the Regulation on the Programme for the Systematic Monitoring of the Soil Quality, soil degradation risk assessment indicators and a methodology for the development of the remediation programmes ("Official Gazette of RS" no. 88/10), indicators for evaluation of risks from soil degradation were defined as follows:

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1) Degree of endangerment of land from erosion;
2) Degree of endangerment of land from loss of organic materials;
3) Degree of endangerment of land with risk from land compaction;
4) Degree of endangerment of land from salination and /or equalization;
5) Degree of endangerment of land from slides, except slides, which can be created by mining activities during for the duration of activities;
6) Degree of endangerment of land from acidification;
7) Degree of endangerment of land from chemical pollution.

The selection of indicators for assessing the risk of land degradation is performed on the basis of the expected condition or results from previous studies. Indicators for assessing the risk of degradation are evaluated on the basis of general elements for the assessment of land degradation, which are given in the Annex of the Regulation. The degree of threat from chemical pollution of land is determined on the basis of the limit values and remediation of pollutants specified in the Regulation. Data collection and production of indicators related to soil erosion and the content of organic carbon in the soil need to be harmonised with the methodology outlined in the Technical Instruction for Data Collection for Soil Erosion and Data on Organic Carbon in the Soil for Europe through the EIONET network.

Soil erosion

Water erosion is a very complex process of destroying soil particles at the soil surface (or in stream channels) including their transport from the upper to the lower parts of the watershed, by the energy of overland flow at the slopes or flowing in the streams. Geological erosion is generally slow (less than 100 $m^3 km^{-2} years^{-1}$). Accelerated erosion which interests us in this paper is developing in relation with human activities: overgrazing, clearing the forests, repeated fires, poor soil management, reduced fallow, unbalance of nutrients and soil organic matter will progressively lead to soil degradation, runoff and erosion (Roose, E., 1993). Erosion processes and sediment transport are wide spread all over the earth surface affecting many of human activities. The essential economic activities such as: agriculture, forestry, industry, water management, civil engineering, etc., have more or less something in common with the erosion and sediment problems. The problems are also present in non-economic activities such as: environment protection, recreation, etc. The economic and social effects of soil erosion and social effects of soil erosion and sediment transport are therefore very important.

Geomorphological features of the Serbian territory are strongly related to water erosion predominating in the southern region and wind erosion in the northern plain. The further review of erosion problems relates to the soil erosion by water. Water erosion depends on a number of physical-geographical and anthropogenic factors such as parent material, composition relief, climate, vegetal cover (land use). As a consequence of such natural conditions, practically all of the territory of Serbia is under erosion processes of different intensities (from low to the excessive erosion).

Water erosion causes great damages such as soil loss, water loss, loss of nutrients, disturbance of runoff regime in the watersheds, catastrophic floods, reservoirs siltation,

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etc. Damage initially caused by erosion is the loss of the upper fertile soil horizon, coupled with a loss of organic and mineral nutrients from steep and ploughed land, leading to inadequate air and water relations in the soil. The damage caused by water erosion results from detaching and transporting the fertile soil horizon from the slopes, as well as through torrential flows. Erosion removes organic and mineral nutrients from the topsoil, causing the soil structure to become destroyed, leading to the disturbance of soil characteristics of air and water relationship.

One of the most widely accepted and applied empirical models in Serbia and the Balkan region, East and Central Europe, is the Erosion Potential Model (EPM) (Kostadinov et al. 2018). For the classification of erosion processes in Serbia, the EPM is used predominantly, according to which erosion is grouped in five categories of intensity - from very weak to excessive. The map of erosion on the territory of the Republic of Serbia is shown in Figure 2. It also presents a partially modified map taken from the Water Management Basis of the Republic of Serbia (due to the additionally performed erosion control works). From the erosion map it can be seen that in the northern, flatland area of the country the most frequent are week and very week erosion, while in the central and southern parts of Serbia erosion processes with a significantly higher intensity, with pronounced areas of intensive and excessive erosion. In this area, very week erosion occurs only in the plains, in the valleys of the river. Distribution of water erosion processes in Serbia is provided in the Table 1.

Table 1: Distribution of Water Erosion Processes in Serbia (Source: Water Resources Management Basic Plan of Serbia, 1996)

Category	Erosion Processes Intensity	Area	
I	Excessive Erosion	2,888.0	3.27
II	Intensive Erosion	9,138.0	10.34
III	Medium Erosion	19,386.0	21.94
IV	Weak Erosion	43,914.0	49.78
V	Very weak Erosion	13,035.0	14.75
Total		**88,361.0**	100

Sediment transport related to gross erosion (total erosion production), is also considerable. Total average annual gross erosion in Serbia amounts to 37,249,975.0 m^3, i.e. specific annual gross erosion amounts to 421.57 $m^3 \cdot km^{-2}$ while annual sediment transport is 9,350,765.00 m^3 and specific annual sediment transport is 105.80 $m^3 \cdot km^{-2}$. If annual gross erosion is turned into equivalent hectares of soil 20 cm thick, it can be concluded that every year 20,525 ha is endangered.

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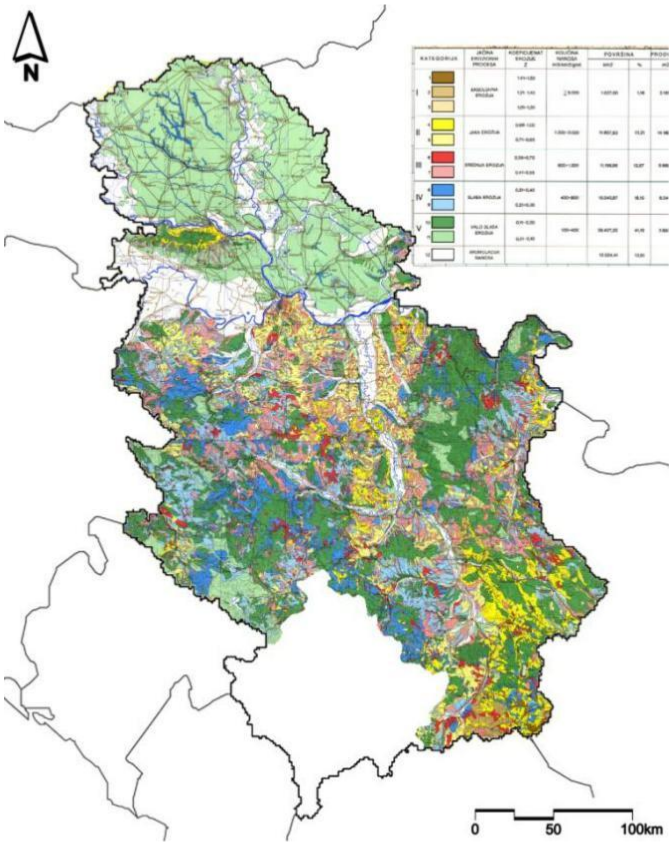

Figure 2: Soil erosion map of Serbia (modified map from Soil erosion map of Serbia, 1983)

Wind erosion in Vojvodina

Natural and anthropogenic conditions in the area of Vojvodina favor the occurrence of water and wind erosion. In this, the dominant form is wind erosion. The occurrence of wind erosion is most often related only to areas where it has taken on catastrophic conditions and where the damage is very visible (deserts, sands, etc.). However, the fact is that wind-induced erosion processes are present in all areas and different types of soil, and especially in large plains and unprotected agricultural plots that are exposed to aggressive climate-meteorological impacts. Global considerations of land degradation by various degradation processes show that significant areas, not only in the arid and desert regions of the World, but throughout Europe, are more or less affected by wind erosion. According to analysis by competent institutions and experts, it is estimated according to the European Environment Agency - EEA (2000) that wind erosion in Europe is endangering about 42 million hectares; or as stated by Oldeman (1990), about 19% of available arable land. Certainly, the area of Vojvodina is not exempted from similar wind-borne effects, so based on natural characteristics it is located in the zone of moderate to medium intensity of wind erosion, but with potentially high to very high risk of the occurrence and intensification of these processes caused by human activity

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(United States Department of Agriculture - USDA, 1999). In addition, in the Report on trends in the quality of environment and natural resources of the Ministry of Natural Resources and Environment, the Republic of Serbia (2003) states that, due to intensive agriculture, significant areas of arable land in Serbia are very degraded, and that in Vojvodina "The main cause of the deterioration of soil quality is wind erosion". After all, even in the beginning of the 20th century it was clearly pointed out that "agronomic sciences will not achieve top successes unless the forces of water and wind erosion are not studied and find ways to minimize their effect on as little as possible" (Savić et al., 2002).

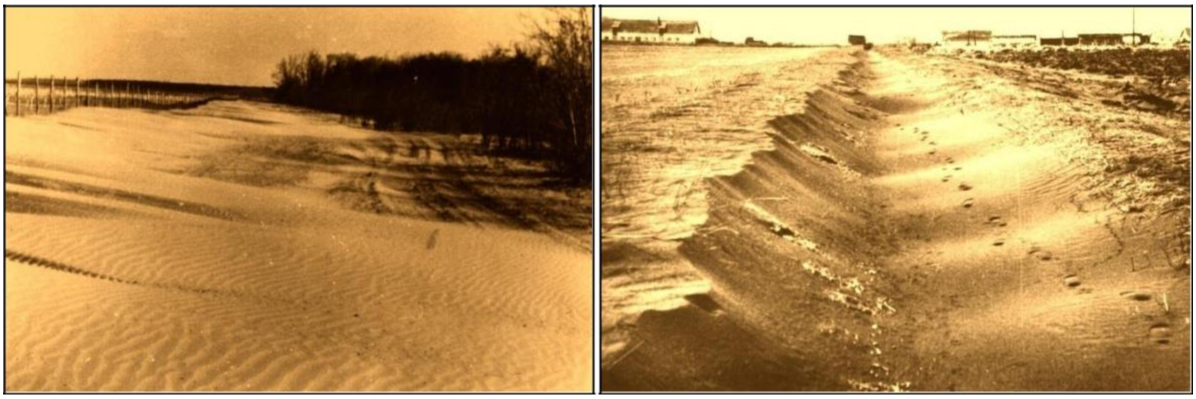

Figure 3. Wind erosion in the orchard of the Subotica-Horgos sandstones and the melioration canal

The reasons and causes for this assessment of the vulnerability of the Vojvodina plain to wind erosion are found in the following facts. Natural and anthropogenic conditions (relief, climate, soil, vegetation, way of land use, organization of the land territory, etc.) favor occurrence and development of wind erosion. Continental climate of the Pannonian lowland with frequent, strong and dry wind speeds of up to 40 m/s; annual rainfall is sometimes below 300 mm; high temperature amplitude; a distinctive plain relief; insufficient (6.4%) and poorly distributed wood land; over 70% of areas under arable land with a fine mechanical composition that are part of the year without any vegetation cover and which can be highly erodible in intensive agricultural production; large agricultural plots aggregated by land consolidation; small areas under irrigation systems; altered sowing structure; perennial extreme drought periods are just some of the factors that indicate that the potential threat to Vojvodina by wind erosion is really high, and that with the possible realization of the forecasted climate change it can be even more higher. In conjunction with anthropogenic factors, inadequate method of use and organization of land, which most often play a crucial role, the erosion processes in this highly agricultural area, in the case of the most unfavorable coincidence of relevant factors, can be intensified to the extent of catastrophic scale and shape. In such circumstances, significant soil degradation can occur, taking of nutrients and protective substances from the soil, as well as the spread of bulk pollution and endangering the production of health-safe food. Therefore, wind erosion in the area of Vojvodina belongs to important factors of soil degradation. This type of erosion caused by wind causes

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evident damage, primarily in agriculture and water management (Figure 3), but adversely affects all components of the environment, and hence the obvious agronomic, water management, economic and environmental aspects of this problem (Savić, 1999; Letić and Savić, 2002; Savić and Letić, 2003).

Wind erosion is a complex process, not only by the number and interconnectedness of the factors that lead to its intensification, but also in the sense that id develops in several phases: the tearing and launching of soil particles of various shapes, dimensions and composition; moving them to a certain distance; and finally, temporary or permanent disposal, deposition. Adverse environmental impacts occur at each of these phases.

Unlike fluvial erosion, in which the direction and direction of the erosion processes are determined by the dominant inclination and the fall of the terrain, wind erosion can occur in all directions. The complexity of wind erosion is reflected in that its main agent is wind which is a very complex and variable (by all elements: direction, direction, velocity, strength, frequency). The effects of the climate are not directly expressed - through the impact on the intensity of wind erosion, but also indirectly - by influencing other factors of the process, by "preparing" the surface layer of the soil (drying, crushing aggregates, reducing the roughness, vegetation state, etc.) in this way, the preconditions for the coincidence of all the necessary elements for the production and initiation of the sediments at a certain point. Inclusion of climate properties is indispensable in testing the potential danger of wind erosion, and in this sense, the term "erodibility of climate" is often used. The climatic factor does not depend solely on individual relevant sizes, but precisely from their unfavorable coincidence (the occurrence of sufficiently strong wind with a lack of precipitation and higher temperatures - drought).

A significant factor contributing to the intensification of the erosion process in a large way is land use and the presence of areas under forest vegetation. As much as 85% of the total area of Vojvodina is covered by agricultural land, and 75% is cultivated under arable land. The application of agro-technical measures in intensive agricultural production results in the vulnerability of surfaces to erosion processes (bare, without any vegetation cover and a crushed surface layer of soil). In addition, Vojvodina belongs to areas with extremely low forestation (www.psp.vojvodina.gov.rs; Vlatković, 1986). Only 137,000 ha, or about 6.4% of the total area of Vojvodina, is covered by forests. For certain areas in the zone of agricultural regions, forestry is only 1.5% on average, and in some areas it is below 1% (Figure 4, Figure 5). There are areas where there are no trees in the range of 10 to 25 kilometers (Dožić, 2006). Therefore, this area has all the characteristics of the agricultural steppe and it is considered to be a highly endangered (agro) ecosystem of degradation processes caused by erosion. Estimated optimal forestry of Vojvodina is about 14-15% of the total area (Vlatković, 1986).

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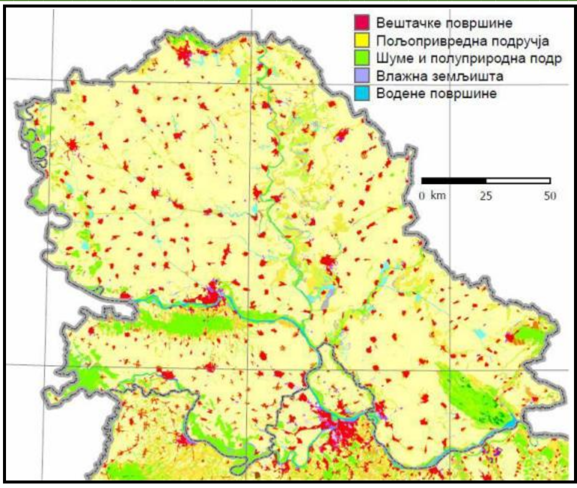

Figure 4. CORINE Land Cover - Vojvodina. (www.eea.europa.eu)

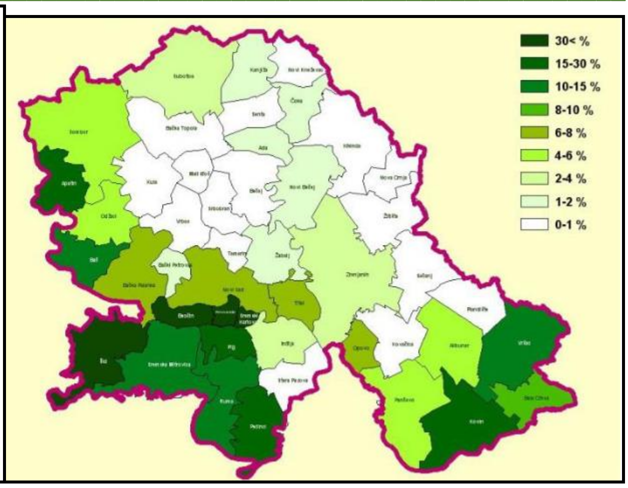

Figure 5. Map of forestation in Vojvodina by municipalities (%). (www.psp.vojvodina.gov.rs)

Studies of wind erosion in Vojvodina were concentrated mainly on two characteristic sites: Deliblatska and Suboticko-Horgoška peščara (Jevtić, 1975; Letić, 1989; Savić, 2000; Velojic, 2016). The significance of this research is remarkable for the first concrete, immediate field measurements and process determinations, but also due to the ecological values and specificities of the sites themselves. However, for Vojvodina as a whole, such sandy soils (arenosol) cover only a few percent (approximately 2%). Thus, in order to give a global assessment of the degree of development of wind erosion in this area and its adverse environmental impact, it is pertinent to look at and define this process primarily on soils of the type Chernozem and its like.

The most important and long lasting monitoring of the process of wind erosion and relevant causative factors is carried out in parallel and systematically on two eolomeric stations ("A" and "B") on the Subotica sandstone in the vicinity of the settlement Tavankut. These sites are characterized by soil type arenosol, light mechanical composition and potentially the most pronounced erodibility. In addition, monitoring of wind erosion was also established on the experimental field of Rimski Šančevi near Novi Sad; and in the area of PIK Bečej under the irrigation system. These two experimental erosion fields are found on soils of the type Chernozem, on arable land under conventional agricultural production. The representativeness and importance of these sites comes out from the fact that Chernozem and its similar soils are by far the most prevalent, covering over 80% of all arable areas of Vojvodina, and from the aspect of agriculture they are most important (Savić et al., 2002). The intensity of the erosion processes is measured by static and rotary catchers of eolian sediments. Static eolomers are of the type "deflametar", they are set in a group of four clips oriented to different directions, cardinal directionjs: NO, SE, SW and NW, selected on the basis of dominant winds (Figure 6).

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Figure 6. Rotary and static catchers of eolian sediments

A comparative depiction of the intensity of wind erosion on the Subotica-Horgos sandstone, on both erosion fields "A" and "B" (Figure 5), illustrates the results of the research which indicate from 4 to as much as 98 times, on average about 20 times the annual production of eolic sediments from unprotected cultivable of land (erosion intensity from 1.3 to 43.2 on average 6.9 kg / m per year) compared to land in forest vegetation protected area (0.1 to 0.6 average 0.36 kg / m per year).

On the other two sites, the annual erosion intensities on the Chernozem (Rimski Šančevi and Becej) soils are significantly smaller and more uniform than at the Tavankut measuring station - "A", but at the same time higher, on average 3-7 times, than on the Tavankut - "B" which is also on the sand but under protection from the wind (Figure 7). Measured quantities of eolic deposits at the Rimski Šančevi ranged from 0.8 to 1.5 kg /m' annually (on average 1.15), and at the location Becej 1.05 to 3.1 kg / m' per year (about 2.50 on average). This relationship between the intensity of deflation processes on different erosion fields is clearly confirmed by the powerful calming effect of vegetation, even on potentially highly erodible lands of light mechanical composition such as Tavankut sands. And on the soil of the Chernozem type, the most intense erosion processes take place during the early spring and autumn (Savić, 2000).

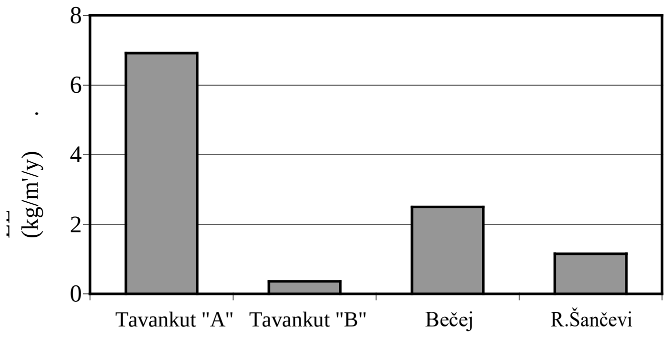

Figure 7. Average annual intensities of eolic erosion measured by static catchers, EE deposits (kg / m / year). Measuring stations Tavankut "A" and "B", Bečej and R. Šančevi

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The potential intensity of wind erosion in the area of Vojvodina was also determined by the method of calculation (Pasak, 1967), which, on the basis of the relevant elements of the climate and substrate, defines the potential production of the eolian sediments. According to this method, the representative samples of all regions were selected and relevant parameters were analyzed, and the results of the obtained values of potential intensities of wind erosion were shown on the map of the potential vulnerability of the area of Vojvodina with wind erosion (t / ha / year) (Figure 8). A summary review, according to the degree of vulnerability of the area of Vojvodina to wind erosion, is given in Table 2(Letić et al., 2011), with the conclusion that over 86% of the areas are in the category of disturbed and very disturbed land.

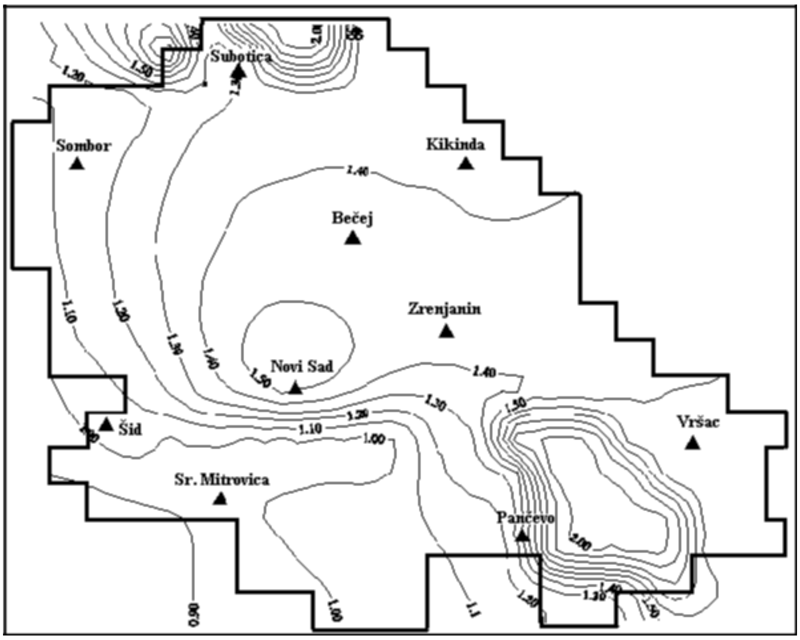

Figure 8. A schematic map of Vojvodina with the isolines of potential annual erosion (t / ha / year) according to the Pasak method

Eolic sediments originated from agricultural surfaces is burdened by the presence of various organic (humus, plant parts, seeds, etc.), nutrients and crop protection chemicals (mineral fertilizers, pesticides, etc.), and its occurrence in aquatories is adversely affecting water quality by direct toxic action, by the influence of excessive algae development and the growth of other aquatic weed vegetation, the intensification of the eutrophication process, etc. which can pose serious difficulties for the state of such ecosystems. In addition to the quantitative analysis of the production or the intensity of wind erosion, the properties of the affected eolic sediments should be monitored regularly. With unprotected fertile plowed orange surfaces, wind erosion triggers the finest soil particles - a deposit rich in mineral and organic matter. The removal of nutrients from soil through eolic erosion depends on the degree of development of erosion processes and the composition of the surface layer of the soil.

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Table 2. Potential intensities of wind erosion in Vojvodina determined by the Pasac method (VOV, 1985; Letić et al., 2011)

WIND EROSION			DEGREE OF VULNERABILITY
Intensity	Area		
(t/ha)	(1000 ha)	(%)	
0.30	137.09	6.37	I – Very low (6.37%)
0.80 0.90	37.80 117.00	1.76 5.44	II - Low (7.20%)
1.00 1.10 1.20 1.30 1.40 1.50 2.00	 257.40 244.80 356.40 476.27 424.80 54.90	 11.96 11.38 16.57 22.14 19.75 2.55	III - Moderate (84.35%)
2.00	44.84	2.08	IV - High (2.08%)
Total:	2.151,30	100.00	

The observed values of nutrients in most sediment samples significantly exceeded their average content in the surrounding intensively cultivated land area, such as the dominantly present Chernozem soil type (Bogdanovic et al., 1993; Zivkovic et al., 1972). For instance, it was found that around 83% of the analyzed canal sediment samples N content exceeded the average reference N content for the Chernozem soil type by> 7.5-fold (in average by 2.4-fold). The portion of sediments with P and K content that exceeded the average reference level for the surrounding dominant soil type was detected in> 60% of the analyzed samples. Also, it was detected that the P and K content in canal sediments exceeded those in the surrounding land by 12.5-fold and 17-fold respectively (in average by 2-fold).

Certainly the occurrence and transport of eolian deposits from remote areas can not be prevented, but their impact on degradation processes is much less frequent and to a lesser degree. There are many more important processes of wind erosion that occur directly on the cultivated, loose unprotected areas of the arable land in immediate cropping, with an unfavorable coincidence of causative factors. It is therefore desirable that such processes be reduced to as little as possible by the optimal management of land and water resources (BMPs – "Best Management Practices"), by establishing appropriate wind and erosion protection, by applying adequate meliorative and agro-technical measures to repair and preserve favorable soil structure and increase its resistance to the effect of wind erosion.

Land cover and changes in land use

Land use change is one of the indicators for monitoring the status of the land. The indicator is calculated by analysing maps based on images from the Landsat satellites CLC (Corine Land Cover) base for 1990, 2000 and 2006, i.e. on the basis of the trend of increase in surface area which changed the purpose of land use in a certain period of time (5 - 10 years) on the basis of the CLC database changes (Table 3).

Table 3: Origin of urban land taken by different categories of land cover (Source: Corine Land Cover database)

Categories	Land use in ha		
	1990 - 2000	**2000 - 2006**	**2006 - 2012**
Pastures and mixed farmland	2,818	2,280	1,148
Arable land and permanent crops	2,468	939	1,777
Water bodies	58	0	14
Open spaces with little or no vegetation	0	0	0
Natural grassland	12	3	8
Forest and transitional woodland shrub	2,094	1,066	1,264
Wetlands	21	36	30

The analysis of Corine Land Cover database for 2006 revealed that agricultural areas dominate in Serbia, spreading over 58% of the country. About 26% is occupied by arable land, 16% by complex cultivation and 13% by principally agricultural land with areas of natural vegetation.
Corine Land Cover database analysis for 2012 shows presence of 29 out of 44 classes of CLC nomenclature. Agricultural surfaces are dominant with over 55% of the entire territory of the country. Woods and semi-natural areas cover almost 40% of the land (broadleaves forests – 27 %). Land provided under artificial surfaces covers almost 3.6% of the territory, and the rest of approximately 1.6% is classified as humid areas and water basins (SEPA, 2015).

Analysis of the change of intended land use in 2006-2012 period carried out by shows that most changes occurred under artificial surface category (3,037 ha increase). Agricultural land is reduced by 4,391 ha in the observed period. Surfaces under the category of forests and semi-natural areas increased by 1,157 ha, 420 ha of humid regions – classified under inland wetlands – disappeared, while areas under water basins increased by 686 ha, mostly as a result of construction of new artificial lakes. The indicator defines trends in the change of intended use of agricultural, forest.

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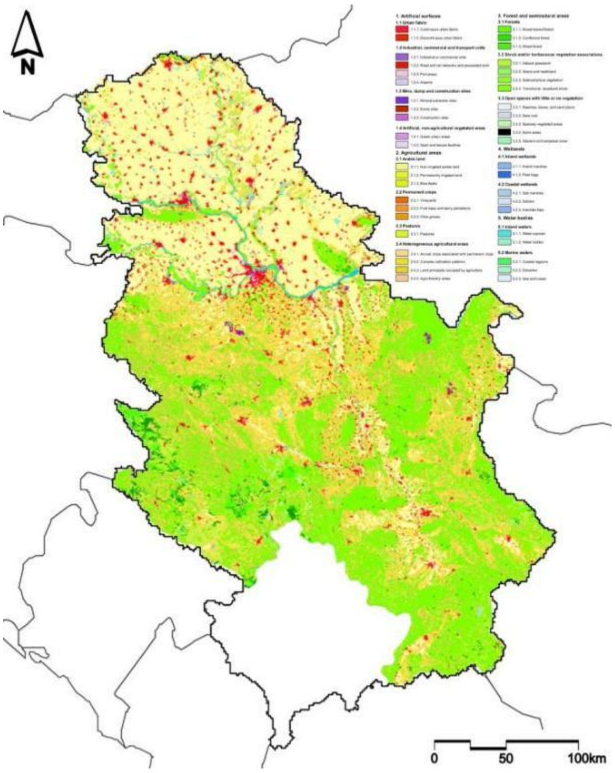

Figure 9: CORINE Land Cover (modified map from CORINE Land Cover (CLC), 2006)

Land acquisition by the expansion of artificial surfaces and the accompanying infrastructure is the main cause of the change in the use of land (SEPA, 2009). This type of change leads to disruption of biodiversity, reduction in the number of species and habitat and fragmentation of the habitat.

According to the Serbian land use statistics in 2016 the Republic of Serbia has 3,439,887 ha of utilized agricultural land and 2,597,808 ha of arable land (Table 4).

Table 4 **:** Utilized agricultural area by categories in 2016 (ha)

Total	**Arable land**	**Permanent grassland**		**Permanent plantations**			
		Meadows	**Pastures**	**Orchards**	**Vineyards**	**Nurseries**	**Other permanent plantations**
3,439,887	2,597,808	342,926	311,211	164,062	22,150	1,112	618

According to the Statistical Yearbook (2017) arable land participated with 75.5% in the total agricultural area, fruit plantations/orchards with 4.8%, vineyards with 0.6%, permanent grassland with 10.0% and pastures with 9.0%. In the structure of sown

arable land areas cereals participated with 67.9%, industrial crops with 15.7%, vegetables with 2.6%, and fodder crops with 9.1%.
When compared to the 2005, the share of agricultural land decreased by 1,672,000 ha or 33%, while the share of arable land decreased by 39%.

The Environmental Protection Agency (EPA) is monitoring indicators of land use changes. The EPA is legally covered by national and international regulations and report to the European Agency for Environmental Protection (EEA) - Indicator CSI 014 - Land take; UNECE - Indicator E21 - Land uptake.

Organic carbon content in the soil

In Serbia, a systematic assessment of organic matter reserves in soils has not yet been carried out been done yet. The results of the analysis carried out by the Provincial Department of Agriculture in 2002 - 2006 in the territory of Vojvodina show that the humus content of arable land is above 3%. The results of the analysis of humus, made in 2008 in Vojvodina, show that humus content has the average value of 3.16%. The results of the analysis of humus content in Central Serbia in 2008, indicates that 49.9% soil has low (1 - 3%) to moderate humus content (3 - 5%). Based on the recommendations and procedures set out in the Proposal for a Directive of the EU, it is necessary to establish a measurement program to mitigate or prevent organic matter decline. Countries with inadequate datasets regarding the organic matter in the soil should immediately implement sampling programs to determine the baseline status of the organic matter in the soil.
The land is the main terrestrial reservoir of carbon, even small carbon stock changes may affect the overall carbon balance in terrestrial ecosystems. The organic carbon content in the topsoil (0-30 cm depth layer) in the territory of Serbia is 705.84x10^{12}g (Tg).
In 50% of the territory of Serbia, soil organic carbon stored in the topsoil is up to 2%. Organic carbon stock in the topsoil (0 - 30cm) is 40.71% higher in forests and semi-natural areas compared with agricultural land.

An indicator of the content of organic carbon in the soil is calculated on the basis of information on the content of organic carbon expressed in t /ha and in %, for the topsoil layer of 0 - 30 cm and a layer of 0 - 100 cm. A list of accepted pedotransfer function for determining bulk density necessary for determining the content of organic carbon in the soil is available in the Technical guidelines for the collection of soil erosion and soil organic carbon data for Europe through EIONET, (European Commission, 2010).
The analysis of samples obtained from agricultural land in 2013 during a systematic control of agricultural soil fertility, indicates that the majority of samples (54.21%) had a low organic carbon content (1.1 - 2%), middle organic carbon content (2.1 to 6%) had 32.96% of the samples, while a very low content (<1%) had 12.83% of the samples. Reserves of organic carbon in the soil on the basis of land use at a depth of 0 - 30 cm are shown on the map (Figure 10).

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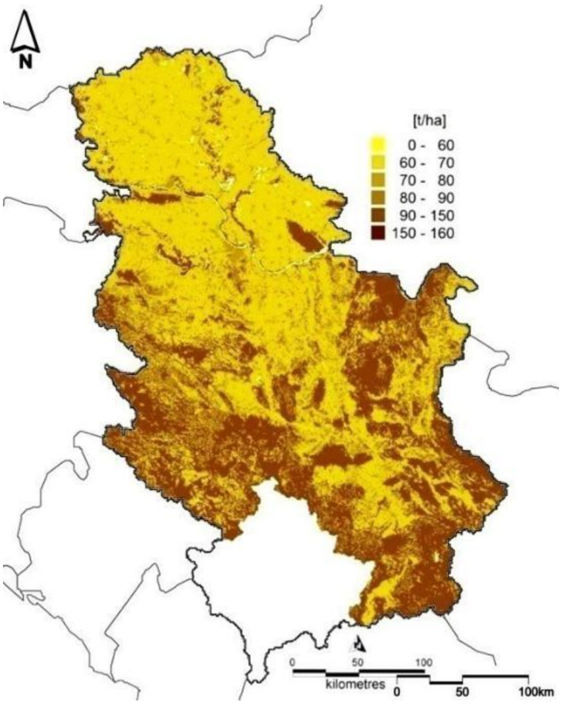

Figure 10: Map of organic carbon content in soil in Serbia (modified map from Report on the state of the environment in the republic of Serbia, 2015)

Management of contaminated sites

Localized pollution is linked to areas of increased industrial activity, inadequately regulated landfills, mineral extraction sites, military warehouses, and areas where there has been accidents and pollution of land. The management of contaminated sites can be done based on indicators (list of indicators related to land). Since 2006, the Agency for Environmental Protection has begun to develop a national inventory of contaminated sites. On the territory of Serbia, 422 sites are identified, of which 366 sites are potentially contaminated.

According to the Inventory of Contaminated Sites, in 2013 (see Figure 3), public municipal landfill sites occupied the largest part of the total sites (43.13%), followed by industrial and commercial sites (36.30%), and industrial waste landfills (10.43%). The territory of Serbia has 3,251 illegal landfills, mostly located in rural areas. A database of potentially contaminated and contaminated sites in the industry includes 222 sites, and the largest contribution to localised pollution of land has oil industry (41.89%), followed by the chemical industry (14.41%), metal industry (11.71%), power plants (8.57%) and mines (4.50%) (Vidojević et al, 2015).

The annual national costs for managing contaminated sites in the EU amounted to 10 euros per capita, and in the Republic of Serbia, it is 40 euros per capita.

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Institutional set-up concerning soil management, legal and policy

governance Organization of soil management

The soil protection authority in Serbia is the Ministry of Agriculture and Environmental Protection (MAEP). In 2009, the Directorate for Agricultural Land was established in the MAEP, that is according to the Law on Agricultural Land, responsible for performing tasks regarding protection, development, and use of agricultural land and the management of agricultural land owned by the state. This body consists of five organizational units, and one of them is the Department for the Protection and Development of Agricultural Land.

MAEP is responsible and involved in the protection and improvement of the environment; inspection in the area of environmental protection; environmental protection; air protection; climate changes; water pollution protection in order to prevent deterioration of the quality of surface and groundwater; protection of land from pollution, management of chemicals and biocide products and others.

The Serbian Environmental Protection Agency (SEPA) was established in 2003 as a body within the MAEP responsible for professional activities related to the development, coordination and management of the national information system for environmental protection (monitoring the state of environmental factors through environmental indicators, preparing the registry of pollutants, etc.); implementation of the national monitoring of air, water, land and other resource quality; the collection and compilation of environmental data, processing and preparation of environmental condition reports and implementation of environmental policy; cooperation with the European Environment Agency (EEA) and the European Network for Information and Observation (EIONET), as well as other duties specified by law.

Legal framework

The laws which regulate the area of land resources in Serbia are primarily the Law on Land Protection (OG of RS, No.112 / 15), the Law on Agricultural Land (OG of RS, No. 112/15), and the Law on Environmental Protection (OG of RS, No 43/2011).

The Law on the Land Protection is the most important law in the field of land resources that regulates the protection, systematic monitoring, remediation, re-cultivation, inspection, and other issues.

On the basis of the Law on Environmental Protection, the Serbian government adopted a Regulation on the program of systematic monitoring of soil quality, indicators for risk assessment of the soil degradation and a methodology for the development of remediation programs (OG of RS, No. 88/10).

Ordinance on the content and method of environmental protection information system management (OG of RS, No 112/09) provides the basis for the Regulation on the National List of Indicators of Environmental Protection (OG of RS, No. 37/11). The National List of Indicators includes a set of indicators related to land, which support the systematisation of information on the condition of land, land use changes and factors regarding land degradation. Contaminated site management is regulated by the

regulation on the establishment of criteria for assessing the status of the endangered environment and priorities for rehabilitation and remediation (OG of RS, No. 22/10).
The establishment of systematic monitoring of soil quality has a legal basis in the Law on Environmental Protection ("Official Gazette of RS" no. 135/04), 135/2004, 36/2009, 72/2009, 43/2011) and it is in line with the objectives set out in the national strategies National Programme of Environmental Protection ("Official Gazette of RS" no. 12/10) and in the National Sustainable Development Strategy of the Republic of Serbia ("Official Gazette of RS" no. 57/08).
In response to concerns about the degradation of soils in the EU, the Commission published the Thematic Strategy for Soil Protection in 2006. The proposal for the Directive, which establishes the frameworks for soil protection was published together with the Thematic Strategy but has never been adopted. On the contrary, Serbia adopted its own Law on Land Protection. Before the adoption of this law, soil protection was largely ensured through the Law on Agricultural Land and the Law on Environmental Protection. Many ordinances and regulations for land monitoring, adopted in the period 2009 - 2011 and according to the Law on Environmental Protection, are fully compliant with EU requirements.
A rulebook on the program of systematic monitoring of soil quality, indicators for risk assessment of the soil degradation and a methodology for development of remediation programs are provided as suggested by the European Commission in 2006 (COM (2006) 232). Soil contamination represents a recognized threat in Europe, but even so, it is difficult to quantify the real level of localised pollution, given that many European countries do not have comprehensive inventories of contaminated sites. The EU has no legal framework that obliges States to identify contaminated sites. Identification and monitoring of the contaminated sites in Serbia are harmonised with EU regulations: The European Pollutant Release and Transfer Register (E-PRTR) 166/2006 / EEC; Directive on Integrated Pollution Prevention and Control 19 96/61/EEC, 2008/1/EEC; Regulations of the European Agency for Environmental Protection (EEA) (Indicator CSI 015 - Progress in management of contaminated sites).
Monitoring the state of erosion and organic carbon in the soil is carried out in compliance with the Technical Guidelines for the Collection of Soil Erosion and Soil Organic Carbon Data for Europe through EIONET, 2010 (European Commission, Directorate General JRC).

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