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

Co-funded by the Erasmus+ Programme of the European Union

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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WP1 - Analysis of soil erosion state and torrential floods in Western Balkan Countries

1.1. Analysis state of soil degradation/soil erosion in WBC

Regional report

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Introduction

The Western Balkans is a neologism coined to describe the countries of "ex-Yugoslavia (minus Slovenia and Croatia) plus Albania". The region includes Serbia, Bosnia and Herzegovina, Montenegro, North Macedonia and Albania. Western Balkan Countries (WBC) are located in Balkan Peninsula in Southeast Europe.

Soil erosion is considered as one of the major threats to European soils, particularly in the Mediterranean areas *(*CEC, 2002*).* Erosion is understood to be a physical phenomenon that results in the displacement of soil and rock particles by water, wind, ice and gravity. The South and Southeast region of Europe is significantly prone to water erosion. In parts of the region, erosion has reached a stage of irreversibility and in some places erosion has practically ceased because there is no soil left. With a very slow rate of soil formation, any soil loss of more than 1 t/ha/y can be considered as irreversible within a time span of 50–100 years. Losses of 20 to 40 t/ha in individual storms, that may happen once every few years, are measured regularly in Europe with losses of more than 100 t/ha in extreme events (Morgan, 1992).

Relief of the WBC is dominantly hilly, hilly mountain and mountain. Most of the area is covered by mountain ranges running from the northwest to the southeast. The main ranges are the Dinaric Alps in Bosnia and Herzegovina, Montenegro and Albania, the Shara-Pindus massif which spreads along the border between Albania and North Macedonia and Stara Planina in Serbia

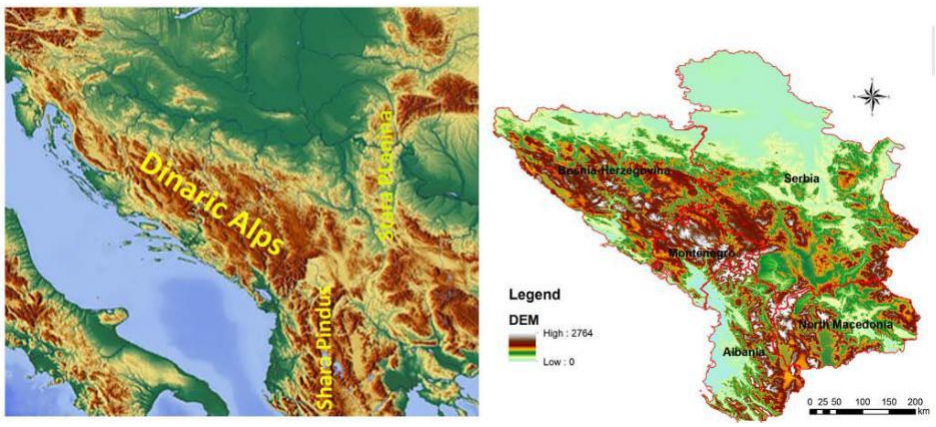

Figure 1 and 2 - Mountains and DEM of the Western Balkan Countries

In Serbia there are parts of South Carpathians and Rhodopes. Mountains in Eastern part of North Macedonia are continuation of Rila-Rhodopes Mountain. Dinaric Alps and Shara-Pindus massif are between the most rugged and extensively mountainous area of Europe. The rugged mountains, composed of limestone and dolomite, are a barrier to travel from the coast to the interior; there are no natural passes. Sinkholes and caverns dominate the landscape. The Dinaric Alps rise to 8,839 feet (2,694 meters) at Mount Jezercës (Maja e Jezercës) in the North Albanian Alps (Prokletije).

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The coast is indented with numerous natural harbors, but the limestone ranges prohibit any natural access to the agricultural hinterland. Interior basins of the range, though isolated, have both fertile soils and dense population. https://www.britannica.com/place/Dinaric-Alps. Only on Shara Mountain there are 70 peaks over 2000 m. The highest peak on the WBC is Korab (2764 m) located on the Deshat Mountain that is connected to Shara Mountain on the north. Rugged relief, steep slopes, lithology structure and climate conditions cause various and severe erosion processes, rock weathering falling events, talus cones, landslides and debris torrents.

There is a dense **drainage network** in the region. Water resources from the WBC belong to: a)Adriatic, b) Black Sea and c)Aegean basin i.e Albania (a), BiH (a,b), North Macedonia (a,b,c), Montenegro (a, b), Serbia (a,b.c), The main river in the region considered is the Danube that belong to the Black Sea basin. The Danube receive water from the following rivers from WBC: Sava (BiH), Drina (BiH, Serbia, Montenegro) , Morava (Serbia, North Macedonia) and Tisa (Serbia). The source of water from the rivers Neretva (BiH), Drim/Drini (Montenegro, Albania, Serbia, North Macedonia) drain into Adriatic Sea, as well as all the other rivers in Albania . The river Vardar and Strumica (North Macedonia) are flowing to the Aegean Sea.

Figure 3 - Drainage network (http://www.grida.no/resources/6855 with annotations)

The WBC experiences a range of **climates** in accordance to of the size of their geographic area. Albania has a Mediterranean climate with mild, wet winters and hot, dry summers, as occurs with the southern part of Montenegro and the coastal and lowland areas of Bosnia and Herzegovina. The climate in the remaining areas of Bosnia and Herzegovina ranges from temperate continental to alpine. The far north of Montenegro has a continental climate, and the central and northern parts have some characteristics of mountain climate, but with Mediterranean Sea influences on temperature and precipitation. The climate of Serbia varies from temperate continental in most areas, to continental in the mountains and warm

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continental in the south-west. The climate in North Macedonia varies from sub-Mediterranean, moderate continental/sub-Mediterranean to continental and alpine on the highest mountains.

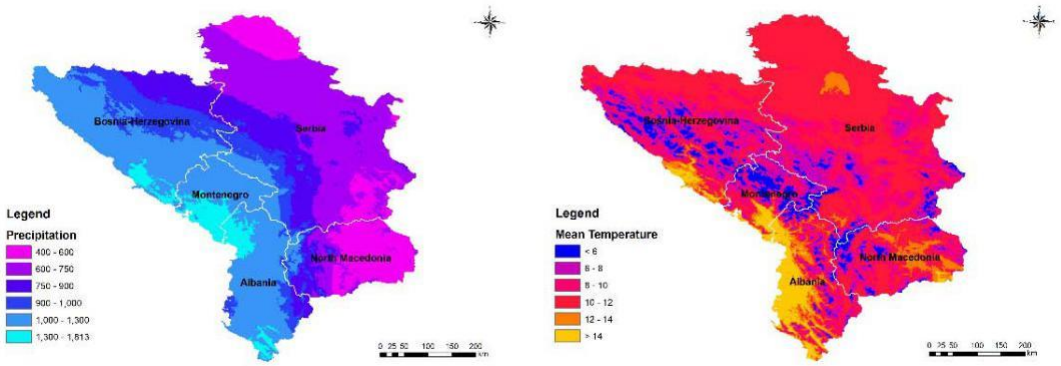

Figure 4 - Isohyet and Isothermal maps of WBC

The mean temperatures vary between 0-14$_o$C. Only the mountain ranges have mean annual temperatures below 6 degrees and on the other hand, the continental valleys varies between 10 and 14 degrees and the coastal areas have temperatures above 14 degrees. The mean annual precipitation of this region is also quite diverse and it can vary from 450 mm (North Macedonia) to more then 2500 mm (Albania and Montenegro). There are two separate regions with high and low precipitation. The high precipitation region starts from the coast of the Adriatic Sea and goes inside the continent to the higher ranges of the mountains (Dinarides and Šar Planina range). The dry area is located North, northeast and east from the mountain range where the total annual sum of precipitation is bellow 750 mm. This occurred because the humid wind from the Adriatic sea discharge all the water when is forced to reach the altitude of the W side of the Mountain. The expected scenarios due to the climate changes for the next 100 years for the region would elevate the temperature and decrease the precipitation i.e. rising temperatures up to 4,5$_o$C , and decrease of the precipitation up to 25% , which would be important for the erosion and control activities in the region.

Land Cover is heterogeneous. Generally, forests dominate in the region, especially in Montenegro and BiH. Although in North Macedonia, 50% of the territory belongs to the class "forest", significant part of these forests are degraded with low cover.

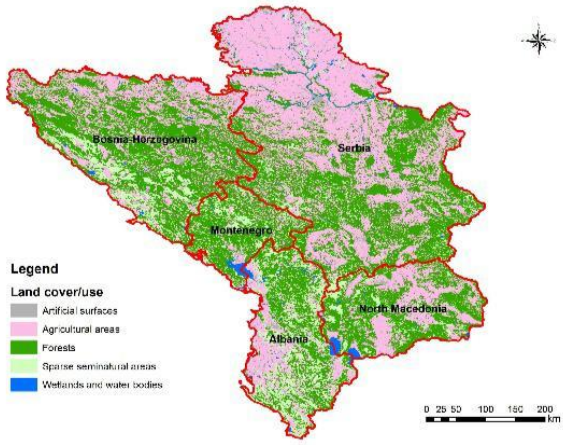

Figure 5 - CORINE LC/LU 2012

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In the following text, will be analyzed in detail, conditions of soil, soil degradation soil erosion in Serbia, Bosnia and Hercegovina and North Macedonia.

Status of soil data

In the past was developed a Soil Map of Yugoslavia in a working scale 1:50 000 according to the methodology by Š koricA., Ćiric M. and Filipovski G (1964) - SCF. Soil mapping ended in the 80's and in 1985 was published a book "Classification of soils in Yugoslavia".

Later after 2000, in each country, all sheets of Soil Map were scanned and digitized. The same was done for the analytical data (physical and chemical properties) from all annexes containing soil profiles. After digitization, the old classification was translated into the official nationals soil classification system as well as into the current FAO classification (World Reference Base for Soil Resources). Only the soil database for North Macedonia is available free on internet. (https://www.google.com/search?client=firefox-b-d&q=masis) Beside basic soil map, as digital output additionally were created the following thematic maps: Maps on spatial distribution of: pH, CaCO, organic matters, clay, dust and sand and Initial maps on soil suitability for cultivation. Soil information system of North Macedonia is free for usage.

In Serbia are delineated 30 cartographic unite , out of them 24 soil types and 6 other, in Bosna and Hercegovina 30 cartographic units, out of them and in Macedonia 63 cartographic units out of them 21 soil types and 42 soil complexes.

In the mountain regions dominate cambisols (eutric and distric cambisols, calcocambisols and alcomelanosols, according to the old methodogy).

Leptosols (molic, rendzic and lithic) cover 37,5% in Bosna and Hercegovina, 15% in Serbia and 7,5% clear and in North Macedonia on 20% in a complex with other soil types. Cambisols cover 29,7% in Bosna and Hercegovina, 35% in Serbia and in North Macedonia on 15,8% clear and 14,6% in soil complex. Luvisols cover 11,5 in Bosna and Hercegovina, while much less in other countries. Fluvisols cover 2,9% in Bosna and Hercegovina, 7,6% in Serbia, while in North Macedonia 8%. Characteristic soil type in Serbia that is not significantly spread in other countries is "chernozem" that cover 13,8% while in North Macedonia cover only 0,52% in complex with other soil types. In North Macedonia (on 0,43%) and Serbia (2,5%) are spread salty soils (solonetz and solonchak) too, that are not presented in Bosna and Hercegovina.

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Land and Soil degradation

Land degradation and soil degradation are very similar terms. Land degradation is lowering of the productive capacity of land. It thus covers various forms of soil degradation, adverse human impacts on water resources, deforestation, and lowering of the productive capacity of rangelands. Soil degradation is defined as a change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries. Degraded soils have a health status such, that they do not provide the normal goods and services of the particular soil in its ecosystem. Several FAO publications define that soil degradation "includes soil erosion by water and wind, deterioration in soil physical, chemical and biological properties, waterlogging, and the build-up of toxicities, particularly salts, in the soil.

There are five basic **land-use categories**, which can be matched up with the land cover classes described before and which are subject to land degradation: Cropland; Grazing land (used for animal production) – pastures and meadows,; Forest; Mixed land use (mainly agroforestry, agro-pastoralism, silvo-pastoralism, transitional woodland); non-vegetated artificial land use (mining, human settlements, communication, energy and water infrastructure). These different land uses are subject to specific forms of land degradation. (Blinkov and Mukaetov 2017)

The land cover/use distribution Is presented on the figure bellow.

Table 1 - Land cover/use distribution in the region (%)

Country	Area (km^2)	forest	Semi-naturalareas	pastures&mosaic	arableland &permanentcrops	other	total
BiH	51,129	53	8	31	4	4	100
North Macedonia	25,713	50	9	24	12	5	100
Serbia	88,385	38	4	27	25	6	100

Data Source: CORINE LCU , European Environment agency

Land degradation

Land degradation neutrality (LDN) is defined as a “state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems”. The baseline is expressed as the initial (t_0) estimated value of each of the three indicators used as proxies of land-based natural capital and the ecosystem services that flow from that land base: land cover/land use change, land productivity status and trends, soil organic carbon status and trends. The baseline of LDN indicators was calculated with estimation of the average values across the 10 years baseline period of the following indicators: Land

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Cover/Land Cover change (LC/LCC), Land Productivity Dynamics (LPD) and Soil Organic Carbon (SOC). Data by ESA-CCA global data service and CORINE LCU has significant differences.

Land cover changes data express loss of productive land in the period 2000-2012 in all 3 countries. In Bosnia and Hercegovina, in this period 8658 ha agricultural land were converted in artificial land, 2330 ha in forest land and 318,7 ha in water areas, and on the other hand in the period 2000-2006, 946 ha of forests are converted into artificial land. LC changes in Serbia in the period 2006-2012 show loss of productive land and [per LC type are as follow: arable land and permanent crops (-17 km^2), pastures and mosaics (- 26 km^2), forests (+12 km^2), seminatural vegetation (-5 km^2) artificial land (+18 km^2), open spaces and bare soils (+ 6 km^2), wetlands (-4km^2) , water bodies (+7 km^2). IN the North Macedonia, comparison of data from 2000 and 2012 express significant loss of forest (365,8 km^2) and almost the same value (334, 2 km^2) increase of shrubs, grassland and sparsely vegetated areas that is a result of forest fires in 2007; and beside it there is also a notable increasing of the categories of bare-land (39, 28 km^2) and artificial land (41, 25 km^2) which is most probably result of urban expansion and conversion of fertile cropland (-27,7 km^2).

Land productivity dynamic data for Bosna and Hercegovina indicate unacceptable changes (decline, early signs of decline, stable but stressed) on 2,49% of the territory or 1272 km^2. Croplands are mostly affected. Land productivity dynamics data fro Serbia indicate decline in land productivity on 24,900 ha, while early signs of decline and stable but stressed classes areas cover 451,200 ha. Totally, 5.4% of the Serbian territory has negative trends in land productivity (classes 1-3). Land productivity dynamic data for North Macedonia 2000-2010 (according to the Global data) defined as unacceptable 2,35% of the territory of the country and it seems as to be very small area, but in reality there are 585 km^2 with negative land productivity dynamic mostly cropland . Total ***soil organic carbon loss*** for the period 2000-2010, according to the global data are estimated as: Bosna and Hercegovina (102 393 t), Serbia (33 678 t) and North Macedonia (3951 t). **Total land area with trend of degradation** in the period 2000-2010 (as degraded area is as follow: Bosna and Hercegovina (1366 km^2), Serbia (4757 km^2) and North Macedonia (589 km^2)

Soil Degradation

As a result of human development, urbanism and various economic activities soil is exposed to: land consumption, various inappropriate management activities on agriculture, forestry etc. and emissions of various pollutants. Results of these is soil degradation.

Soil degradation has 2 aspects i.e. degradation of soil physical, chemical, and biological characteristics (local and diffuse contamination, soil acidification, alkalization, salinization, depletion of organic matter and nutrients, physical deterioration) and loss of soil (soil sealing, soil erosion, large scale land movement.).

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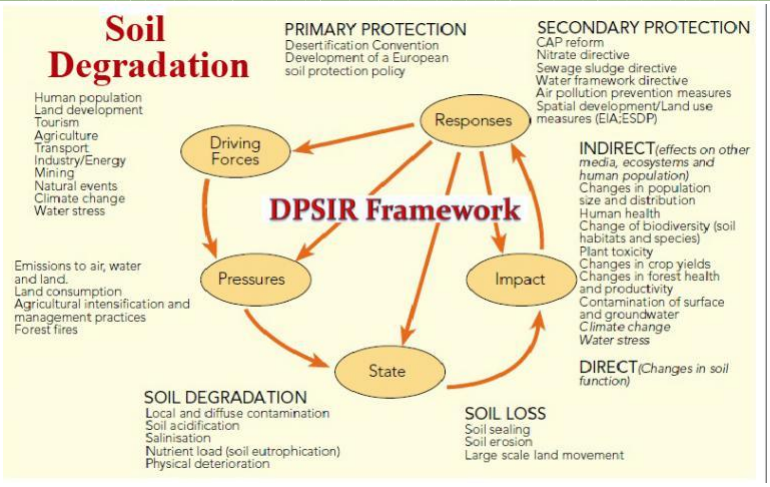

Figure 6 – DPSIR Framework for Soil Degradation – EEA 2015

Soil alkalization and salinization zae not recognized as wide spread problems in all 3 countries. In Serbia and NOrh Macedonia there are natural salines, while in North Macedonia he process of saliziation is forced by inappropriate irrigation but there is no detail ersearch for this.

Depletion of organic matter (soil organic matter refer to consisting of plant and animal residues at various stages of decomposition, cells and tissues of *soil* organisms, and substances synthesized by *soil* organisms unlike soil organic carbon that refer to the quantity of carbon in a carbon pool (i.e., a system which has the capacity to accumulate or release carbon that consist of above-ground biomass and below-ground biomass, dead organic matter and soil soil organic matter). Is very important for soil fertility and yield. In dry areas, depletion of SOM can be rapid, because the processes of decomposition are accelerated at high temperatures. The soils under intensive agriculture production on sloping terrain with heavy texture and shallow soil profile are the most vulnerable soils particularly the soils on hilly relief (lithosol, rendzinas, chromic cambisols, vertisols and the soils on colluvial forms), There is initial general data in all 3 countries that shpuld be improved through proper monitoring system.

Physical deterioration of soil involves the destruction of soil structure, dispersion of soil particles, sealing of pores, compression and increasing density, consolidation, compaction and reduced root penetration, low infiltration even waterlogging, runoff, and accelerated erosion. This situation is provoked mainly with performing bad agricultural practices: absence of crop rotation and improper plowing and unfavorable economical situation of farmers which exploit the soils above its natural performance with almost no inputs. This is significant type of soil degradation but there is no data.

Soil pollution with nitrates, phosphates, sulphates, pesticides, organic pollutants, heavy metals, oil i=s a wide spread problem of soils in the region. There is no regular and long-term monitoring system. Some incidental measurements of soil pollution around certain industrial complexes have been conducted, and these results are relevant only for those localities. The highest number of contaminated sites (422) is monitored in Serbia, but in other countries/territories, this number ranges from, 91 (Bosnia and Herzegovina), to the large number which refers only to the landfill (Macedonia). A particular problem in BiH represents a landmine and other residual explosive materials contamination.

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Soil sealing is a type of soil degradation which become more important with the process of industrialization, expanding of settlements and traffic network. An accelerated increase of built-up areas can be recorded as a consequence of the political and economic changes during the late 1970s and 80s. Rural populations migrated to the cities and new settlements were developed. The concentration of urban population had reached the level of 60% of the whole population. In the last decade migration has been slowed down and the daily migration movements are expanding especially in the areas of gravitation around the economy centers and bigger cities. This is mostly in the suburban area of the city and is result of illegal ban but also as inappropriate planning. Soil sealing affects fertile agricultural land, puts biodiversity at risk, increases water scarcity and contributes to global warming but together with inappropriate and 'wild' urbanization, it significantly contributes to the risk of flooding and damage from flooding. YHre is no enough data for soil sealing and it should be study in future.

A ***soil information system*** was established only in Macedonia in 2015. This system collects data for the following aspects: soil types, administrative divisions, pH values, organic matter map, CaCO3, clay, silt and sand content, land capability. On the other hand in Bosnia nd Hercegovina there is significant data and in Serbia there is data only regarding some soil characteristics (Serbia). All soil maps are available in GIS format. The soil classification system is transposed according to the World Reference Base for Soil Resources (WRB) criteria.

A functional system for **soil monitoring** in these countries, however, has not yet been established. Reporting systems of soil quality monitoring in BiH are in process of being established in accordance with EEA indicators and EIONET requirements. No soil monitoring system does exist in Macedonia. Characteristics of soil profiles in this country analysed in the past are presented in the soil information system. The Serbian Environmental Protection Agency is responsible for professional activities related to the data collection and production of indicators related to soil erosion and the content of organic carbon in the soil. A methodology for monitoring carbon stocks and organic carbon contained in the soil was developed. In Serbia, studies for determining and monitoring the content of organic matter in the soil for specific areas or measurements were performed, but the measurement is not carried out systematically and values are not relevant for the entire territory of the country. Evaluation of total carbon stocks and carbon content in the soil is done using data prepared by the JRC of the European Commission. The values of the content of organic carbon, which are presented in the national reports of some countries, or where is an indication of their existence, are the result of the development of research projects funded by the EU or national level.

Desertification is a new recognized natural hazard in the country. Drylands cover great part of North Macedonia and norther part of Serbia (Vojvodina). Climate conditions are the main reason for desertification. According to the calculation almost 1/4 of the North Macedonia is vulnerable to desertification. On the other hand unfavorable climate scenarios up to 2100 for the region (decrease of annual precipitations, increase of frequency of high intensity rainfalls and increase of temperature) give and opinion that this problem will be more intense even in near future and shpuld be payed more attention on it.

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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 $m^3km^{-2}years^{-1}$). 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.

Various methods, models and approaches to erosion risk assessment are used by various countries in Europe. There is a significant difference within the scientific community in several erosion related issues, including the definition and acceptance of erosion, erosion intensity measurement, erosion intensity modeling, and they particularly depend on a scientist's provenience (various schools, various professions etc.). At the European level, there is no unified classification of erosion or a unified model for erosion intensity and risk (Blinkov 2015).

Erosion mapping

Generally, official data about erosion intensity of the WB countries was developed in the 80's and 90's of the XX century. The common characteristics of former SFRJ countries is that erosion maps were created using the EPM – Erosion Potential Method. All maps were created using expert judgment approach through direct on-field mapping of erosion processes on a scale of 1:50 000. These data were later digitized (scanned, georeferenced and vectorized) in a GIS environment. (Blinkov 2015).

The latest research on soil erosion in BiH dates from 1985, when a Map of Soil Erosion of BiH was developed by Lazarević (1985). Unfortunately, that map has not been updated and moreover, data disappeared during the conflict period in Bosnia (Tošić, 2007; Tošić, 2008). Since 2004 part of the erosion map was reconstructed, but only for the Republic of Srpska territory (Tošić et al., 2012).

Erosion Map od Serbia is also developed in the 1973 and updated in 1984 using EPM (Kostadinov S. 2006).

The Erosion Map of the North Macedonia was prepared by the team from Water Development Institute led by Gorgević M. in the period 1981 – 1993. Erosion potential method (EPM) by Gavrilović was used with direct on-field mapping. Team was firstly trained for subjective assessment of processes during on-field mapping. Team used m maps in a scale 1: 50 000. A summarized report was produced in 1993. Later, in 2002, the working maps were scanned, georeferenced and vectorized.

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In the last 15 years there are a lot of studies where erosion intensity was calculated using modelling in a GIS environment using EPM, RUSLE or any other method, but those studies were launched only for some parts of the countries and not for the whole country

Taking in consideration that everywhere was used the same methodology and scale , data can be easily compared.

For Bosna and Hercegovina full data exist only for entity Republika Srpska.

Erosion intensity

Table 2 A review of erosion intensity per category in some Western Balkan Countries

	Erosion process intensity	Erosion intensity	BIH (Republika Srpska)		Serbia		North Macedonia	
		(m^3 km^{-2} yr^{-1})	km^2	%	km^2	%	km^2	%
I	Excessive	> 3000	263	1,22	2888	3,27	698	2,71
II	High	1500 – 3000	386	1,79	9138	10,34	1832	7,12
III	Moderate	1000 – 1500	2385	11,05	19386	21,94	6893	26,81
IV	Weak	500 – 1000	1975	9,15	43914	49,78	7936	30,86
V	Very weak	70 – 500	16568	76,77	13035	14,75	7463	29,02
							891	3,47
	Total		21851	100	88361	100	25 713	100.00

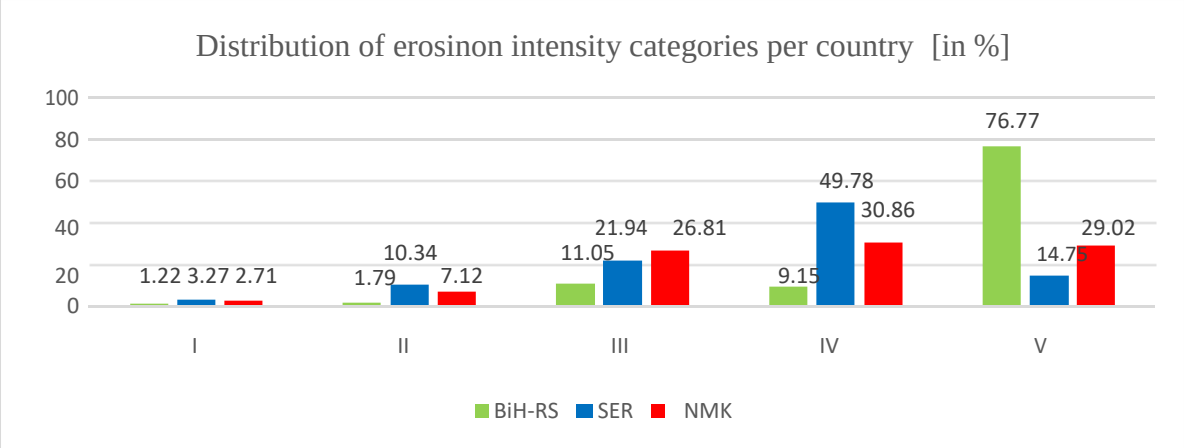

Figure 2 – Comparison of erosion intensity per country

On a level of Bosna and Hercegovina, the total average amount of sediment, created on territory of SR BiH per year is 16.518,031 m³, or 323 m³/km². According to 1985 erosion map of the Republic of Srpska 21851.04 km^2 of the total Republic's territory was under different intensity of erosion, while 3277.19 km^2 were manifested as accumulations. According to categories of erosion 1.22 % of the territory was affected by excessive erosion, 1.79 % by intensive erosion, 11.05% by medium erosion, 9.15% by slight erosion, and 76.77% by very slight erosion (Tošić et al., 2011).

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Total average annual gross erosion in Serbia amounts to 37,249,975.0 m_3y_{-1}, specific annual gross erosion amounts to 421.57 m_3 $km_{-2}y_{-1}$, annual sediment transport is 9,350,765.0 m_3y_{-1} and the specific annual sediment transport is 105.80 m_3 $km_{-2}y_{-1}$. The permanent soil loss in Serbia is 487.86 m_3 $km_{-2}y_{-1}$ and in Kosovo and Metohija 248.98 m_3 $km_{-2}y_{-1}$ The most endangered region in Serbia is Southeast part of the country closed to the borders with Macedonia and Bulgaria. Sediment transport related to gross erosion (total erosion production) in Serbia, 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.

According to the Erosion map of Macedonia (Water Development Institute, 1993), an area of 9423 km_2 or 36.65% of the total state area is in the highest categories (I–III). The total annual erosion production for North Macedonia is about $17*10_6$ m_3y_{-1} or 685 m_3 $km_{-2}y_{-1}$. An amount of $7.5*10^6$ m^3/ y or 303 m_3 $km_{-2}y_{-1}$ of sediment are moved away from the site where it is eroded. A significant part of produced material within Macedonia, about $3*10_6$ m_3y_{-1}, is not carried through the downstream sections of the rivers to the exit of the state territory, but are deposited in natural lakes and reservoirs.

Situation in Serbia and North Macedonia is very similar regarding percentage of territory affected by the strongest I and II category.

Table 3 – Comparison of erosion intensity per country

Country	Area	Annual Erosion		Map	Source
	km^2	10^6 m^3	m^3/km^2	scale	
Bosna and Hercegovina	51,129	16.5	323	1:25,000	Lazić Z. (2012)
North Macedonia	25,713	17.0	661	1:50,000	Gorgević et al. (1993)
Serbia	88,385	37.0	419	1:50,000	Kostadinov S. (2007)
Total /average	165,227	70,5	431		

In the region total erosion intensity expresses as annual production of erosive material is $70,5 *10^6$ m^3 or 431 m^3/km^2 which is higher than European average value.

Wind erosion as phenomenon is represented in all 3 countries but mostly in Serbia in plane Vojvodina lowland. Research on intensity of wind erosion exist only in Serbia (Jevtić, 1975; Letić, 1989; Savić, 2000; Velojic, 2016). According to Letic 2011, over 86% of the areas are in the category of disturbed and very disturbed land. Research show wind erosion intensity 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).

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Description of erosion processes

Hilly terrain and a relatively huge quantity of precipitation in BiH means that a significant proportion of the BIH territory is exposed to water-induced erosion. This phenomenon is most prevalent in central and southern parts of the country where the annual quantity of precipitation amounts to no less than 2,000 mm. As more than 80% of the BiH territory exists on slopes exceeding 13% water-induced erosion is an increasingly present problem, especially in surfaces that suffered from unplanned exploitation of forests and total deforestation of the terrain. In the northern part of BiH hydromorphic soils are dominant on flat and slightly hilly terrains. In those areas erosion risk is at a much lower level from the point of view of potential erosion, but agricultural production is the basis of the intensive development of erosion processes, and on these soils surface erosion happens. In addition, besides water erosion, one should not forget the risks of aeolian erosion in the southern part of the country where shallow soils dominate on limestone/dolomite substrata with extensive vegetation or without and the risk of aeolian erosion is high.

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).

Due to the natural conditions as well as human activities, various type of erosion processes can be defined in the country as follow: water erosion (dominantly), wind erosion (mostly in central part), karstic and glacial erosion on the high mountains). By type are presented sheet erosion, rills, shallow and deep gullies, streambank erosion, mass movement erosion (landslides and landfalls). Rock weathering are significant in the mountain region and are significant contributors of sediment. In different parts of the country various erosion processes per type are presented. Western part of the country characterize with Alpine configuration and various processes from shet erosion to mass movement erosion. Central part of the country (along the river Vardar and lowest parts of its tributaries Bregalnica and Crna Reka) on the altitude < 450 m asl., characterize with semiarid climate and various sediments. Beside typical sheet, rill and gully erosion, taking in consideration the lithological structure, in this area has appearance of landslides. The mountains in eastern region belong to Serbo-Macedonian Massif that's characterize by the domination of very old Precambrian and Rifey-Cambrian lithological complexes. Precipitations are higher then country average values. Depp gullies U and W type and pyramidal forms are characteristic and intensity of erosion is extremely high.

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Institutional set-up concerning soil management, legal and policy governance

World and EU policy

Table 4 - The most important recent Milestones in soil governance and sustainable development

Year	
1982	FAO World Soil Charter
1988	Intergovernmental Panel on Climate Change (IPCC)
1992	UN Conference on Environment and Development
	Rio Declaration
	Agenda 21
	Global Environmental Facility
	UN Convention to Combat Desertification (UNCCD)
	UN Framework to Combat Climate Change (UNFCCC)
	Convention on Biological Diversity (CBD)
1997	Kyoto Protocol
2000	Millennium Development Goals (MDGs)
2005	Millennium Ecosystem Assessment
2008	UNCCD's Zero Net Land Degradation
2011	Global Soil Partnership initiated (FAO/EU)
2012	Rio+20
	Sustainable Development Goals (SDGs) and Post-2015 Development Agenda
2013	Intergovernmental Technical Panel on Soils (ITPS) of the GSP
	Updated FAO World Soil Charter
	Land and Soils integrated in the Open Working Group of the Sustainable Development Goals
	Regional Soil Partnerships of the GSP
2015	International Year of Soils declared by the UN General Assembly

Source: FAO and ITPS. 2015. Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy

In the year 2006 the European Commission adopted its Soil Thematic Strategy (COM 2006/231) that included also a proposal for a Soil Framework Directive. In 2007, Germany, France, Netherlands Austria and United Kingdom could not accept the text of the proposed Directive. Some five years after the adoption of the Soil Thematic Strategy, on 13 February 2012 the European Commission published a policy report on the implementation of the Strategy and ongoing activities (COM(2012) 46). However the member states did not agree to this legislation and in April 2014 the Commission decided to withdraw its proposal. The commitment to soil protection is still one if its aim. In the seventh Environmental Action Programme it is clearly stated that sustainable management of soil is equally important as its protection and the remediation of contaminated sites. In 2012 the European Commission reported on the implementation of its Soil Thematic Strategy (COM 2012/46). The Soil Thematic Strategy foresees setting out a framework for action on awareness raising, research, integration of soil protection and a proposal for a framework directive that was withdrawn later.

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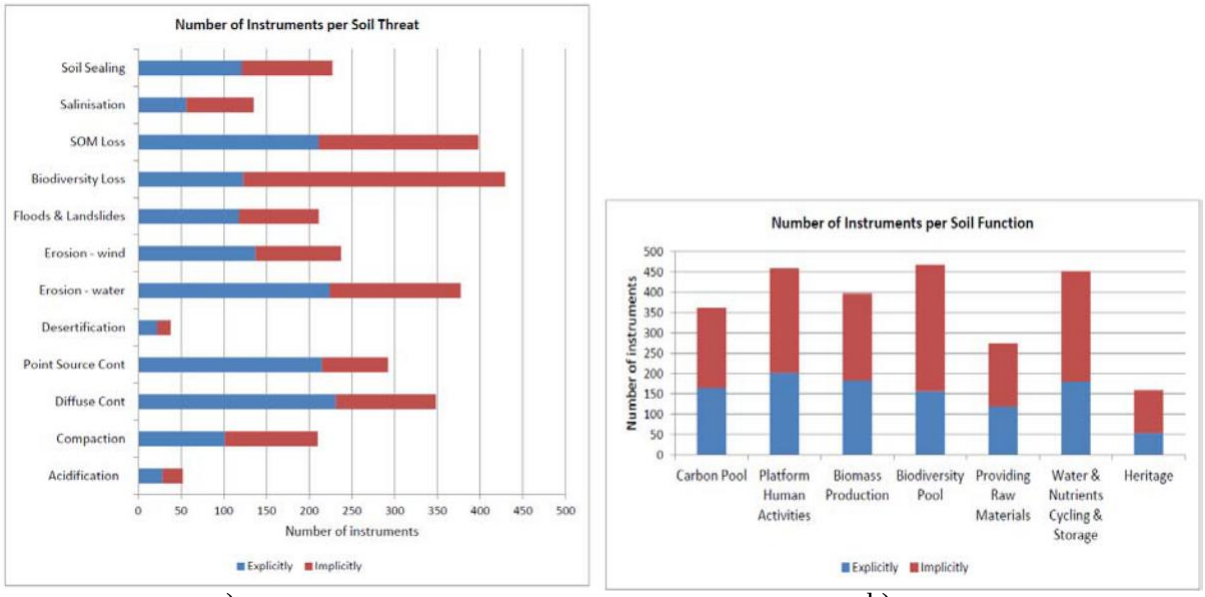
A recent study (Frelih-Larsen et al. 2017) examines all relevant EU policies in relation to soil management, protection and remediation of contaminated sites. It concludes that like for forest policy a number of EU key legislation have an impact on soil, e.g. pillar 1 and 2 of the rural development regulations, the EU Forest Strategy, Nitrates Directive, Natura 2000 legislation, Water Framework Directive etc. Other EU legislation that somehow relates to soil exist as they aim to prevent acidification (e.g. the National Emission Ceilings Directive), as well there are those that aim to control emissions from installations both to land and water (e.g. the Industrial Emissions Directive 2010/75/EU, the Environmental Liability Directive 2004/35/EC, and the Landfill Directive 1999/31/EC). Exact 35 policy instruments were identified as being relevant for soil protection on EU level. A total of 671 Member State instruments are included in the Soil Wiki, or an average of 24 instruments per Member State. Approximately 74% of these 671 instruments are regulatory instruments, and the majority of instruments (61%) are binding instruments. Moreover, 12% of instruments are regulatory non-binding instruments (e.g., strategies and action plans), and 27% are non-regulatory instruments (monitoring, funding and awareness-raising schemes).



a) b)

Figure 8 - a) Coverage of Soil Threats across the EU (aggregating MS instruments)
b) Coverage of Soil Functions by Member State instruments (aggregating MS instruments)

Organization of soil management

In North Macedonia and in Serbia organization is similar because the main Governmental institutions responsible for various issues related to soil and land are the Ministry of Environment and Physical Planning (MOEPP) and the Ministry of Agriculture, Forestry and Water Management (MAFWE) in North Macedonia and Ministry of |Environment and Ministry of Agriculture, Forestry and Water Economy in Serbia. There are other governmental bodies (agencies/directorate, independent or as a part of the up mined ministries) that are indirectly included in soil protection as those responsible for rural development, hydro meteorological affairs, spatial planning etc.

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On the other hand, in Bosnia and Hercegovina, taking in consideration the state organization and decentralized political and administrative structure: 3 entities (Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District), as well as cantons and municipalities. Ona state level, The Sector for Natural Resources, Energy and Environmental Protection within the Ministry of Foreign Trade and |Economy Relations (MoFTER) was appointed as a coordination body for land issues for the purpose of common operation at the international level, but only with prior consent of Entity Ministries. Beside this, each of 3 entity has various organizational structure regrading soil and generally environment protection. In federation of Bosnia the relevant ministries are Ministry of Agriculture, Water management and forestry and the Ministry of Environment and tourism. In Republika Srspka are responsible Ministry for Agriculture, Forest and Water and the Ministry for construction and ecology.

However, for general land policy is competent the Ministry responsible for agriculture, while for protection of soil as medium is competent the Ministry responsible for environment.

Legal framework

The existing legislation regulating the issues of land and soil, its spatial planning and use is in line with the Entity legislation according to the Constitution of BiH. Entities are mandated for land related matters, namely the ministries and administrative organizations. There is no land or environmental legislation at the national level.

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). he 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).

No specific legislation for soil exists to date in North Macedonia. Soil protection is regulated by several laws: for environment. Nature, agriculture, forest, water, spatial planning..

The most relevant documents for soil protection adopted in all 3 countries are: “National Action Plan to Combat Land Degradation and Desertification” and “Land Degradation Neutrality Target setting programme”. Other adopted national documents relevant for soil protection are those related to: The National strategy for Sustainable Development; The National Water Strategy, The National Rural Programme, 2014 - 2020; The National Strategy for Land Consolidation of Agricultural land; The national communication on climate change; National Spatial Plan; The National Strategy for Sustainable Forestry Development; The National Strategy for Biodiversity Protection; Waste Management Strategy etc.

Regarding **Erosion control,** this matter is mostly regulated within the Law on Waters. Provisions that refer erosion controls are almost the same in all 3 countries. Within the Law on Water in all 3 countries there is a chapter about Adverse impact of water (where erosion and torrents are completely regulated) i.e in BIH (Ch. VII. Regulation of rivers and other water bodies and protection form adverse impact of water art.80 -97), Serbia (Ch.4 – Water management activities – 4.1.1.2 – Protection from erosion and torrents art.61-65) North Macedonia (Ch.5 – Protection from adverse impact of water art.125 – 141). In all 3 laws there are provisions about: establishing erosive areas,

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responsibilities for proclaiming erosive areas, forbidden activities within it, obligatory measure and activities for erosion control etc.

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