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Soil health in the Western Balkans

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Contents

Abstract

This study is a compilation of evidence to support the development of a soil component for a ***JRC Science for Policy Report on the "Status of Environment and Climate in the Western Balkans"***[1]. This document attempts to benchmark a range of issues affecting soil health with considerations on the accession progress for an eventual Soil Health Law under the 2030 Soil Strategy.

The outcomes reported here are based on a literature review of 139 sources, bilateral exchanges with national soil experts in all Western Balkans countries, and on the personal experience of the authors. It should be emphasised that current data are scarce, and as such, the results should be considered as a primarily assessment and not definitive.

Based on the results of this study it is concluded that **soil degradation is prevalent and extensive throughout the Western Balkans region**. Soils are under pressure, but the intensity of various soil health indicators varies between them and among the countries. Climate change was not part of this study. Nevertheless, its impacts will be relevant in the coming decades, if not preventive mitigation, remediation, and adaptation actions will be needed to lessen their impacts.

With relevance to soil health **indicator 1 "Soil nutrients and Nitrate Vulnerable Zones",** it is estimated that the area of agriculture land affected due to an imbalance of direct inputs of nutrients in agricultural systems (excluding air pollution issues) to be in the range of **5.15% of the total agriculture area**.

Regarding soil health **indicator 2 "Organic carbon"** it is estimated that the area of land affected due to low and declining of carbon stocks to be in the range of less than **5% of the total land area of the region and about 10% for agriculture land**.

Soil health **indicator 3 "Soil erosion"** is the most relevant and aggressive process. It is estimated that the area of **agriculture land with failure due to water erosion to be in the range of 30% while about 45% of the total land area is affected** by soil erosion.

Data are not available on the extent and degree of soil health **indicator 4 "Compaction"**. Except for very few sporadic case studies in Serbia, no other sources are available. Therefore, it is suggested that soil compaction should be included without delay in both national and EU research programmes.

Soil health **indicator 5 "Pollution including risks to food"** is very relevant in the Western Balkans where a total of **2 735 contaminated sites** are reported. However, the general consensus is that this is an under estimation. This is the result of mining and industrial activities and, to a lesser extent, from agriculture practices. However, their areal extent is unknown, expect for a few countries. Some soils are also naturally contaminated with **heavy metals** due to the geological characteristics of their parent materials. **Contamination and waste management remain problematic** as relevant data are scarce or often lacking entirely. They include local hotspots (e.g., ex-industrial land, landfills, military compounds, etc.), agricultural land (pesticides, metals, sewage sludge, plastics) as well as unquantified emerging pollutants.

A preliminary assessment of soil health **indicator 6 "Soil sealing"** in the Western Balkans shows that **0.87% of the total land area in the region is artificially covered**. Agriculture land appears to have experienced the biggest loses. Land take and sealing is driven by rapid economic expansion and housing needs.

Soil health **indicator 7 "Salinisation"** was combined also with sodicity and a special soil type typical for the Western Balkans or the magnesial rich soils, locally known as Smonitsa or Chromic Vertisols characterised by their very dark colour and high clay content. They cover large areas in Serbia, North Macedonia, and Albania and are being cultivated for many years, despite their poor chemical and physical properties. Salinity in the region is

[1] https://publications.jrc.ec.europa.eu/repository/handle/JRC129172

both caused by natural conditions and unsustainable irrigation practices. Overall, it is estimated that these areas cover **just under than 10%** of the whole territory of the Western Balkans.

Regarding soil health **indicator 8 "Desertification"** none of the countries meet the criteria of aridity index as described by the UNCCD, but they all have signed the Convention. **In Albania and Montenegro, about 25% of the territory is estimated be subject to desertification**. Furthermore, land degradation in the general context is present in all the countries with **soil erosion as the most prominent factor** affecting large areas (**overlap with soil health indicator 3**).

No data were available for soil health **indicator 9 "Soil biodiversity".**

Organic farming in the Western Balkans covers **only 2.56% of the total farming area,** which very low compared with the EGD target to make 25% of the farming in the EU organic by 2030.

The region has a total population of 17.4 million inhabitants that have great aspirations for EU membership. Among other benefits, the proximity with the EU is expected to boost also sustainable soil management. But this would be possible when Western Balkans soil scientists would be further integrated with the EU soil science community, especially through greater involvement in the European Soil Partnership. The positive experience of the European Soil Bureau Network (ESBN) coordinated by JRC could be re vitalised. **Soil data in many countries are obsolete and the only new regional source is the LUCAS survey of 2015.** This brings to the attention for new national soil survey campaigns and the start without delay of **a further LUCAS Soil exercise throughout the region to** facilitate data comparisons and establish **trends in monitoring**. **Training of new young soil scientists** should also be encouraged as their number is rapidly decreasing.

It is unfortunate that the Western Balkans countries are not eligible for funding through the EJP SOIL Initiative. In that context the JRC could play a more prominent role in the region by supporting these countries to enhance their research capacities and bring them in line with other EU peers.

In conclusion, it is very difficult to make a regional assessment on the extent of unhealthy soils in the Western Balkans. The overwhelming literature review conducted in this study points out that **soil erosion is the most relevant degradation process followed by soil pollution**. All other factors are present but with a lesser extent and intensity. Unsustainable land management practices and natural causes of soil degradation are interlinked and is very hard to make a distinction between them. The 2030 EU Soil Strategy has set a vision for healthy soils for 2050. Therefore, the countries of the Western Balkans should align their soil protection policies through improving legislation and enforcing its implementation.

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Authors

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1 Introduction

1.1 Why this report

The six countries of the Western Balkans (Albania, Bosnia and Herzegovina, Kosovo[2], Montenegro, North Macedonia, and Serbia) are at different steps in their way to joining the European Union. However, before joining, they must align and implement their legislations with the EU "acquis" or the accumulated legislation, legal acts, and court decisions that constitute the body of the EU laws.

Figure 1 The location of Western Balkan countries

Source: Google Maps

The adoption, implementation, and enforcement of the EU acquis on Environment is an obligation for accessing countries in the framework of the stabilisation and association process. This implies reducing the emissions of pollutants and GHG as priorities, which are strongly interlinked with energy, transport, and land use policies.

[2] This designation is without prejudice to positions on status and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

The Green Agenda for the Western Balkans, envisaged by the European Green Deal (EGD), details five pillars of action targeting: (1) climate action, (2) circular economy, (3) biodiversity, (4) fighting pollution of air, water, and soil and (5) sustainable food systems and rural areas. Digitalisation will be a key enabler for the above five pillars in line with the concept of the dual green and digital transition.

Based on the EGD targets, soil condition is recognized as a vital element of these five pillars. In particular:

- the vision for healthy soils being developed under the EU Soil Strategy and Legally Binding Soil Restoration Targets that are being developed under the Biodiversity Strategy,
- the EU Climate Law notes the need for increased sequestration of organic carbon by agricultural soils as a major component of climate regulation and in mitigation of the effects of emissions,
- more efficient nutrient cycles and reduction in soil sealing are explicit objectives of the Circular Economy Action Plan,
- a Soil Pollution Watch List together with a Clean Soil Monitoring and Outlook Report are foreseen under the Zero Pollution Action,
- sustainable agriculture objectives under the Farm2Fork Strategy are built on balanced soil nutrient management and the reduction of pesticide residues in soil,
- research and innovation challenges set by the Soil Mission under Horizon Europe.

Soil erosion and overall land degradation are considered severe problems in many areas around the Western Balkans (WB), especially for the mountainous regions. The JRC estimates that soil erosion affects more than 20% of the combined Serbian and Montenegrin territory while Albania is losing between 20 and 70 tonnes per hectare of soil annually (Kovacs et al., 2012). Combating land degradation and restoring degraded land include sustainable food production, improved and sustainable forest management, soil organic carbon management, ecosystem conservation and land restoration, reduced deforestation and degradation, and reduced food loss and waste.

Countries in the Western Balkans could undertake actions to address soil degradation and desertification which can offer co-benefits also for other key environmental issues such as water pollution and scarcity, and biodiversity loss, as mentioned also in the EU Soil Thematic Strategy. As a unique and complex ecosystem, soil provides an array of goods and services that are vital for life on the planet, but soils are under pressure along with all the organisms living within it.

Besides providing food, fresh water, protection from floods and storms, healthy soils mitigate natural disasters, pest, and diseases, contribute to regulating the climate change, combating land degradation and enhance food security. The main challenges at the regional and national level are related to the lack of political commitment to improve implementation of soil and related policy instruments, which are hampered by a lack of financial resources to establish a current and policy relevant knowledge base. In this context, Western Balkans partners are encouraged to align their policies to the EGD Strategies and to support the EU position at upcoming international negotiations on the global post-2020 biodiversity framework.

The EU Soil Thematic Strategy identified a series of pressures that affect soil condition. These include erosion, compaction, sealing, salinization, landslides, and pollution (both in a local and diffuse sense), which in turn affects soil organic matter levels and soil biodiversity. Pressures acting on the soils of the EU, together with their impacts, are described in more detail by (Jones et al., 2012; FAO & ITPS 2015; Montanarella and Panagos, 2021a; Montanarella and Panagos, 2021b).

These are taken further by a new Soil Strategy for 2030, published in 2021 and entitled “Reaping the benefits of healthy soils for people, food, nature and climate” (EC 2021). The

Strategy sets out a framework for protecting, restoring and the sustainable use of soils. The vision of the Strategy is that by 2050, all EU soil ecosystems will be in a healthy condition in order to fully address the major societal challenges of achieving climate neutrality and becoming resilient to climate change, developing a clean and circular bio-based economy, reversing biodiversity loss, safeguarding human health, halting desertification and reversing land degradation.

In this respect, understanding the health of a soil is highly relevant. Degraded soils have partially or completely lost their capacity to provide the functions and services listed above. In some cases, the adoption of sustainable soil management practices can lead to a full recovery after some years (e.g. in case of loss of carbon and biodiversity or compaction and erosion of the top fertile layer). In other cases, active restoration measures are needed for sometimes only partial recovery (e.g. for sealed, desertified, salinised or acidified soils). In some cases, degradation can be irreversible in terms of human timescales.

A key element of the Strategy is the proposal for a Soil Health Law (by 2023), which aims to specify the conditions for a healthy soil, determine options for monitoring soil and lay out rules conducive to sustainable soil use and restoration. It is clear that compliance with the expectations of this legislation will have to be considered by Western Balkan countries.

A significant step forward in the EU is also the proposal for a dedicated Mission on Soil Health and Food named “A Soil Deal for Europe”, with a target to more than double the extent of healthy soils across the EU through a greater uptake of sustainable soil management measures, driven by respective policy frameworks. A key success of the Mission proposal and implementation plan was based on an evidence collection study on an analysis of the state of soil health in Europe, reflecting a range of pressures on soil (see Annex 1[3]).

This report aims to support the JRC’s efforts to fill information gaps on soil health condition across the Western Balkans based on an extensive review of the current evidence base of the state of WB soils. The purpose is to identify the main pressures affecting soil health at country and regional level, also highlighting the best management practices and policy areas of concern. The study will complement a parallel exercise to map relevant soil policy targets in the EGD.

Data to characterize the overall state of pressures on soils in the Western Balkan region are largely lacking (e.g. diffuse soil pollution, compaction), making it difficult to quantify the geographical extent of the pressures or to establish quantitative trend assessments of overall soil health. The assumption is that all soils are under pressure, even if only considering indirect pressures, from air pollution and climate change. However, soil pollution, compaction and secondary salinization are probably the biggest unknowns. Soil pollution includes both local hotspots (e.g. ex-industrial land, landfills, etc.) and more widespread contamination reflecting inputs from air pollution legacy, agricultural land use (pesticides, metals, sewage sludge) as well as other unquantified sources.

[3] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-health-and-food_en

This report attempts to provide relevant evidence for each country and at the regional level to:

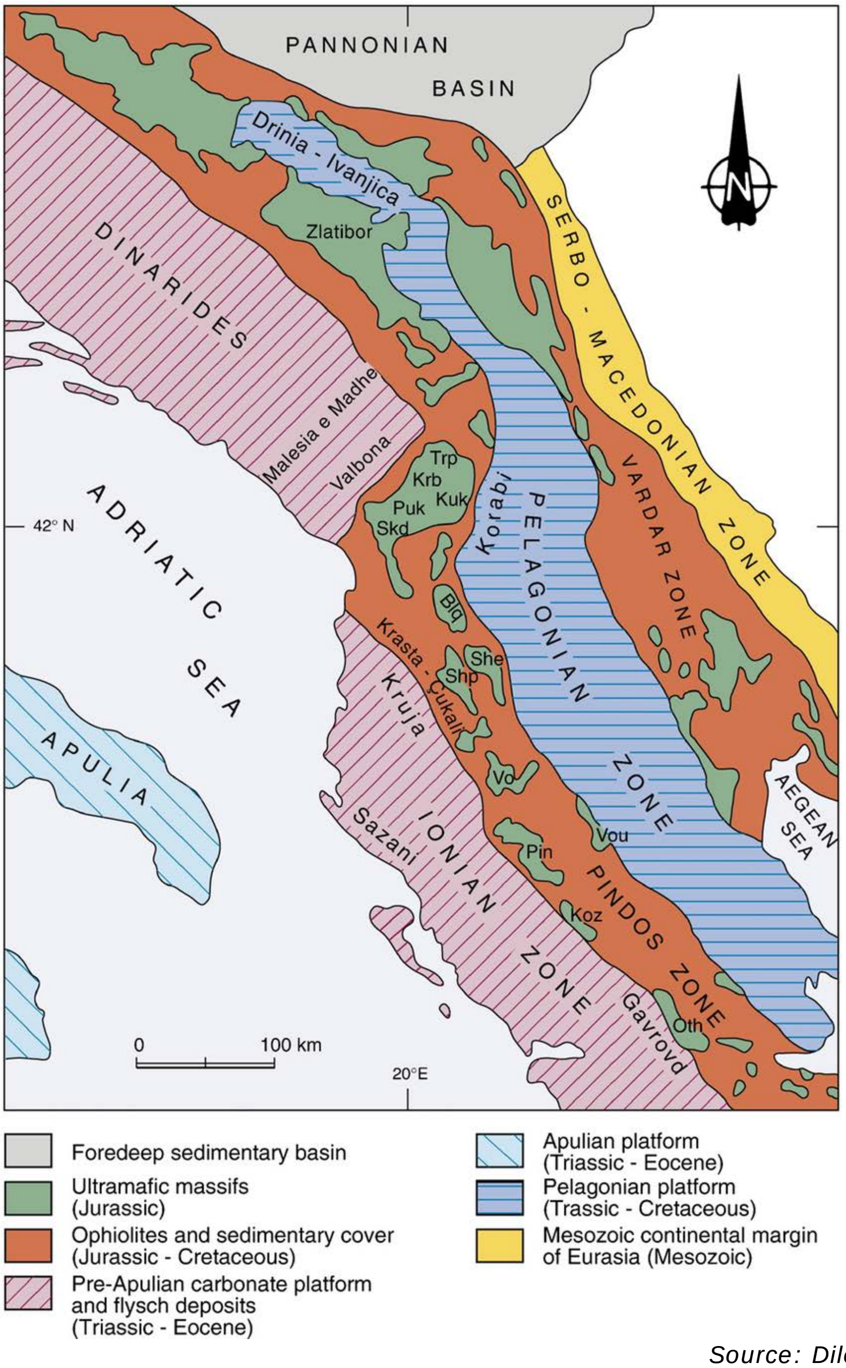
- Examine the relevant evidence base for soil degradation in the Western Balkans (based on scientific publications, policy reports, relevant datasets)
- For all countries of interest, report the area of land (and % of any relevant area, e.g. croplands) with failure of soil health indicator, for the following issues that are singly, or in combination, resulting in a decline in soil condition and health:
  - Soil nutrient assessments (e.g. Gross Nutrient Balance, excess nitrogen/vulnerable zones, phosphorus)
  - Organic carbon fluxes (in organic soils and cropland mineral soils)
  - Erosion (by water and wind, coastal erosion, agricultural land under severe erosion)
  - Compaction
  - Pollution (local and diffuse – with as much breakdown as possible, evidence on microplastic and emerging containments would be appreciated) and waste streams with relevance to soil
  - Soil sealing and net land take
  - Salinisation
  - Desertification
  - Pressures on soil biodiversity

2 Status of soil health across Western Balkans in 2020

2.1 Geomorphological setting, climatic conditions, and associated soils

The Western Balkans region is made of a variety of landscapes, great lithological and geomorphic diversity that ultimately is reflected in the formation of very different soil types.

Figure 2 Simplified geological map of the west-central Balkan Peninsula, showing major tectonic zones and ophiolite occurrences.



Source: Dilek et al., 2007.

In most parts of the Western Balkans, agriculture is the most important branch of economy. For centuries, farmers have used the high natural potential of the region for agricultural activities. This is illustrated by the fact that the share of the agricultural area is around 21% of the overall territory of the region.

The loess deposits of the Pannonian plain expanding largely in Serbia, and to lesser extent in Bosnia and Herzegovina, host some of the most fertile soils of Europe (Fig. 3). It is exceptional that some of the thickest European loess areas are recorded here reaching depths of 100 m in places (Koloszar, 2010; Sümegi et al., 2018), preserving a quasi-continuous paleoenvironmental record extending back to the Early Pleistocene (Buggle et al., 2013; Markovic et al., 2011, 2015; Schaetzl et al., 2018). The research in the Middle Danube Basin has provided important contribution to loess research (Markovic et al., 2016; Obreht et al., 2019). These loess deposits are inter merged with alluvial depositions of the Danube River within which Serbia has about 10.2% of its territory, Bosnia and Herzegovina 4.6%, while Montenegro, North Macedonia, Kosovo and Albania less than 1%.

Figure 3 Fertile soils derived from loess on the Pannonian plain in Serbia

Source: Wikipedia, public domain

Other important geomorphologic formations are the karsts, particularly distributed in Bosnia and Herzegovina, Montenegro and to a lesser extent in Albania and North Macedonia. For instance, the Trebišnjica in Bosnia and Herzegovina is one of the largest sinking rivers in the world; one of its effluents, Ombla, springs out of a huge cave near Dubrovnik in Croatia and then drains into the Adriatic Sea.

These limestone karstic structures have been unequally uplifted with altitudes varying between 1 300 m above sea level in Kotor (Montenegro) to 200 m in the eastern part to the country. Overall, the topography in the limestone areas is karstic, heavily fractured by tectonic events with many dolines, sharp ridges, and residual reliefs in the weathered limestones. On the bottom of the dolines and karstic depressions, small villages, farms, and rural communities are concentrated while the highest heigh of the massive Dinaric Alps is 2 694m (Maja e Jezerces) in Albania.

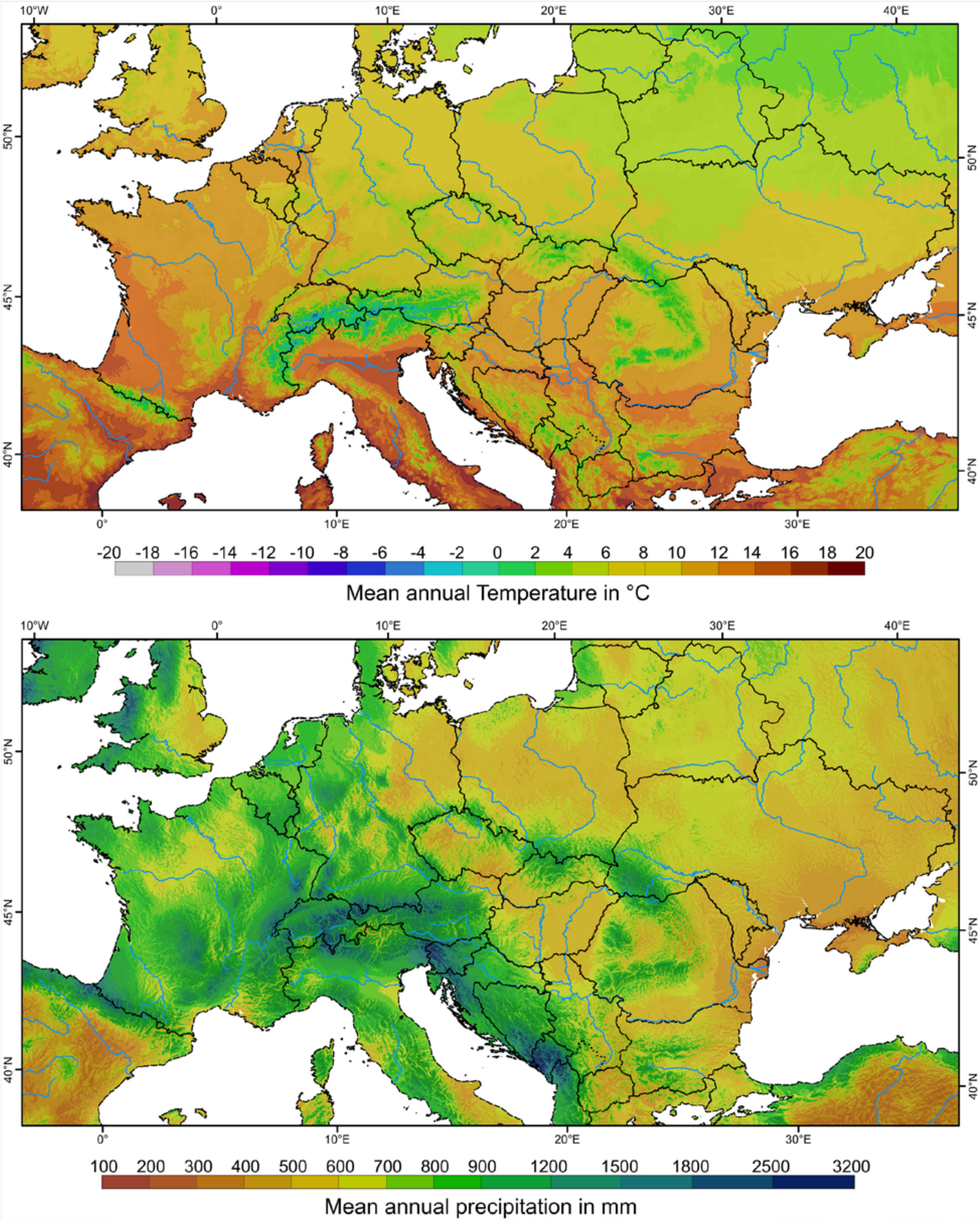
Furthermore, some still active glaciers were discovered in Albania on 15 September 2007, making it one of the southernmost glaciers of the European continent (Lenaerts, et al., 2013).

The flat lands of western coastal plains of Albania were formed mostly during the Quaternary period due to the alluvial depositions of seven rivers draining into the Adriatic and Ionian Seas. They form the largest alluvial plains of the Western Balkans, after the Danube basin. Instead, the Montenegrin coast is more fragmented with ranges of karst mountains that often show up right from the coast.

Other important flat lands typical of a graben formation are in the fields of Kosovo. With exception of Albania and Montenegro (Bosnia and Herzegovina have only 10 km coast), Serbia, Kosovo and North Macedonia are landlocked countries. The biggest lakes are Shkoder (bordering Albania and Montenegro), Ohrid (border Albania and North Macedonia) and Prespa (bordering Albania, North Macedonia, and Greece).

Climate varies from typical Mediterranean along the coasts (dry and hot summers and wet mild winters) with continental climate conditions in the uplands and higher mountain ranges (Fig. 4).

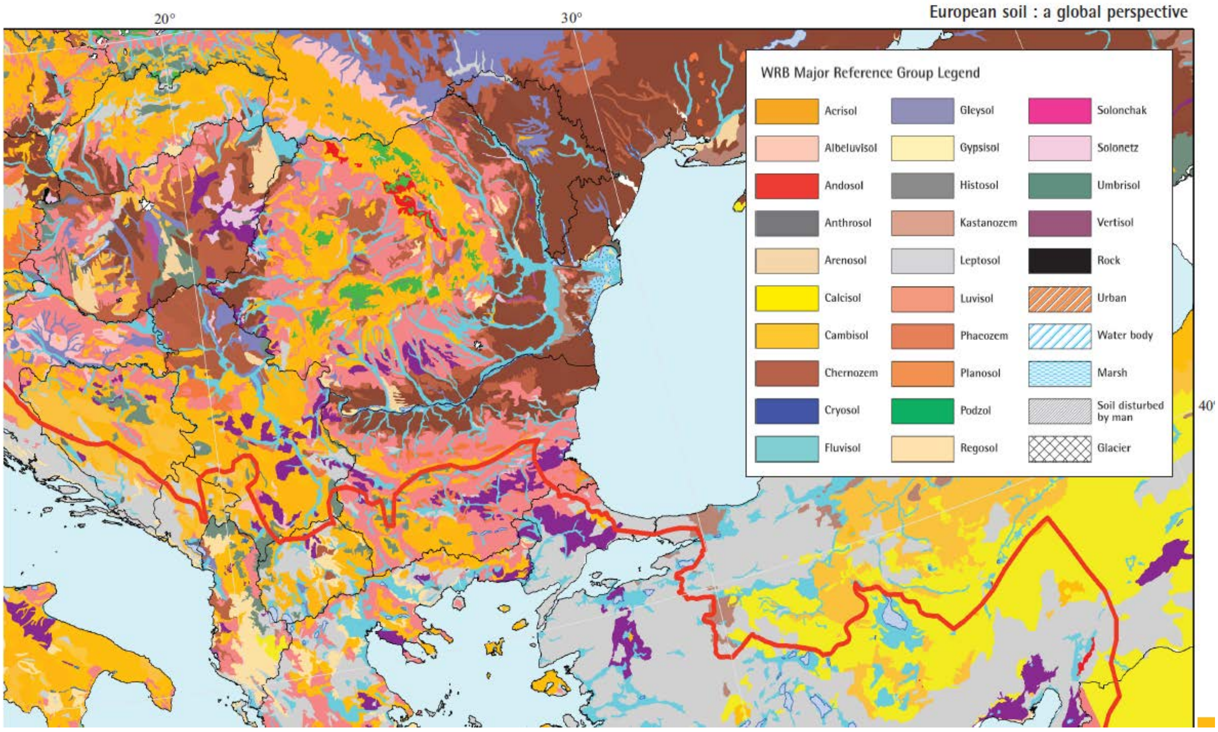
Figure 4 Climatic conditions in Europe. Mean annual air temperature on the upper part and annual precipitation in the lower map. Note the higher temperatures along the Mediterranean coast and the higher precipitation in the border between Albania and Montenegro. In Montenegro at the village of Crkvice (940 m above sea level), an annual rate 7 000 mm has been recorded making it the rainiest place in Europe.



Data adapted from Karger et al., (2017).

The soils of the Western Balkans are the result of the pedogenetic process with lithology, topography and climate playing a dominant role as soil forming factors. The large diversity is represented by Cambisols, Luvisols, Chernozems, Kastanozems, Phaeozems, Umbrisols, Fluvisols, Gleysols, Histosols, Arenosols, Calcisols, Leptosols, Regosols, Vertisols, Solonchacks, Solonetz, Anthrosols, and Technosols (Fig. 5).

Figure 5 General representation of the soil distribution in the Western Balkans. (The red line shows the delineation of the Mediterranean watershed).



Source: Soil Atlas of Europe (Jones A, Montanarella, L, Jones R. 2005)

Cambisols, Luvisols, Chernozems, Kastanozems, Phaeozems, Umbrisols, and Fluvisols are very fertile soils, typical for flatlands as well as uplands and used mostly for cereals, horticulture, fruit trees, vines, and forage crops providing higher yields even with minimum inputs. But they are under pressure from urban expansion, soil sealing, compaction, pollution and (perhaps) over fertilization causing chemical pollution.

Leptosols and Regosols are mostly located in the uplands and the mountain regions. They are often covered with forests, shrublands and natural pastures. Erosion and landslides are a problem, exacerbated by forest fires, and overgrazing. Histosols cover relatively small areas, Arenosols usually follow the coastal sand dunes, Solonchacks and Solonetz most widely found in Albania, North Macedonia, and Serbia, while Vertisols are also evident throughout the region. Gleysols have limited extent typically found in former drained wetlands and in depressions while Calcisols usually are found in the hilly areas of Albania, Montenegro and at limited extent all over the region. Large parts of them are used for the cultivation of olive groves and vines.

Finally, Anthrosols and Technosols cover limited areas compared to other soils but are widely distributed in the vicinity of the large urban areas as the best testimony of the urban sprawl.

3 Methodology

This report was prepared following the methodology described by the Soil Health and Food Mission "Caring for Soil is Caring for Life" Annex 1[4], primarily based on literature review and on the personal knowledge and experience of the authors. An important relevant source of information was derived from a Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH funded study conducted in 2016 (Zdruli and Cukaliev, 2016) to establish the *Areas with Natural Constraints in the Southeast Europe: Assessment and provide Policy Recommendations* that was published by the Regional Rural Development *Standing Working Group* (*SWG*) in South-Eastern Europe based in Skopje, Macedonia.

Seven experts were identified in all the countries included in the study. They are acknowledged at the beginning of this report. The data required were designed as given in Tables 1 and 2. Data sources came from national statistics and expert assessments. Should be noted that these types of data are scattered throughout the region and their availability depends on each country. The most problematic remains Kosovo due to many reasons, as extensive soil data are still at the archives in Serbia. On the other side there are countries like Montenegro, North Macedonia and Serbia that have better data in terms of availability and quality, but to a lesser extent in Bosnia and Herzegovina.

Another crucial problem derives from the fact that soil classification and laboratory analyses have been performed with different methods and systems that often are not compatible with the ones used in other parts of Europe, typically the Western countries. A harmonisation effort was made during the preparation of the Soil Atlas of Europe (Jones et al, 2005) but due to its scale of 1:1 million the representativity of the Western Balkans soils is rather limited. This has also caused a "black hole" in several JRC publications with the Western Balkan countries missing to be part of these studies.

The implementation of the LUCAS sampling campaign in 2015 in the region was an important step forward. Yet not a comprehensive report has been published to report the results of these data. Nevertheless, the JRC will be conducting another parallel study to fill in this gap. The other shortcoming comes from the fact that in the absence of at least two LUCAS sampling cycles data comparison becomes impossible and the assessments do not clearly point the trend in soil health indicators. Monitoring also becomes very difficult, if not irrelevant.

It is for these reasons, and maybe more, that the region has an urgent need to boost soil surveys, collect new soil samples, to enhance soil laboratories, train staff, especially young technicians, and a new generation of pedologists, as they are almost becoming "extinct". It is very important to start as soon as possible LUCAS2 soil sampling campaign. The process will be much easier since the georeferenced sites are already inserted into the national and JRC databases and the sampling campaign will be smoother.

[4] https://ec.europa.eu/info/publications/caring-soil-caring-life_en

Table 1 Summary of land use/land cover for the Western Balkans countries as of 2020

Countries	Pop. million	Area km^2	Agriculture land[1] (against total territory)						Organic farming[2] (against total agric. land)		Forest and areas with forestry biomass including shrubs (against total territory)		Permanent meadows and pastures (against total territory)		Other areas[3] (against total territory)	
			Cropland		Permanent crops		Total (cropland and permanent crops)									
			km2	%	km2	%	km2	%	km2	%	km2	%	km2	%	km2	%
Albania	2.8	28748	6143.5	21.4	846.5	2.9	6960.0	24.3	6.5	0.1	10771.1	37.5	4780.8	16.6	6236.1	21.6
Bosnia & Herzegovina	3.3	51130	12288.6	24.0	54.6	0.1	12343.3	24.1	9.0	0.1	31263.2	61.1	6505.8	12.7	1101.0	2.0
Kosovo	1.8	11000	3109.6	28.3	206.5	1.9	3316.1	30.1	1.6	0.1	4500.0	40.9	1550.0	14.1	1633.9	14.9
Montenegro	0.6	13888	92.1	0.7	26.6	0.2	118.7	0.8	8.7	7.3	8275.4	59.6	2082.3	17.5	3066.7	22.8
North Macedonia	2.0	25436	4130.5	16.2	401.3	1.6	4531.8	17.8	39.6	0.2	11534.5	45.4	8038.1	31.6	1292.0	5.2
Serbia	6.9	88407	25699.3	29.1	2062.3	2.3	27761.6	31.4	212.6	7.7	28500.0	32.2	6753.1	7.6	25399.3	28.7
TOTAL	**17.4**	**218609**	**51463.7**	**19.9**	**3597.9**	**1.5**[4]	**55031.5**	**21.4**[4]	**278.0**	**2.6**[4]	**94844.2**	**46.1**[4]	**30055.0**	**16.7**[4]	**38731.8**	**15.9**[4]

Notes

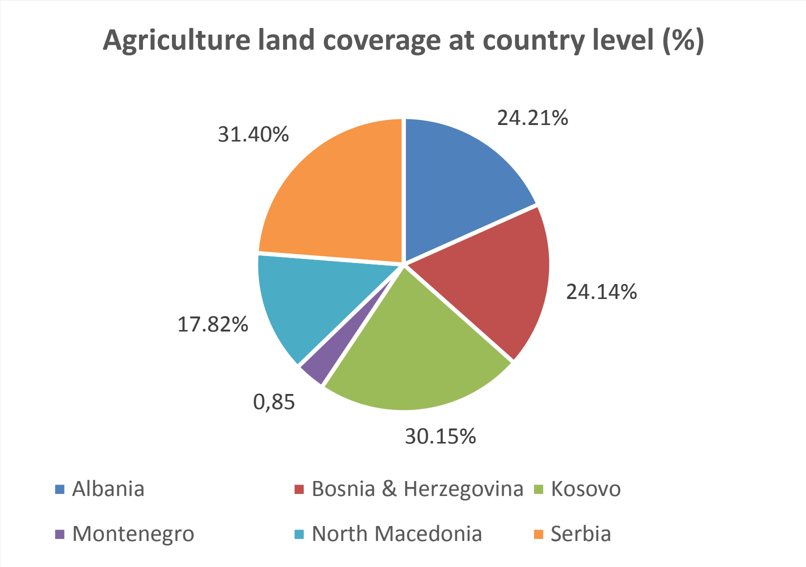
[1] Agriculture land includes cropland (i.e., cereals, industrial such as sugar beet, sunflower, horticulture in open field and greenhouses, forage crops), and permanent crops (fruit trees, olives, vineyards, citrus).

[2] Data from 'The World of Organic Agriculture, Statistics and Emerging Trends 2020' FiBL/FOAM

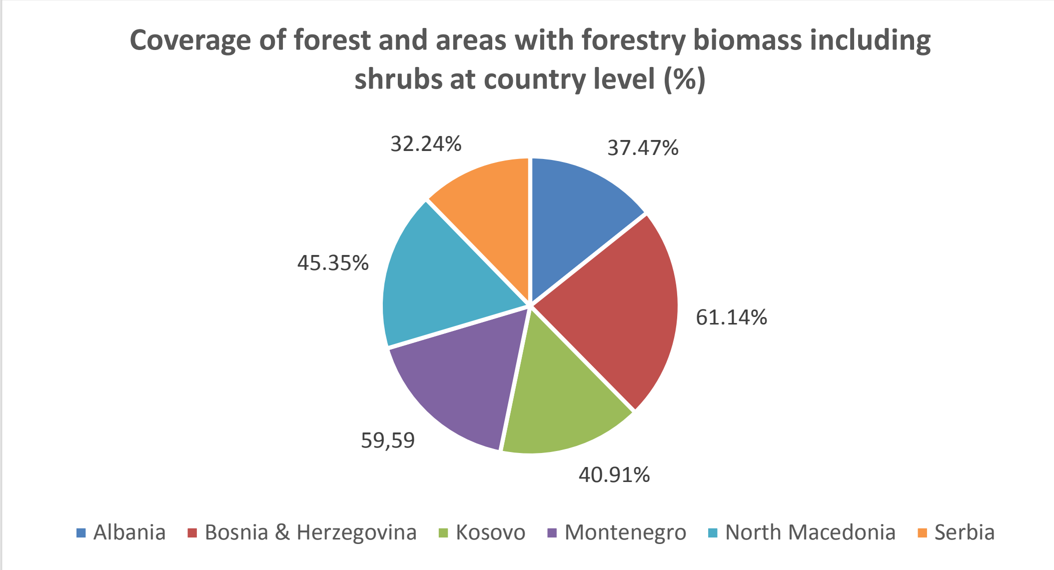
[3] Includes land occupied by buildings, infrastructure, quarries, tracks, ponds, water bodies, infertile land impossible for agriculture use, rocky areas, etc. Sealed areas cover a small fraction, but mostly in the best soils of the country.

[4] Weighted percentages at regional level considering the countries surface areas.

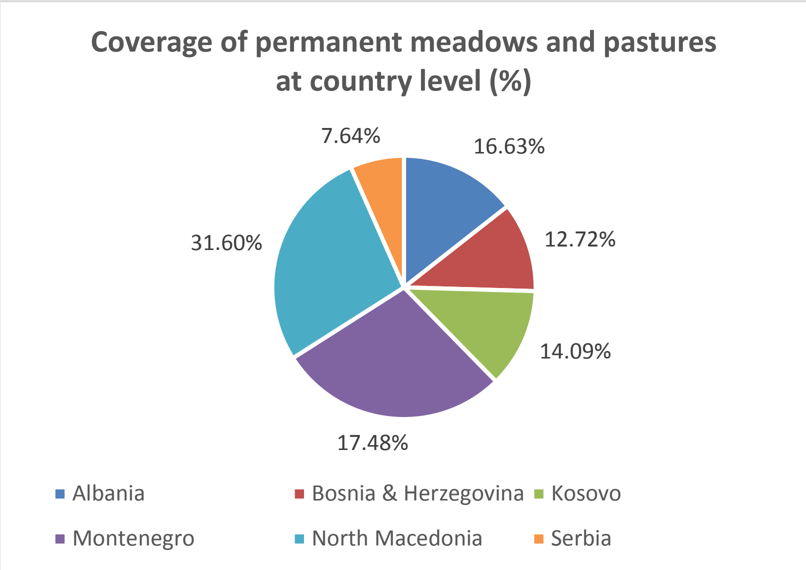
Source: National Statistics and information provided by national experts acknowledged in this report.



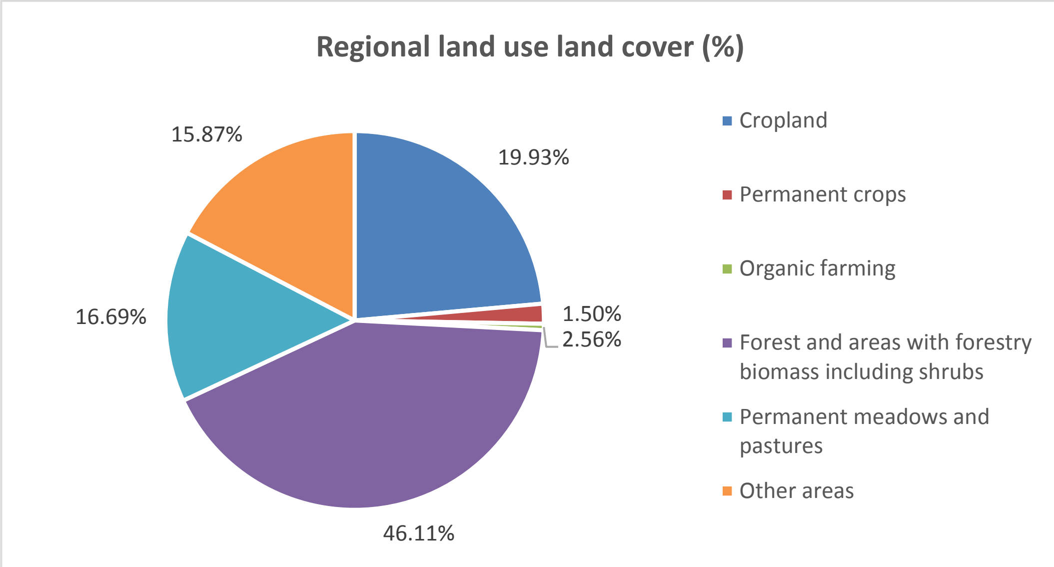
Agriculture land coverage at country level (%)
31.40%
24.21%
24.14%
17.82%
0,85
30.15%
Albania
Bosnia & Herzegovina
Kosovo
Montenegro
North Macedonia
Serbia



Coverage of forest and areas with forestry biomass including shrubs at country level (%)
32.24%
37.47%
45.35%
61.14%
59,59
40.91%
Albania
Bosnia & Herzegovina
Kosovo
Montenegro
North Macedonia
Serbia



Coverage of permanent meadows and pastures at country level (%)
7.64%
16.63%
31.60%
12.72%
14.09%
17.48%
Albania
Bosnia & Herzegovina
Kosovo
Montenegro
North Macedonia
Serbia



Regional land use land cover (%)
15.87%
19.93%
16.69%
1.50%
2.56%
46.11%
Cropland
Permanent crops
Organic farming
Forest and areas with forestry biomass including shrubs
Permanent meadows and pastures
Other areas

Table 2 Summary of soil health indicators and their pressures on agriculture land for the Western Balkans countries

Countries	**Agriculture land** km^2	**Soil health indicators: pressures on agriculture land**											
		Excess use of N[1]	**Soil Organic Carbon losses from**[2]		**Compaction**	**Erosion**		**Pollution**	**Saline-** Soda-fication	**Soil Acidity**: ≤5pH topsoil	**Soil sealing** and land take (2000 - 2020)	**Desertification**	Pressures on **soil biodiversity**
			Mineral soils	Organic soils		Water >10t/ha/yr[1]	wind						
		kg/ha/yr^{-1}	km^2	km^2	km^2	%	%	km^2	ha	km^2	km^2	%	%
Albania	6 960	N/A	5 959	100	N/A	93	N/A	N/A	420	900	500[4]	25.0	N/A
Bosnia & Herzegovina	12 343	N/A	12 282	6.2	N/A	80	N/A	3000	N/A	8 500	70	-	N/A
Kosovo	3 316	N/A	3316	-	N/A	60	N/A	N/A	-	N/A	10	N/A	N/A
Montenegro	119	N/A	N/A	-	N/A	90		N/A	N/A	N/A	N/A	N/A	
North Macedonia	4 532	N/A	4 532	-	N/A	90	N/A	430	713	326	362	13.7	N/A
Serbia	27 762	N/A	N/A	N/A	N/A	86	85[3]	324	2 330	N/A	134	N/A	N/A
TOTAL	**55 032**												

Notes

[1] Provides the extent both in open fields and greenhouses. The indicator Gross nutrient balance expressed as nitrogen added to and removed from agricultural land

[2] Estimates the extent of SOC losses both in mineral and organic soils due to unsustainable management practices and/or natural conditions

[3] refers to Vojvodina

Compaction, pollution (local and diffuse) and salinization/sodification, magnesial soils (Smonitsa) on existing data or estimates.

Soil sealing and land take data for the 2000-2020 period. [4] For Albania, the area refers to the period 1990-2020
Estimates the percentage of agriculture land affected by desertification based on the aridity index and land degradation impacts on the reduction of land to fulfill ecosystem functions

4 Summary of the study results

The proposal for a Soil Health and Food Mission[5] put forward the goal to make at least 75% of the EU soils healthy by 2030 since between 60-70% of them are already unhealthy due to mismanagement or poorly quantified pollution sources. However, to reach this goal would require: "*a radical change in current land management practices that is both feasible and necessary. Soils will also benefit from improvement to indirect drivers of change such as reductions in air pollution and carbon emissions*".

The situation in the Western Balkans (WB) regarding soil health remains largely unknown as recognised also by the European Environment Agency (EEA) in their SOER2020 report. Therefore, this study provides some first insight inputs to shed light on the present situation of soil health at regional and country level. As previously mentioned, results should be taken as preliminary and not final due to the data quality and their availability. Nevertheless, the study was able to provide a general overview of the soil health in the Western Balkan region as it is described in the following sections.

4.1 Regional status

4.1.1 Summary of the existing data

- The Western Balkans land area is: **218 609 km^2 with a population of 17.4 million people**
- Agriculture area[6] in WB: **5 503 154 ha** or **21.44%** of the land area
- Forests and areas with forestry biomass including shrubs: **9 484 417 ha** of the **46.11**% of the land
- Pastures and meadows cover: **3 005 501 ha** of the **16.69%** of the land area
- Croplands occupies **5 146 367 ha** of the **19.93**% of the land area
- Artificial areas occupy **less than 1%** of the total land area of the Western Balkans
- "Natural soils" (i.e., without intensive management regimes) cover about **80%** of the Western Balkans (includes forests, pastures, and meadows).

[5] http://ec.europa.eu/mission-soil

[6] Cropland and permanent crops, without including pastures and meadows

4.2 Status of soil health indicators in the Western Balkans:

4.2.1 Soil nutrients and Nitrate Vulnerable Zones

It is estimated that the area of agriculture land with failure of soil health indicator due to direct inputs nutrient issues in agricultural systems (excluding air pollution) to be in the range of 5.15% of the total agriculture area.

Fertilizer use is a necessity to allow farmers to maximize their yields on most conventional farms. But historically, their use has also created problems: fertilizers have facilitated large-scale monocultures, disrupted ecosystems, and largely minimized the need to monitor long-term soil health. Furthermore, from a practical perspective, over-fertilizing crops can lead to unintended consequences. A growing body of research suggests that in addition to downstream “dead zones” and algae blooms, excess fertilizer can often also hurt crop yields, especially crops like wheat and corn, during droughts because of soil eutrophication—a build-up of nutrients that lets plants grow so quickly, they can obstruct themselves out. Moreover, excess fertilizer applied during a drought year can create a boom-and-bust season because of the crops’ struggle for water (Van Sundert, et al., 2021). Finally, there is widespread agreement that the use of nitrogen fertilizers in still growing around the world’s farming, at a time when the average global efficiency of its use is stagnant, and hence the surplus nitrogen that is not taken up by crops is also growing at a troubling rate (Sasakova et al., 2018; Zhang et al., 2021; Chang et al., 2021).

The standard procedure for estimating the nutrient balance in the EU agriculture soils is the Gross Nutrient Balance Indicator (EUROSTAT 2020) that provides insights into the links between the use of agricultural nutrients, their losses to the environment, and the sustainable use of soil nutrients resources (Häußermann, et al., 2020). It consists of the Gross Nitrogen Balance and the Gross Phosphorus Balance and is intended to be an indicator of the potential threat of surplus or deficit of two important soil and plant nutrients in agricultural land. It shows the link between agricultural activities and the environmental impact, identifying the factors determining the nutrients surplus or deficit and the trends over time.

Nitrogen (N) and Phosphorus (P) are key elements for plants to grow. A persistent deficit of these nutrients can lead in the long-term to the so-called process of nutrient mining causing soil degradation and erosion. When N and P are however persistently applied in excess, they can cause surface and groundwater (including drinking water) pollution and eutrophication. The Gross Nitrogen Balance also includes Nitrogenous Emissions from livestock production and the application of manure and fertilizers.

Scattered available data for the WB show that the largest amounts of fertilisers, especially N are applied in the greenhouses followed by open field horticulture crops. Based on this assumption, the total area of greenhouses and horticulture crops (Table 3) was calculated for the whole region totalling **286 444 ha (or about 5.20% of total agriculture land)**. This was based on reported data for the years between 2016 till 2020 depending on the country’s national statistics. It appears that North Macedonia has the largest surface area covered by greenhouses and open fields horticulture when compares with the rest of the countries.

It is finally stipulated (due to missing data) that these types of land uses (Table 3) are subject to nutrient imbalances and vulnerable to nutrient contamination due to overuse of chemical fertilisers.

Table 3 Total area of greenhouses and horticulture crops

	Country	Greenhouses (ha)	Horticulture crops (ha)	Total (ha)
1	Albania	1 750	41 000	42 750
2	Bosnia and Herzegovina	715	75 000	75 715
3	Kosovo	413	28 191	28 604
4	Montenegro	48	4 125	4 173
5	North Macedonia	6 622	59 000	65 622
6	Serbia	60	69 520	69 580
	TOTAL	**9 608**	**276 836**	**286 444**

Other farmland uses including cereals, industrial such as sugar beet and sunflower, as well as forage crops, and permanent crops (fruit trees, olives, vineyards, citrus) that cover **5 503 154 ha (or 94.85%)** of the total agriculture area of the WB overall **are not subject of over fertilization**.

Nitrate Vulnerable Zones (NVZ)

The European Commission (EC) Nitrates Directive requires that areas of land that drain into waters polluted by nitrates to be designated as Nitrate Vulnerable Zones (NVZs). Farmers with land in NVZs must follow mandatory rules to tackle nitrate loss from agriculture. It is well known that Nitrogen, apart from agriculture crops, is also vital for aquatic ecosystems, supporting the growth of algae and plants which provide food and habitat for fish and smaller organisms that live in the water. But too much nitrogen in water can result in serious environmental and human health issues.

The most appropriate assessment of NVZs for the Western Balkans is to concentrate on the Danube River basin. According to several calculations, the total nitrogen emissions in the basin are about 600 000 tons per year. This assessment comes from the MONERIS (MOdelling Nutrient Emissions in RIver Systems)[7] water quality model which has been used for the entire basin and for hydrological conditions of the period 2009-2012 to estimate spatial patterns of nitrogen emissions in the basin and assess the various contributing pathways. Subsurface flow is the most important pathway for nitrogen emissions, responsible for about 50% of all nitrogen emissions. Diffuse inputs dominate the basin-wide nitrogen emissions– with roughly 80% of the total load. Emissions from point sources, such as wastewater treatment plants and industrial dischargers, contribute 20% of the total load.

The main emission sources are agricultural fields with 40% of the total load. Urban areas – such as wastewater discharges, runoff from paved surfaces and combined sewer overflows – as well as natural lands where atmospheric deposition provides nitrogen input are significant source areas as well. Several implemented measures have substantially reduced nitrogen inputs into surface waters and groundwater in the Danube River Basin, but further efforts are still needed. The long-term average for the period 2003-2012 of observed nitrogen river loads at the mouth of the Danube is about 500 000 tons per year. Due to the larger part of the Danube basin inside its territory, it is estimated that among the six Western Balkan countries, Serbia should have the largest contribution of N discharge, which nevertheless is very limited compared to the nutrient loads coming from all other countries that drain their waters into the basin

Scattered data for Albania have estimated that in only one year erosion washes away 1.2 million tons of organic carbon, 100 000 tons of nitrate, 60 000 tons of phosphates, and 16 000 tons of potassium (Laze and Kovaçi, 1996). Other studies (Qilimi, 1996) showed that

[7] https://www.icpdr.org/main/publications/nitrogen-pollution-danube-basin

soil fertility declined mainly in organic matter content, nitrogen, and potassium compared to 20 years ago, resulting in nutrient mining of the soils.

To further reduce nitrogen pollution, wastewater treatment plants must be upgraded with nitrogen-removal technology, however measures to introduce best practices in agriculture and land management are especially needed, since diffuse pathways make up a major part of the total nitrogen emissions. A key set of best agricultural practices related to farming and land management has been identified, which are in line with the provisions of the EU Nitrates Directive and the pillars of the Common Agricultural Policy in the EU Member States. In addition to regulatory actions to comply with basic standards, economic incentives for farmers can ensure higher efficiency and better practical performance in implementing measures. However, further efforts are needed to achieve better use of the available financial instruments and to appropriately finance and implement agricultural measures.

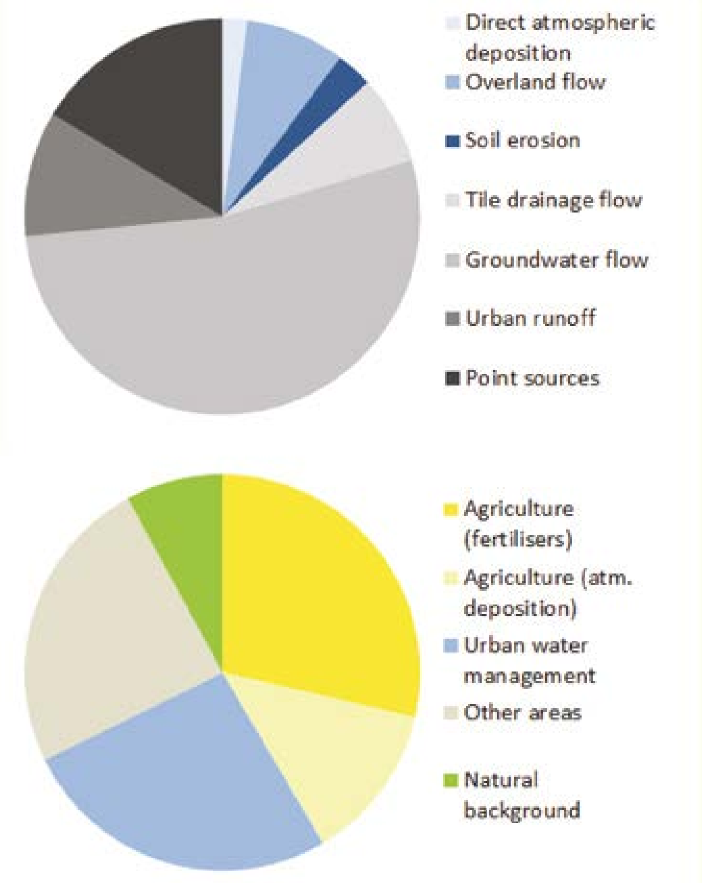


Figure 6 Different sources of Nitrogen load into the Danube River basin

Source: Draft DRBM Plan – Update 2015

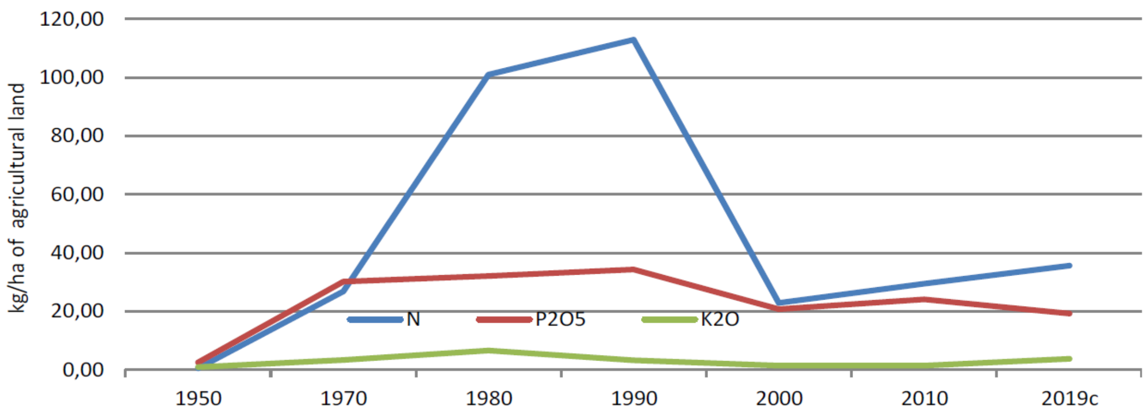
The general understanding is that due to economic costs, fertilizer use, especially Nitrogen is used in excess primarily in greenhouses and open fields vegetable crops, and much less to other crops.

Albania

Natural soil constraints in Albania have been identified as saline and sodic soils (about 10 000 ha, even though recent estimates point out at about 30 000 ha), 60 000 ha alkaline soils mostly in the western coastal area, acidity (or low pH) in about 90 000 ha, largely distributed in the north-eastern part of the country, magnesial (serpentine) soils in about 12 000 ha and heavy clay soils covering 60 000 ha (Zdruli, 2005; Zdruli et al., 2002).

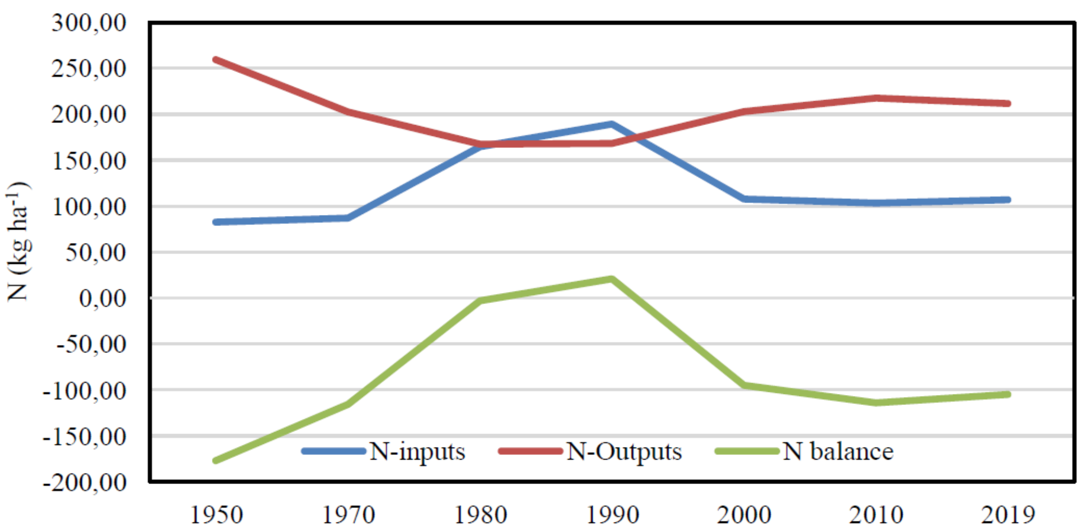
When considering agriculture practices related to nutrient management sporadic data show that for 2019 there were deficits for: N -104.8 kg ha^{-1}, P -8.7 kg ha^{-1} and for K -134.5 kg ha^{-1} (Gjoka et al., 2021) making Albania one of the countries with the largest **soil nutrient deficit** compared to the EU and OECD countries (Fig. 6). This deficit is mainly due to the application of small amounts of chemical fertilizers. Therefore, it appears that there are **no environmental pressures or potential risk of pollution** at nationwide scale.

Figure 7 Amount of NPK (kg/ha) of cropland from chemical fertilizers. Note the drastic decline after the political change of 1990.



Source: Gjoka et al., 2021

Figure 8 Temporal variability of NPK input, output, and balance for agriculture crops in Albania for the period 1950-2019.



Source: Gjoka et al., 2021

However, these risks have been documented in the greenhouses and to a lesser extent in open field horticulture crops that are over fertilized with Nitrogen. Instead, Phosphorous and Potassium are used in much lower amounts and do not pose risks of contamination. The other issue is that farmers rely mostly on intuition when applying fertilisers. A survey carried out in 2017 (Gjoka et al., 2021) with farmers that grow watermelon in open fields as well as vegetables in greenhouses revealed that only about 25% of them have carried out soil and water analysis. That is worrisome both for the long-term use of the costly greenhouses, but also for the uncertainty of fertiliser use that remains largely not scientifically based. This has increased N accumulation in the soil and groundwater inside these greenhouses. Furthermore, there are already tens of hectares of greenhouses that are experiencing increased salinisation also due to poor quality irrigation water.

Furthermore, the other issue is the inappropriate **manure storage** with Nitrates' losses into water bodies. Likewise, pesticides are representing a threat for water quality, but data are missing to make the proper estimates.

Bosnia and Herzegovina

World Bank data for the fertilizer consumption in Bosnia and Herzegovina pointed out that it fluctuated substantially in recent years, nevertheless it tended to increase through 1999 - 2018 period ending at 84.8 kilograms per hectare in 2018. Compared to the EU countries this value is far below the average use of fertilisers in the EU. As in the case of Albania, the environmental risk of **degrading soil health due to over fertiliser use in Bosnia and Herzegovina remains low**.

Figure 9 Fertiliser consumption in Bosnia and Herzegovina for the period 2007-2018. Note the descending trend after the year 2015.

DATE	VALUE	CHANGE, %
2018	84.8	-20.39 %
2017	106.5	-1.32 %
2016	107.9	-16.30 %
2015	128.9	7.40 %
2014	120.0	18.10 %
2013	101.6	-15.83 %
2012	120.7	16.80 %
2011	103.4	26.80 %
2010	81.5	12.13 %
2009	72.7	512.52 %
2008	11.9	-44.27 %
2007	21.3	

Source: http://knoema.com

Kosovo

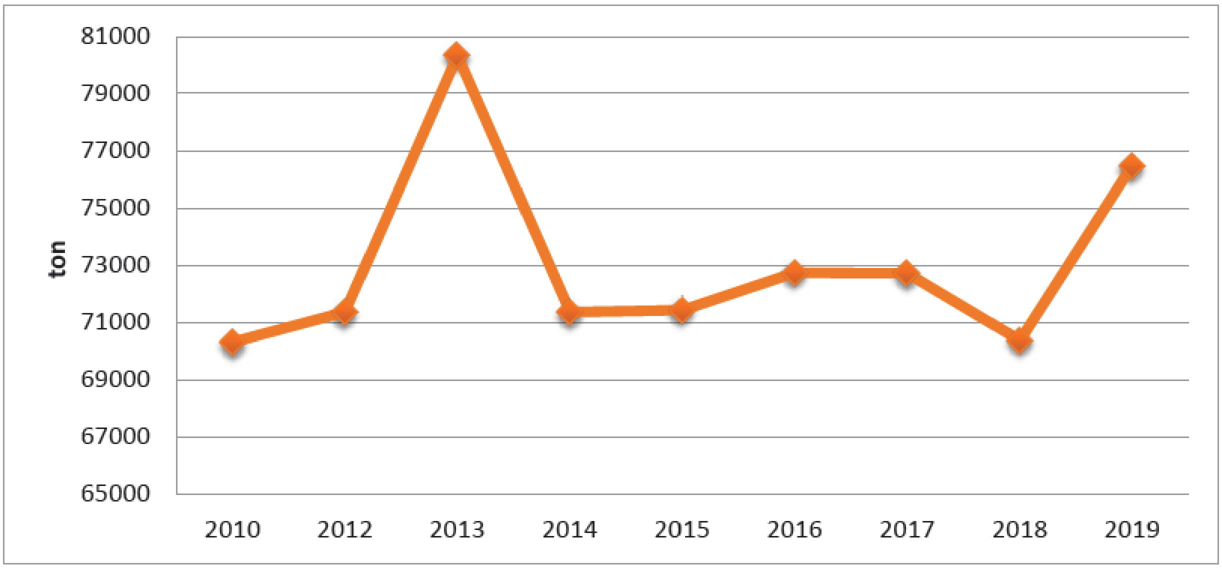
Kosovo has undergone profound changes over the past decade. The legacy of prolonged civil unrest, conflict and war is perhaps most apparent in the field of agriculture. The restart of Kosovo's agriculture after a decade of neglect and depredation suffered during the violence caused by the war is now a priority for the Kosovo government.

To analyse the nutrient dynamics a first assessment of the natural conditions was made. Climate in Kosovo is continental in the east with an average of 660 mm of annual rainfall and 170–200 frost free days while the south-east is influenced by Mediterranean (wetter) climate with 780 mm and a warmer 196–225 frost free days (World Bank, 2000).

Agriculture contributes to about 30% of GDP in Kosovo and supports about 60% of the population currently. The agricultural share of GDP increases to 35% when forestry is included (Statistics Office of Kosovo, 2001).

According to the data from agricultural questionnaires conducted by the Kosovo Agency of Statistics, in 2019 were used about 76 467 tonnes of fertilizers that contain nitrogen (NPK, UREA and ALN), which is higher than previous years. However, compared with the period 2012-2014 there were about 6 100 tonnes less fertilizer used, indicating lower risks of contamination.

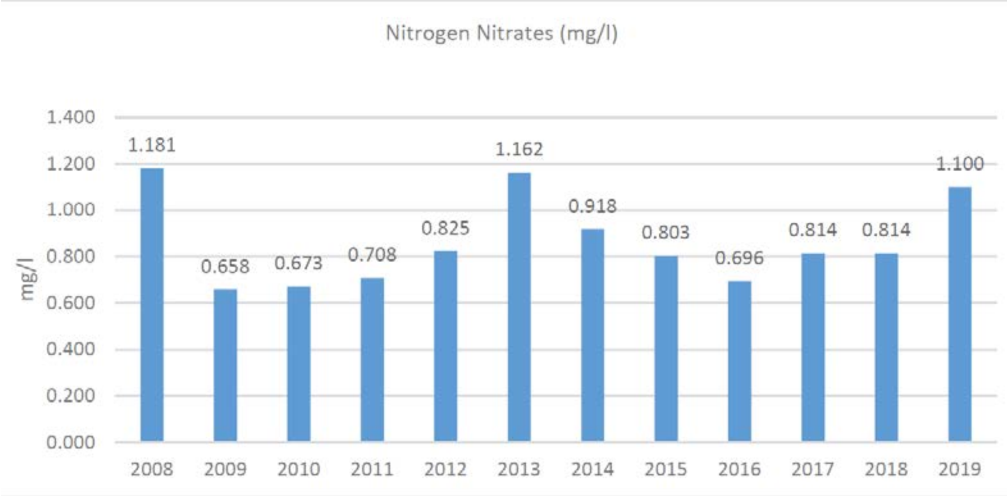
Figure 10 Trends in fertiliser use for the period 2004-2019 in Kosovo



Source: Kosovo environment 2020 report

Figure 11 presents the trend of Nitrate Nitrogen concentration (mg / l) in surface waters (rivers) for the period 2008-2019. The figure shows that the nitrogen concentration of Nitrates during this period is between 0.658 mg / l, as the lowest value recorded in 2009, and 1.181 mg / l as the highest value recorded in 2018. The year 2019, marks an increase in concentration (1.100 mg / l) compared to 2018 (0.814 mg / l). In general, the trend of this indicator for the period 2008-2019, is linear with some small changes with increasing trend for the years 2008, 2013 and 2019.

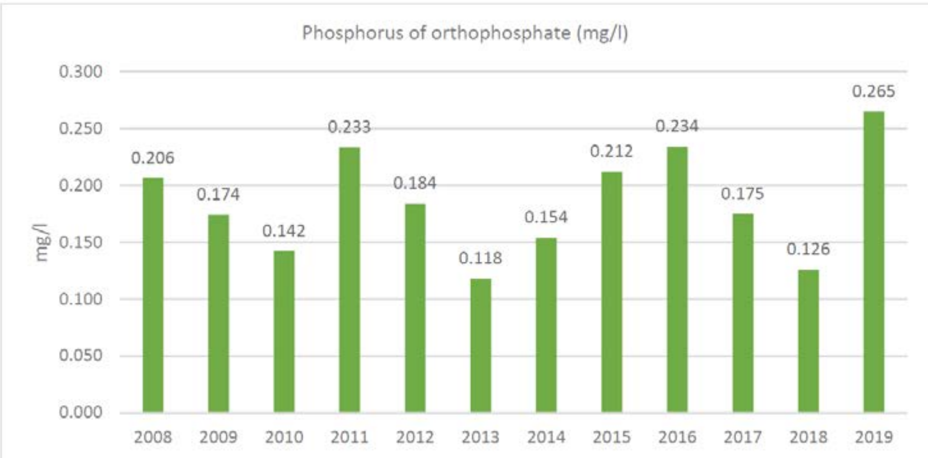
Figure 11. Nitrogen concentration (mg/l) in surface waters of Kosovo



Source: Kosovo environment 2020 report

Figure 12 presents the trend of phosphorus orthophosphate concentration (mg / l) in surface waters (rivers) for the period 2008-2019. The figure shows that the Phosphorus orthophosphate concentration during this period is between 0.118 mg / l, as the lowest value recorded in 2013, and 0.265 mg / l as the highest value recorded in 2019. The year 2019 marks an increase in concentration compared to 2018 (0.126 mg / l). In general, the trend of this indicator for the period 2008-2019 is presented with oscillations (ups and downs) and there is no linear flow.

Figure 12 Phosphorus concentration in surface waters for the period 2008-2019



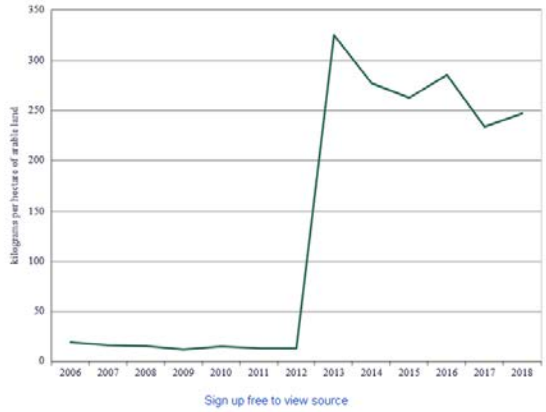
Source: Kosovo environment 2020 report

The area cultivated with vegetables and the greenhouses were considered as potentially vulnerable and they were included in the total area of the region.

Montenegro

In 2018, fertilizer consumption for the country was 246.8 kilograms per hectare and for the period 2009 – 2018 there was a constant tendency of increase (Figure 13). When compared to other countries globally, Montenegro ranks at the 27th stage, which is quite high even when compared to EU countries. Despite data not being available to estimate the nutrient balance, as previously mentioned, the area covered by greenhouses and vegetables were included in the assessments as potentially overloaded particularly with Nitrogen and therefore vulnerable to pollution.

Figure 13 Fertiliser consumption and worldwide ranking of Montenegro for fertiliser use.



DATE	VALUE	CHANGE, %
2018	246.8	5.63 %
2017	233.6	-18.08 %
2016	285.2	8.66 %
2015	262.5	-5.22 %
2014	276.9	-14.77 %
2013	324.9	2,501.12 %
2012	12.5	-0.46 %
2011	12.5	-12.58 %
2010	14.4	26.70 %
2009	11.3	-23.41 %
2008	14.8	-5.38 %
2007	15.6	

		2018	2017	2016	2015	2014	2013	2012	2011	2010	2005
27	Montenegro	246.8	233.6	285.2	262.5	276.9	324.9	12.5	12.5	14.4	–
1	Hong Kong SAR, China	3,573.9	2,807.8	2,715.9	2,394.8	1,973.6	598.0	1,307.3	790.6	616.3	365.8
2	Malaysia	2,106.5	2,169.4	2,143.0	2,105.1	2,491.7	2,170.2	1,916.8	2,183.6	2,166.8	1,596.0
3	Bahrain	1,990.5	211.7	458.9	1,587.8	3,045.6	2,811.9	3,001.4	3,100.7	1,787.1	2,090.2
4	New Zealand	1,895.3	1,863.3	1,552.9	1,766.2	1,364.2	1,245.3	1,359.3	1,483.3	1,244.4	2,133.3
5	Ireland	1,544.9	1,349.0	1,207.3	1,273.9	1,196.0	1,110.3	1,138.8	995.7	1,065.4	458.0
6	Kuwait	1,059.5	1,077.8	1,000.7	1,122.6	671.9	434.1	468.6	441.6	228.4	90.9
7	United Arab Emirates	745.3	708.5	708.5	714.9	629.2	1,033.9	848.2	900.0	737.4	667.1
8	Costa Rica	641.8	636.5	559.7	625.2	584.2	589.8	635.3	706.1	519.3	683.5
9	Egypt, Arab Rep.	569.1	569.1	566.0	566.8	522.6	500.9	463.0	503.6	473.4	600.1
10	Seychelles	515.7	646.0	521.7	816.9	337.1	341.7	525.0	333.3	32.2	34.0
11	Vietnam	415.3	458.0	424.7	432.3	436.8	483.9	371.1	353.8	365.3	339.6
12	China	393.2	421.5	463.2	464.6	464.8	449.1	450.8	440.8	424.4	376.9
13	Ecuador	386.8	345.4	317.9	254.8	344.0	236.2	254.7	275.4	252.1	150.8
14	Korea, Rep.	369.7	356.0	353.6	337.8	345.9	344.7	351.8	337.3	330.3	478.2
15	Trinidad and Tobago	364.0	364.0	364.0	356.0	360.0	308.0	276.0	232.0	228.0	240.0
16	Guatemala	358.3	359.8	303.2	342.1	298.0	284.7	267.1	223.2	189.1	141.7
17	Bangladesh	318.5	303.7	289.4	299.0	279.2	254.6	260.4	255.8	213.0	197.7
18	Oman	316.8	332.7	512.7	397.0	497.3	491.7	525.3	440.4	542.3	597.8
19	Chile	307.6	291.0	293.8	415.8	358.2	347.6	339.4	492.6	373.2	434.8

Source: http://knoema.com

North Macedonia

North Macedonia is a landlocked country on the Balkan peninsula with a total area of 25 710 km² making it the 17th smallest country in Europe and ranked 150th in the world. It lies at an average elevation of 741 meters above sea level. The highest mountain peak (Golem Korab) is at 2 764 meters. The country has 10 140 km² of agricultural land that includes also pastures and meadows, which is almost 39% of its territory. Half of this land is devoted to crop growing, and the other half livestock farming.

In 2018, fertilizer consumption for North Macedonia was 60.8 kilograms per hectare which is one of the lowest in the region. The tendency of fertiliser use shows a constant decline since the year 2007, that, except for 2008, 2009, 2012, the value of 60.8 kg/ha is the lowest in the last decade. Based on these data it is stipulated that the country do not experience soil health problems related to nutrient imbalance, rather the soil fertility of agriculture land could show signs of fertility decline due to nutrient mining.

Nevertheless, since North Macedonia devotes a considerable part of its territory to agriculture, and agriculture related activities, this sector is responsible for 89% of annual national ammonia (NH_3) emissions due to animal husbandry and manure management. In sporadic cases there is overuse of inorganic nitrogen fertilizer and manure additions to soils. Pollution of soil and groundwater from agriculture from excessive fertilizer and manure application, and irrigation with poorly treated wastewater is expected especially in areas with high permeability karst geology. However, no monitoring has been done to confirm the assumption (UNECE, 2019b).

Serbia

Serbia is the largest country in the Western Balkans and with the largest extent of the agriculture land. The country has made progress towards adjusting its legislation with the EU. One of them is the endorsement of the Nitrate Directive that has been partially transposed into the Water Law and the Ministry of Agriculture, Forestry and Water Management (MAFWM) is the authority responsible for determining the vulnerable zones and their boundaries, proposing for adoption of the action programmes with mandatory measures for protected areas designated as vulnerable zones, as well as proposing the adoption of the Code of good agricultural practice. Proposal for the Nitrates Vulnerable Zones and draft of the Code of Good Agricultural Practice has been already developed. Another piece of legislation in progress is the transposition of **Directive 86/278/EEC** on the protection of the environment, and of the soil, when sewage sludge is used in agriculture (Vidojevic et al., 2018).

Though Serbia fertilizer consumption fluctuated substantially in recent years, it tended to decrease through 2009 - 2018 period ending at 72.9 kilograms per hectare in 2018.

Figure 14. Fertiliser consumption and worldwide ranking of Serbia for fertiliser use

Source: http://knoema.com

Based on the data from Figure 14 the total amounts of fertilisers used in Serbia are far below the EU levels. As for the other countries data availability of their use on various crops are not available but as a general agronomic rule their excess use is often relevant for the greenhouses and vegetables, therefore these areas were considered as potentially vulnerable and were included in the regional estimation as well as at country level.

4.2.2 Organic carbon

It is estimated that the land with failure of soil health indicator due to low and declining of carbon stocks to be in the range of less than 5% against the total land area of the region and about 10% for agriculture land.

Even in the EU, despite detailed national SOC data sets are available, a consistent C stock estimation at EU scale yet remains problematic. Data are often not directly comparable, different methods have been used to obtain values (e.g., sampling, laboratory analysis) and access may be restricted. Therefore, any evolution of EU policies on C accounting and sequestration may be constrained by a lack of an accurate SOC estimation and the availability of tools to carry out scenario analysis, especially for agricultural soils (Lugato et al., 2013). Globally, the same problem is recognised and while there are many studies on soil carbon sequestration, there is no single unifying volume that synthesizes knowledge on the impact of different land management practices on soil carbon sequestration rates across the world (The World Bank, 2012).

The main difficulty to assess the changes and trends in Carbon stocks in the Western Balkans is the shortage of data and the missing points for comparisons. The LUCAS survey of 2015 is the only soil survey implemented regionally. These data are still under the scrutiny of validation, but they could not be compared with any previous data to check the changes. Even so, the comparisons would have been almost impossible due to the differences in laboratory analyses, lack of bulk density data, and the diversity of soil survey methodologies. This brings to the attention for new national soil survey campaigns and the start without delay of LUCAS2 in the region.

Based on these considerations, the only possible way to estimate both carbon stocks and their trends is to overlay the only available regional soil map with the land use/land cover systems. Starting from the soil name and the published references (FAO and ITPS, 2020) a correlation could be made to estimate SOC stocks. At the best of consultant's knowledge, apart from the 1:1 million Soil Geographical Database for Europe[8] there is no other source of regional soil information for the Western Balkans countries. However, this assessment was not possible to be conducted in the frame of this contract. Nevertheless, it is estimated that SOC stocks in the Western Balkans are far less compared with other parts of Europe, especially the Northern regions that host large areas of peat soils (Figure 15).

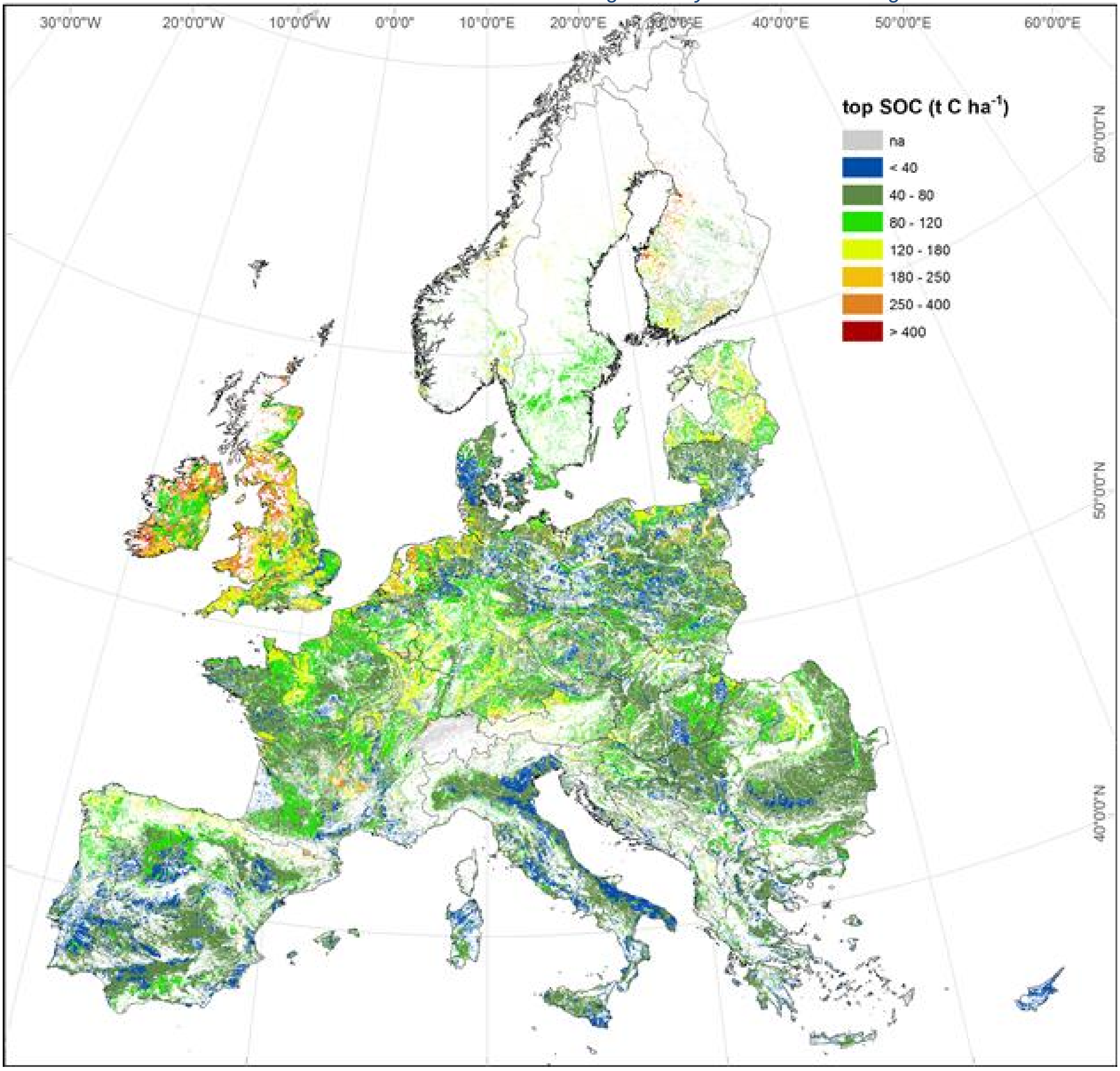
[8] EUROPEAN SOIL DATABASE (europa.eu)

Figure 15 Total SOC stocks (Pg) and mean SOC stocks (t/ha) per WRB name.

Soil Type	Total SOC	Mean SOC	Soil Type	Total SOC	Mean SOC
Leptosols	80.8	51.3	Kastanozems	16.9	47.5
Cambisols	69.6	65.2	Podzoluvisols	15.9	67.5
Gleysols	61.2	100.8	Vertisols	9.5	31.1
Podzols	56.3	88.1	Lixisols	9.3	38.8
Acrisols	47.9	60.1	Andosols	8.6	91
Regosols	45	63.2	Solonetz	8.3	41
Ferralsols	40.2	49.1	Nitisols	7.9	54.4
Luvisols	36.5	45.1	Plinthosols	6.2	45.6
Histosols	35.3	138.7	Greyzems	5.2	79.7
Arenosols	24.7	25.7	Planosols	4.4	48
Calcisols	21.2	21.1	Gypsisols	3.1	24.4
Fluvisols	20.6	59.6	Solonchaks	2.6	20.8
Chernozems	19.7	89.6	Alisols	2.5	56.1
Phaeozems	18.2	62.2	Anthrosols	2.2	40.1

Source: FAO and ITPS, 202)

Figure 16 Topsoil (0-30 cm) SOCs of Europe. Large parts of the Western Balkans are not covered due to lack of data. Carbon stocks are generally in the lower range.



Source: https://esdac.jrc.ec.europa.eu/themes/agricultural-soc-stocks

The following country descriptions are based on existing national data and literature reviews.

Albania

A first assessments of the carbon stocks of Albania was made by Zdruli in 1996 reporting about 0.2 gigatons. The largest stock is in the Cambisols (43%) because these soils have the largest aerial extent, occupying much of the central part of the country. In the Northern Albanian Alps, at elevations exceeding 1 500 m, the soils are shallow and have an udic soil moisture regime (SMR) and a mesic to cryic soil temperature regime (STR) according to Soil Taxonomy classification (Soil Survey Staff, 2014). Under these moisture and temperature environments, SOC accumulation is high. These areas are also covered mostly with forests and so the land is relatively undisturbed. Gleysols and Stagnosols are common on the valley bottoms and these soils along with other wetlands also have high SOC accumulations.

Luvisols and Phaeozems/Kastanaozems predominate on the flat to undulating landscapes and altogether together contribute to about 34% of the total SOC stocks of the country. However, these soils are under increasing pressure from agriculture, sealing and grazing. Erosion rates are increasing and there is much loss of SOC. The Histosols occupy small enclaves and though their presence is important for the watershed and the general ecology, their total contribution of SOC to the national stock is not significant. Histosols cover a very limited area of soils in Albania, moreover they have been totally drained and converted for agriculture. Data show that the average SOC loss due to land reclamation, drainage and cultivation in 38 years was as much as 80.6% for the top 0-30 cm depth or a rate of decrease of 26g/kg/yr-[1] (Zdruli *et al.,* 1995).

Hills and mountains with shallow soils or with rock outcrops occupy about 32% of the total land area. These lands have been denuded of much of their natural vegetation through geologic processes and through accelerated erosion and forest fires. Nevertheless, recent trends point to a quick recovery of the vegetation cover. This land unit only contributes to about 13% of the total SOC. Agricultural lands occupy about 25% of the land area and of this, about half is situated in inland valleys. These lands receive alluvium from the eroded slopes of the hills and mountains and are thus continuously enriched in SOC (Zdruli, 1997). According to FAO Global Forest Resources Assessment, 2015 - country report[9] (no recent data available), **Albania is sequestrating 142.2 million metric tons of total forest carbon**, out of which 49.3 million metric tons of carbon in living biomass and 67.3 million metric tons of carbon in soils up to a depth of 30 cm.

Carbon stocks in Albania most likely have remained stable over the last three decades or after the political change of the 90s. For instance, agriculture land is cultivated at around 50-60% capacity with the rest left fallow. It is well known fact that fallow land tends either to increase carbon sequestration or at least C remains stable. Second positive fact is that alfalfa has become the dominant crop in arable lands, enriching thus the soil with C and N. Third consideration to be made is the extensive brush and shrub cover around the country that has sustained rather stable conditions both in terms of SOC stock and erosion control. On the negative side is the degradation of forests due to illegal cuttings and forest fires that accelerated both erosion and carbon losses. Soil sealing and land take around big cities have also reduced the potential for carbon sequestration.

It is then concluded that **SOC stocks in Albania have remained stable** and overall, the soil health indicator related to **declining Carbon is not critical for the country**.

[9] http://www.fao.org/3/az146e/az146e.pdf

Bosnia and Herzegovina

Soil distribution in Bosnia and Herzegovina is closely related to geomorphology and relief. Bukalo et al., (2016) have described the following pattern: The *flat or lowlands* zone is found in the northern part and represents the most valuable land resources for food production. The most common types of soil are: Stagnic Podzoluvisols, Fluvisols, Umbric Gleysols and Eutric Gleysols. These are important carbon storage areas.

The *hilly zone* is more heterogeneous in terms of soil characteristics and subject to erosion due to increasing slopes above 13%. The most common types of soil are: Chromic Luvisols, Eutric Cambisols, Leptosols – Rendzic Leptosols and Vertisols. Soil Organic Carbon (SOC) stocks are much limited compared to flatlands.

The *mountain zone* is mostly covered by forests and grasslands. As for sown crops, rye, barley, oats and potato dominate. The most common types of soil are: Dystric Cambisols and Dystric Regosols which are predominantly present, followed by Leptosols – Rendzic Leptosols and Regosols. Country wide forests cover more than 3 million ha, or 62% of the total land area, which is one of the highest forest coverage areas for a single country in Europe. Forests are also important areas of carbon sequestration. They store consider amount of SOC but the real data for the country are missing.

The Mediterranean zone, with its warmer climatic conditions, is suitable to grow a wide variety of crops and support intensive farming, as well as traditional arable crops and early vegetables. Fruit and vine-growing are also well developed here nicknaming this as the “region of southern crops”. The most common soil types are: Lithic Leptosols, Regosols, Leptosols – Rendzic Leptosols, Chromic Cambisols, Fluvisols in the river valleys, and Umbric and Eutric Gleysols in the karst fields. In the swamps, Histosols are often present despite in limited extent. SOC stocks in arable lands are lower compared with soils in the karst region. This is a well-known process throughout the Mediterranean part of Europe (Zdruli et al., 2004).

Data on country’s total SOC stocks are not available. Bogunovic et al., (2018) showed that soils of the Livno karst polje depression had high average SOC (7.92%) and SOC stocks of 191.05 t ha^{-1} with Histosols having the highest stocks and Arenosols the lowest. Karst covers 29% of the country’s territory, therefore is an important carbon stock.

As in the case of Albania, the soil health indicator related to **declining Carbon appear not to be critical for the country**.

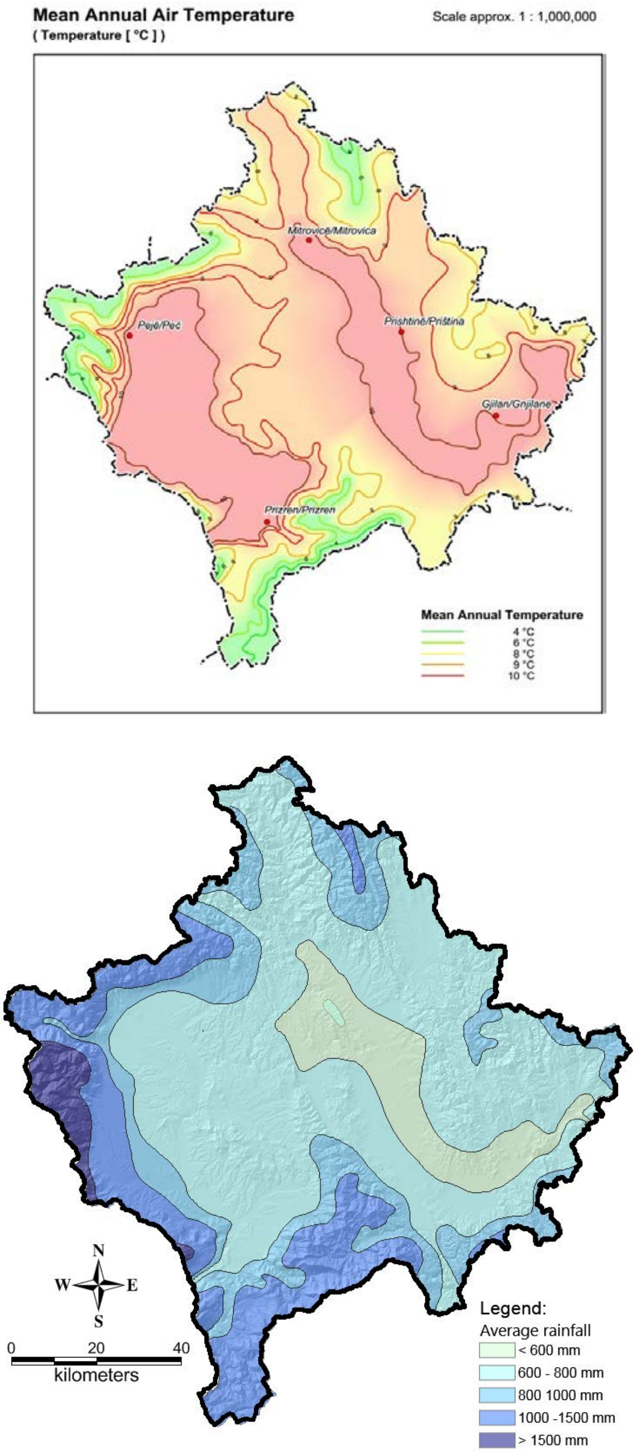
Kosovo

Kosovo borders Albania to the southwest, Montenegro in northwest, Serbia in the northeast and North Macedonia in the south. The diversity of Kosovo’s soils reflects the variety of landscape, geological composition, climate, hydrographic distribution, flora, and human action. In terms of soil quality, the largest part of the territory (56%) is classified as poor, 29% as medium and only 15% of the country’s soils are ranked as good (Tahirsylaj et al., 2016).

The first soil research started in the former Yugoslavia during the 50's that resulted with the preparation of several soil maps of Kosovo at scale 1:50 000. Based on these maps and some additional research, in 1974 was prepared the Pedologic Atlas of Kosovo (IDWR) edited by the Institute "Jaroslav Cerni" of Belgrade, which included 101 systematic mapping units providing data on soil texture, depth, and drainage conditions. Before the Kosovo war of 1999, this atlas has been used as a main source for Agriculture Land Suitability Classification system, where the agricultural land was divided into 8 classes. This system was the basis of the state land taxation in agriculture and in same time served as a source for definition of land use classification. After the war, with funding provided by the EU the Atlas was updated with new data regarding soil texture, depth and drainage.

The climate in most part is continental, resulting in hot summers and cold winters, with Mediterranean and continental influence (average temperature in the country ranges between + 30 °C in summer and -10 °C in winter). However, due to uneven elevations in some parts, there are variations in temperatures and distribution of precipitations (Fig. 17).

Figure 17 Mean annual temperature and average rainfall data for Kosovo

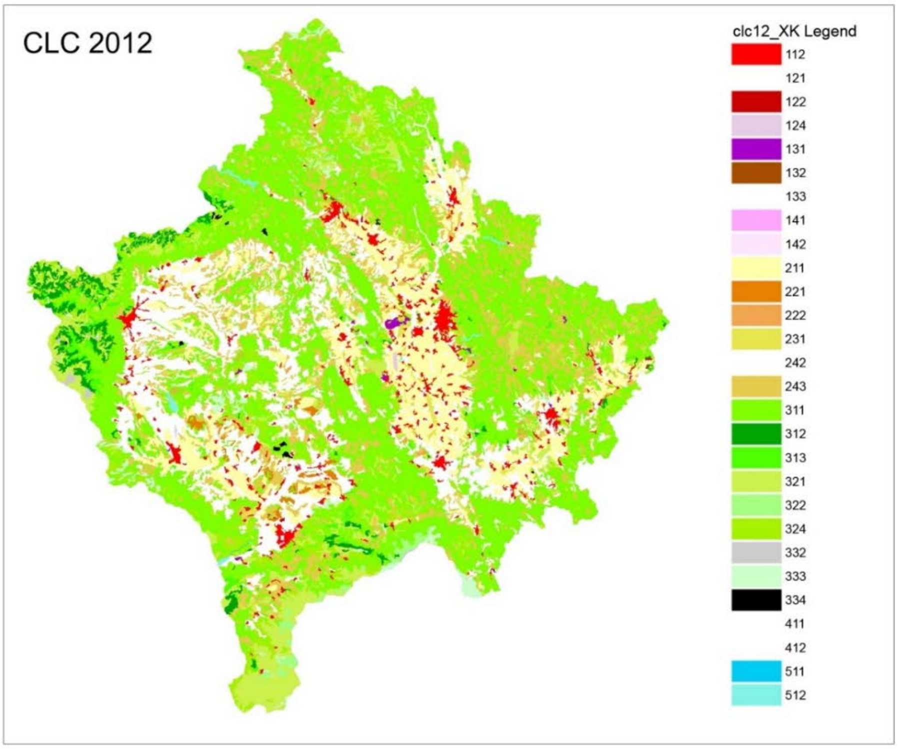


Source: Tahirsylaj, et al., 2016

Land use data are available from CORINE2012 as shown in Figure 18. From a total of 44 CORINE2012 classes in Kosovo are identified 28 of them. These are grouped into four main classes. The largest area is dominated by forests and semi -natural areas (about 57%) followed by agricultural lands (around 40%), while artificial lands cover 3.0% of the total territory and the rest (about 0.3%) is classified as water bodies and wetlands (wetlands).

Data on SOC stocks are not available for Kosovo. Based on the logic that forests and natural areas have the capacity to store more Carbon than arable lands, their large area must be considered in any possible assessment. Flatlands of Fushe Kosova (Field of Kosovo) are under arable farming, mostly cereals, and could be stipulated that SOC levels might be reducing. It is then re-emphasized the need to invest in new soil survey programmes and establish a soil monitoring system.

Figure 18 CORINE 2012 land cover for Kosovo



Source: Tahirsylaj, et al., 2016

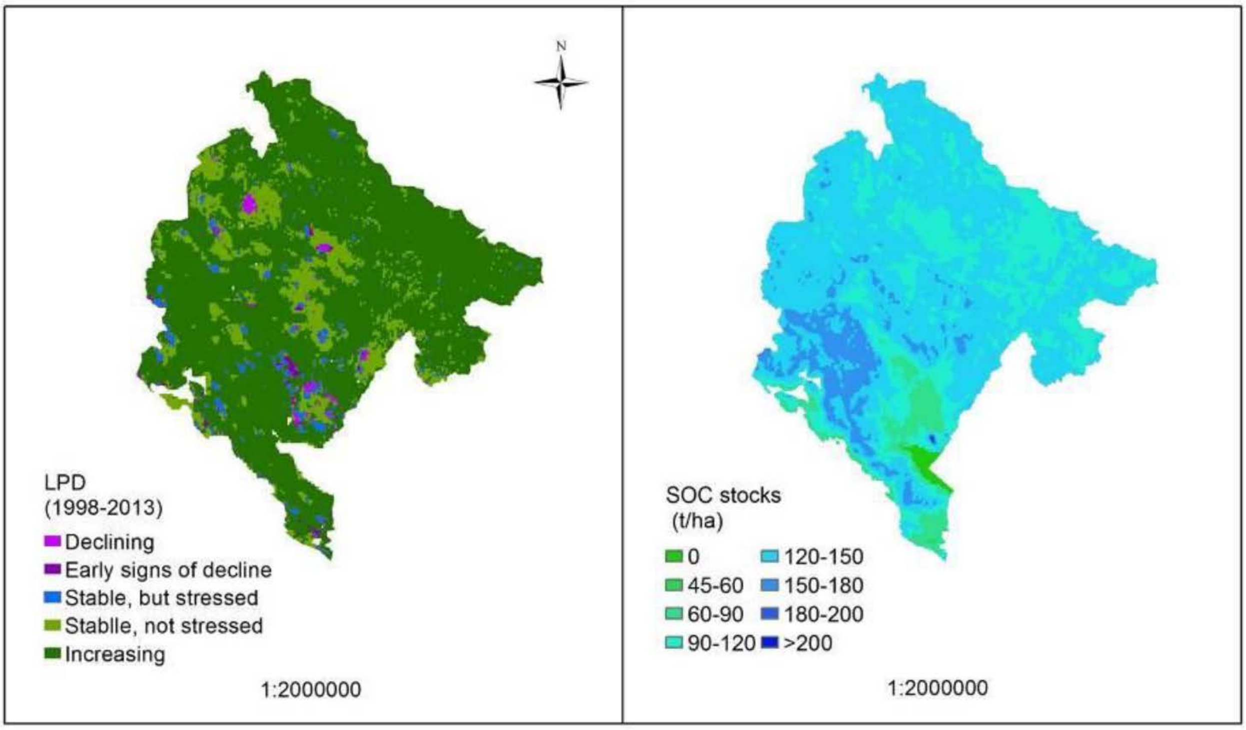
Montenegro

Data for SOC stocks and trends in Montenegro for the period 2000-2010 were available at the publication “Montenegro Land Degradation Neutrality Target Setting Process National Report” prepared with the support of the Land Degradation Neutrality Target Setting Programme (LDN TSP), a partnership initiative implemented by the Secretariat and the Global Mechanism of the UNCCD (LDN, UNCCD, 2018). Data indicate that for the years 2000 and 2010 there was a loss of 800 ha of forests converted to shrubs as well as 1 700 ha of forests were converted to croplands. In total, 74 331 ha were found to be in three JRC land productivity dynamics classes with negative connotation. Data on soil organic carbon (SOC) were provided by ISRIC. The average SOC stock for the entire country is 125.1 t ha^{-1}.

Data on soil organic carbon are provided by ISRIC – World Soil information. Data refer to SOC stocks up to reference depth of 30 cm, in 250 m grids. Soil organic carbon stock (SOC) in t/ha up to a depth of 30 cm is computed following equation of Poeplau *et al*., 2017 using data on SOC content (%, weight), coarse fragments (volume partition), bulk density (tm-3) and soil thickness (0.3 m).

Figure 19 presents soil organic carbon stocks for the territory of Montenegro in the year 2000. An average amount for the entire country is 125.1 t/ha. SOC stocks are the highest in forests 129.9 t/ha, followed by shrubs, grasslands, and sparsely vegetated areas, 124.9 t/ha, and croplands 124.3 t/ha. SOC stocks for six main land use classes are presented in Table 4. National data on soil organic carbon exist in the database of the University of Montenegro – Biotechnical Faculty by means of humus content. These data are sometimes very old and rarely georeferenced. These procedures rarely correspond to the methodological approach of the LDN TSP. To produce SOC stock values some crude assumptions were made which however create additional errors in data. This brings again the need to embark in harmonised regional soil studies and assessments to fill in the methodological shortcomings and poor quality of existing data.

Figure 19 Land productivity dynamics and soil organic carbon stocks in Montenegro



Source: LDN, UNCCD, 2018

It is important to say that a very large part of Montenegro territory is covered with rock outcrops and coarse surface fragments, Nudilithic and Lithic Leptosols, shallow and/or extremely gravelly soils (Fustic and Djuretic, 2000). A great gap in SOC assumptions is evident on these areas. Changes in SOC for the two periods of time were given on a basis of IPCC methodology (IPCC, 2006), which is related to land cover change. However, these are very rough assumptions. Hence, the report of LDN, UNCCD, 2018 concluded that no good quality data is available for the baseline period. Global SOC map of Montenegro should be corrected using good quality national data obtained according to a common EU methodology and including data for the last 10-15 years. ISRIC global data on SOC stocks do not accurately present the actual situation, while national SOC stocks data should be systematized to be presented spatially with a high degree of confidence.

Based on existing information is concluded that SOC values between 0 – 50 t/ha indicate reduced soil structure conditions, fertility, and water retention. This class covers less than 5% of the country and has the highest risk of water erosion. Sustainable land management (SLM) practices should include soil structure stabilization and keeping ground litter/cover on the top surface, as well as implementing agro-forestry restoration and silvo-pastures.

Moderate soil structure, fertility and water retention are defined for the SOC class between 50 – 110 t/ha that covers the largest area of the country (more than 65%). These areas are covered mostly with forests therefore sustainable forestry management and grazing, along with agro-forestry measures should be implemented to maintain/improve SOC levels.

SOC class between 110 – 200 t/ha covers the rest of the territory indicating good soil structure, fertility, and retention, and within this class sustainable forestry, agroforestry and grazing should be considered to maintain and enhance SOC stocks.

Nevertheless, due to the complexity of the landscape, climate conditions and soil cover in Montenegro these SOC classes should be considered as rough assessments. They should be better identified based within similar edaphic and orographic zones after a detailed soil survey to collect new data.

Table 4 summarize the changes of net land productivity dynamics in Montenegro. Forests followed by shrubs and grasslands hold the largest amounts of SOC. Instead, Table 5 provides the changes in SOC stocks based on land use/cover conversions for the period 2000-2010. As it seen there is a small difference of 0.03% in SOC stock changes. Since no further data are available for the period 2010-2020 could be concluded that overall, the situation of SOC stocks remains rather stable.

Table 4 Summary of sub-indicators of net land productivity dynamics in Montenegro

Land Use/Cover Category	Area (2000)	Area (2010)	Net area change (2000-2010)	Net land productivity dynamics (NetLPD)** (km^2)						Soil organic carbon (2000)**
	km^2	km^2	km^2	Declining	Early signs of decline	Stable but stressed	Stable not stressed	Increasing	No Data ***	t/ha
Forest	6900.6	6876.0	-24.6	3.6	20.9	164.2	878.2	5789.8	19.4	129.9
Shrubs, grasslands and sparsely vegetated areas	1589.3	1596.9	7.6	38.9	15.2	62.4	378.2	1096.9	5.3	124.9
Croplands	4515.3	4532.3	17.0	45.0	60.9	277.8	770.2	3373.7	4.6	124.3
Wetlands and water bodies	427.8	427.8	0.0	1.2	0.9	2.9	23.8	150.3	248.8	71.3
Artificial areas	220.5	220.5	0.0	12.1	3.6	30.3	56.3	114.8	3.5	98.2
Bare land and other areas	14.0	14.0	0.0	1.5	0.2	1.8	9.5	0.6	0.5	110.2
SOC average (t/ha)										125.1
Percent of total land area				0.75	0.74	3.95	15.48	77.02	2.06	
Total (km^2)	13667.5	13667.5		102.2	101.7	539.4	2116.1	10526.1	282.0	

(**) Values for NetLPD and SOC are only for areas where Land Use/Cover is unchanged from 2000-2010
(***) 'No Data' includes snow, ice, desert areas, water bodies and missing pixels

Source: LDN, UNCCD, 2018

Table 5 Changes in SOC stocks based on land use conversions for the period 2000-2010

Changing Land Use/Cover Category	Net area change (2000-2010)	Soil organic carbon 0-30 cm (2000-2010)				
	km^2	2000 ton/ha	2010 ton/ha	2000 total (t)	2010 total (t) ****	2000-2010 loss (t)
Forest to Cropland	17.01	141.5	115.3	240633	196056	-44577
Forest to Shrubs, grasslands and sparsely vegetated areas	7.56	136.8	136.8	103392	103392	0
Total	24.57			344025	299448	-44577
Percent loss total SOC stock (country)						-0.03%

(****) Change in SOC due to changing Land Use/Cover derived from IPCC Good Practice Guidance for LULUCF (2006)

Source: LDN, UNCCD, 2018

North Macedonia

The Republic of North Macedonia is a small (25 713 km^2) landlocked country, located in the middle of the Balkan Peninsula. It has a diverse topography with high mountains and deep valleys, large and small natural lakes, and picturesque rivers. The agricultural land covers about 18% of the surface area while forests and pastures/meadows cover the largest part of the country. North Macedonia has a diverse climate, with eight climatic regions. The average elevation is 829.7 m above sea level, while the mean slope is 15.10 for the 33.56% of the country's territory. The dominant relief forms include hilly-mountainous zone (44%), mountainous zone (21.3%) as well as the flat and flat-hilly zone covering approximately 20% of the territory.

The different geological formations that change even on small distances in their age, as well as mineralogical and petrologic composition, have resulted in high heterogeneity of the soil cover that can be divided into four major zones: a) soils of the plains, b) soils of the sloppy terrains, c) soils of the hilly terrains and lake terraces, and d) soils of the mountainous regions (Aleksovska, et al., 2016).

Soils in the **plains,** are mostly represented by Fluvisols that are the dominant soil type which as a separate cartographic unit covers 136 343.60 ha. (5.45%) of the country territory. The complex of Vertisol+Hymic Calcaric Regosol + Leptosol covers approx. 133 542.20 ha (5.33%). In the dry flat bottom of some valleys there are also Salinic soils– with about 13 863.22 ha. (0.55%).

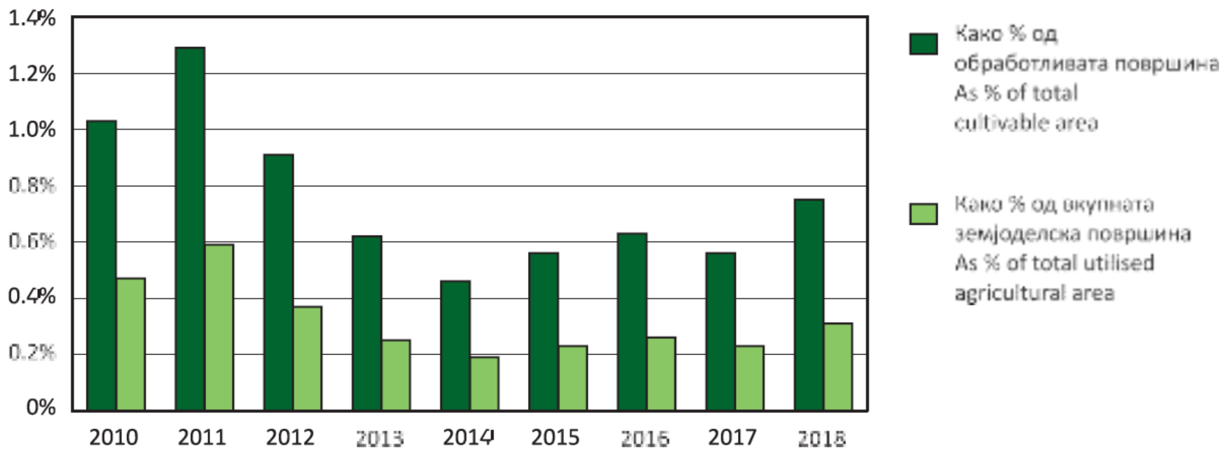
Hilly areas and lake terraces which are spread just above flat bottom of the lowlands are mainly under cover of the following soil types: Regosols which, as a separate cartographic unit cover 108 291.60 ha (4.43%) and in complexes with Hymic Calcaric Regosols, Leptosols, Molic Leptosols and Vertisols altogether cover an additional 100 768.70 ha, (4.03%). Vertisols**,** as a separate cartographic unit cover about 85 779.23 ha (3.43%). Rendzinas (or Phaeozems of WRB) are estimated at 49 678.59 ha. (1.98%). Chromic Cambisols on saprolite, cover 96 594.38 ha, (3.86%), while as a complex with Leptosols, Luvisols, Hymic calcaric Regosols and Vertisols they cover 88 016.32 ha (3.52%).

Sloppy areas which are formed on deposits of proluvial sediments on the foothills of the mountainous areas and in the valleys, are mainly covered by Fluvisols, which as a separate cartographic unit cover an area of 181 391.20 ha. (7.25%).

The most dominating soil types in the mountainous regions are Leptosols, with a total area of 378 325.00 ha. (14.73%), Mollic and Umbric Leptosols, as a separate map unit cover 142 294.80 ha. (5.68%), while as a complex with other mountainous soils they cover much of the higher territory. Calcomelanosols (Calcaric Kastanozems) cover approximately an area of about 238 396.57 ha or 9.52%. Forest Cambisol (Dystric and Eutric Cambisols) are also widespread in the forest regions and as a separate cartographic unit cover a total area of 397 285.20 ha. (18.87%), while as a complex with Mollic and Umbric Leptosols, Leptosols and Regosols they cover an additional area of 377 249.70 ha, (18.07%).

Out of the total area, almost 85% of it is productive land, while the rest of 15.07% is under the category of unproductive land. The productive land is split between forest land (38.18%) and agricultural land (43.54%), which is divided into the following two subcategories: pastures (23.65%) and arable land (19.89%) There are several categories within arable land, among which the dominant category is ploughed lands and gardens with 16.13%. Instead, the areas covered by organic farming have fluctuated over the last decade between 1.3% and 0.2% (Figure 20).

Figure 20 Areas under organic farming in North Macedonia



Source: Ministry of Environment and Physical Planning

Data on SOC stocks and carbon sequestration are not available. Based on the logic of soil distribution, most of them are found in forest areas covered by soils with Mollic features. Under these conditions is also **hard to make predictions on the trends if this soil health indicator is degrading or remaining stable**.

Serbia

The Republic of Serbia is located in the northwestern part of the Balkan Peninsula, in the southern part of Central and Eastern Europe. It extends in the direction south - north between 41°53' and 46°11' north latitude and in the direction west-east between 18°49' and 23°00' east longitude covering a territory of 88 499 km^2. Based on its geographic location and natural characteristics, the Republic of Serbia could be considered both as a Central European, Balkan, Pannonian and Danubian country (Vidojević et al., 2016).

Soil classification and cartography in Serbia has passed through different phases of development. The first classification of soils for the Kingdom of Yugoslavia, was prepared by Stebut in 1927. Other classifications, based on the genetic principles, were published subsequently (Neugebauer et al., 1963; Filipovski et al., 1964). At a later stage and to facilitate international communication, the national system of soil classification in Yugoslavia was adapted to the international classification valid at that time in Europe (Škorić et al., 1973; 1985). That classification is still accepted and in use in the Republic of Serbia.

Vidojević (2015) has investigated in detail the spatial distribution of soil organic carbon (SOC) and SOC sequestration potentials in the soils of Republic of Serbia. Organic carbon stocks were estimated for soil layers 0-30 cm and 0-100 cm based on the results from a database and using soil and land use maps. The database included a total of 1 140 soil profiles which corresponded to 4 335 soil horizons. To establish the relationship between organic carbon content and soil type, a soil map of Serbia was adapted to the WRB classification and divided into 15 437 polygons (map units). SOC stocks were calculated for each reference soil group based on mean values of SOC at 0-30 and 0-100 cm and their areas.

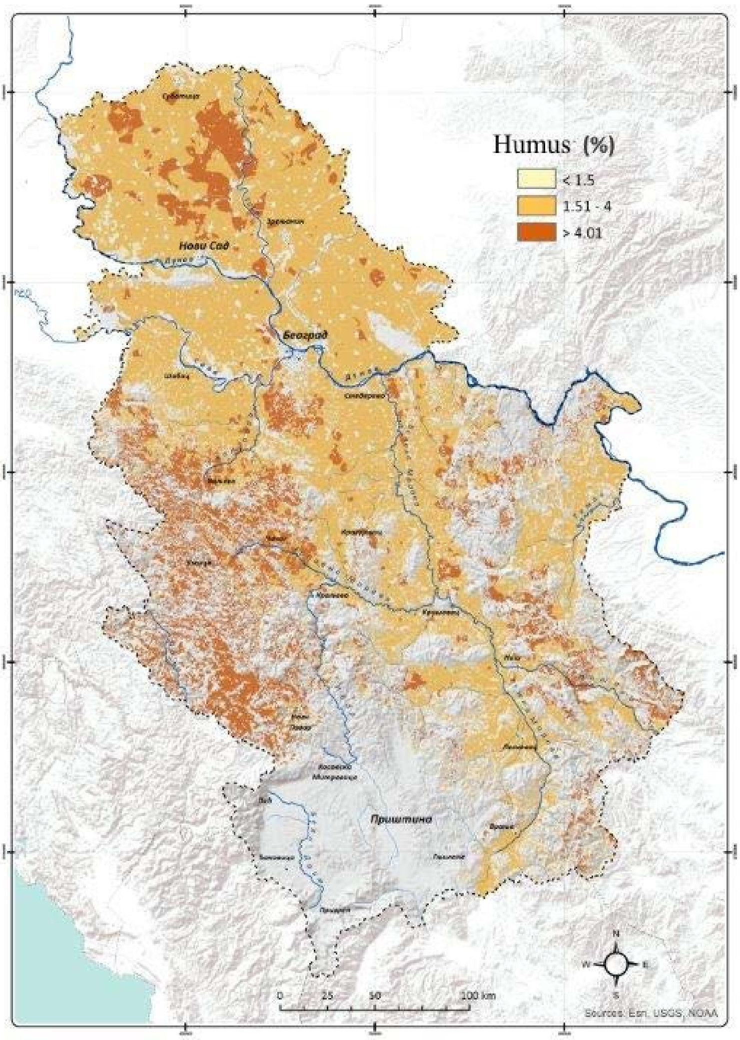
The largest SOC stocks for the soil layers 0-30 cm were found in Cambisol 194.76 x $10^{(12)}$ g and Leptosol 186.43 x $10^{(12)}$ g, and for the soil layers 0-100 cm in Cambisol 274.87 x $10^{(12)}$ g and Chermozem 230.43 x $10^{(12)}$ g. Based on the size of the reference groups, the total area of Republic of Serbia, and the mean SOC values for each reference group, the total SOC stocks were calculated. The obtained values for the soil layers 0-30 cm and 0-100 cm amounted to 695.31 x $10^{(12)}$ g and 1142.42 x $10^{(12)}$ g**,** respectively. The analysis of SOC stocks according to land use showed that **SOC stocks were higher in forested land and semi-natural areas than in agricultural soil** (Belic et al., 2013) by 40.71% and 11.43% at 0-30 cm and 0-100 cm, respectively (Figure 21).

Peatlands

Overall peat areas in the Western Balkans cover less than 1% of the soils and their impact is very limited in terms of regional SOC content and the potential for Carbon sequestration. Many of these areas have been drained, such as in Albania and put for arable farming. The process was associated with enormous CO_2 emissions and C losses.

Remaining Histosols should be protected and possibly left aside from agriculture.

Figure 21 Soil organic matter in agricultural soil to the depth of 0-30 cm (%)



Source: Vidojevic et al., 2016

Another interesting study was conducted in the vineyard region of Niš, which represents a medium-sized vineyard region in Serbia where land use and relief was shown to be important factors controlling SOC content. Instead, spatial distribution of organic carbon withing the vineyards was not influenced by altitude, but from the different soil management practices. The deep tillage at 60–80 cm, along with application of organic amendments, showed the potential to preserve SOC in the subsoil and prevent carbon loss from the surface layer. This study (Jakšić et al., 2021) included the examination of different factors that influence SOC dynamics. They included: (i) the state of SOC in topsoil and subsoil of vineyards compared to the nearest forest, (ii) the influence of soil management on SOC, (iii) the variation of SOC content with topographic position, (iv) soil erosion intensity to estimate the significance of SOC leaching from upper to lower topographic positions, and finally (v) the significance of SOC for reducing the susceptibility of soil to compaction.

The most important findings show a close correlation between elevation and SOC (Vidojević et al., 2021). Previous studies (Manoljović et al., 2011; Vidojević, 2015) in Serbian soils have shown that organic carbon content has decreased from 52.7 g kg^{1} (1 450 m.a.s.l.) to 39.4 g kg^{1} (500 m.a.s.l.). The study of Jaksic et al (2021) confirmed these trends with the following results of the SOC content: 35.60 g kg^{1} at 500–1 000 m.a.s.l., 18.70 g kg^{1} at 200–500 m.a.s.l. and 15.20 g kg^{1} at altitudes below 200 m.a.s.l. This study offers important feedback for similar areas under vineyards in Serbia and in other Western Balkans countries with similar soil and climate conditions.

SOC stocks in Serbia and carbon sequestration are estimated to be stable. The largest amount is in forest areas compared with arable lands. Soil distribution, along with other factors such as elevation, land cover, relief and most importantly land management have strong impacts on SOC content and distribution.

4.2.3 Water Erosion

It is estimated that the area of agriculture land with failure of soil health indicator due to water erosion to be in the range of 30 % and about 45% of the total land area is affected by soil erosion.

Soil erosion is the most studied degradation process in the Western Balkans with a legacy of historical publications. Most of them were based on the methodology developed by a Serbian scientist Gavrilovic (1972).

Ivan Blinkov from the Faculty of Forestry, University in Skopje, in North Macedonia published a paper in 2015 entitled: *"The Balkans: the most erosive part of Europe"*. Based on literature review and on his own research he compared the erosion rates of the rest of Europe with those of the Western Balkans (WB) and found out that "*the erosion intensity in the WB is 548 m^3 km^{-2} (equal to 5.48 t ha^{-1}) and the total amount of annual produced erosive material is 419.9*10^6 m^3*". In comparison, the mean average annual erosion intensity for Europe is calculated as 3.13 t ha^{-1} y^{-1} [10]. Data show that the mean annual intensity of erosion in Albania and Montenegro are well above the accepted threshold of 10 t ha^{-1} y^{-1}. It should be emphasised that soil erosion is the most studied soil degradation process in the region, but often associated with conflicting data due to the diversity of the methodologies implemented.

Nevertheless, and despite that there is ample agreement in the region that erosion is the most important process of soil degradation, additional studies are necessary to verify the results and produce reliable conclusions. Erosion is a very dynamic process and changes continuously due to changes in land cover and rainfall patterns, these last influenced also by climate change. Therefore, regional harmonised studies should be conducted implementing similar methodologies and models widely used in the EU (Panagos et al., 2015; Panagos et al., 2021). The region has the capacity and qualified experts to do this. The only difficulty could be related to climate data availability and (perhaps) obsolete soil data in some countries (i.e., Kosovo). LUCAS soil data of 2015 survey could be the starting point and if another such survey could be conducted, the outcomes will be further enhanced. It is unfortunate that Western Balkans countries are not eligible for funding through the EJP SOIL Initiative[11]. In that context the JRC should play a better role in the region to support these countries to enhance their capacities and bring them in line with other EU peers.

Paradoxically, efforts by the Governments of the region and the legislation in place to control erosion were better implemented during the period before the political changes of the 90s that transformed radically the Western Balkans region. In Albania for instance, the month of December was nicknamed as the *"the month of afforestation and erosion control"* and the same programmes were implemented in the previous Yugoslavia. While no one regret the fall of the political system that opened the door to democracy, some lessons of

[10] Note that Panagos et al., (2015) put this value 2.46t-ha^{-1}-y^{-1}

[11] https://ejpsoil.eu/

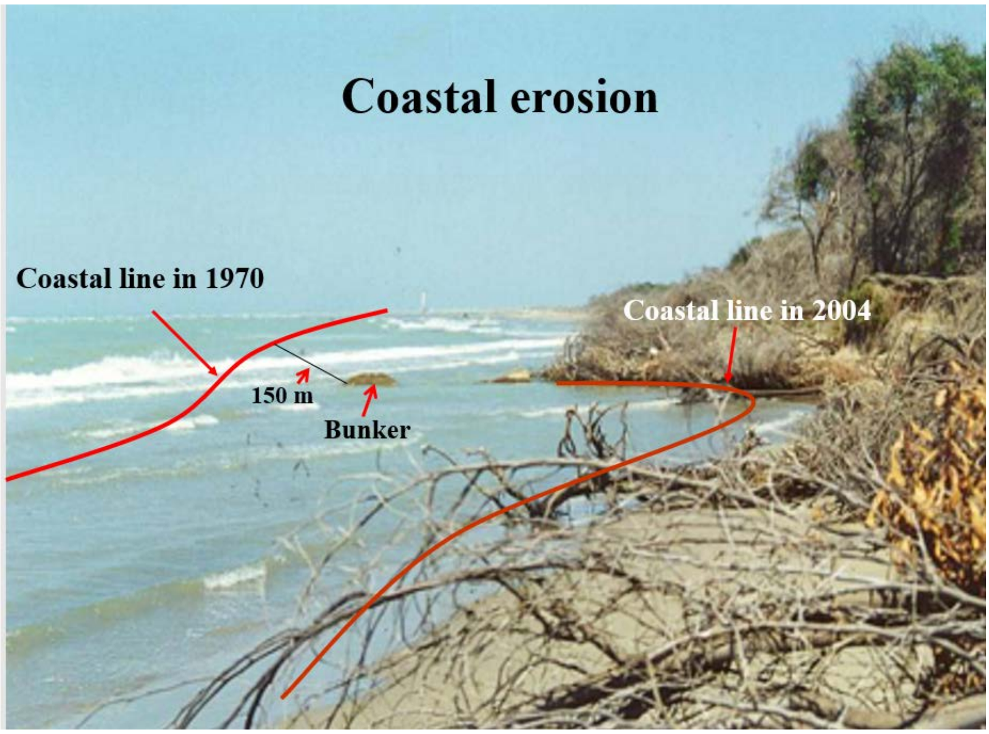
the past may be revitalised again to protect the soils in a region, marked as the most eroded in Europe.

Albania

Albania has a dense river network with seven main rivers flowing from East to the West to the Adriatic and Ionian Seas comprising a large hydrographical catchment of 43 300 km^2, but only one third of it is out of the country's political borders. Soil loss via water erosion is a widespread phenomenon estimated at 2-3 times higher than in other Mediterranean countries and 10 to 100 times greater than in many other European countries (Kovats, 2012). The typical Mediterranean climate is one of the most aggressive ones in terms of erosion (heavy rainfall intensities, high rainfall amounts, drought as a permanent process, etc.). These processes along with the topographic and soil conditions (steep slopes, silty soils, low humus content) already classify more than 50% of the total land area in Albania as naturally erosive. This is amplified by the anthropogenic impacts (illegal forest cutting, fires, cultivated steep slopes, up-down cultivations, bare soils after harvesting, overgrazing, absence of erosion protection measures) resulting in significant soil loss rates (Kovats, 2012).

Coastal erosion and erosive river flows, along with flash flooding in coastal regions are also common (Fig. 22). By 2030, it is predicted that approximately 32 percent of the coastal areas will experience regular flooding, and large amounts of arable lands may be lost due to inundation and increased salinity[12].

Figure 22 Coastal erosion has been characterized by increased sediment deposits at the river Seman in Fier along the Adriatic coast eroding beaches further away from the river mouth which had led in changes of the coastline. Note that in the 1970s, the bunker was 150 m inland of the coast but by 2004 was fully covered by the sea.



Source: Lushaj and Zdruli, 2006.

[12] Third National Communication of the Republic of Albania under the United Nations Framework Convention on Climate Change, June 2016

Various authors report a wide range of soil loss and sediment transport level in the country. Bockheim (2001) states a national average soil erosion rate of 27.2 tons per hectare per year, which results in an annual sediment flux of 60 million tons carried by the Albanian watercourses. Bruci et al., 2003 reports a soil loss range of 20-100 t ha^{-1} yr^{-1}. They computed for the north, middle and south-east region of the country an annual average agricultural erosion rate of 15, 53 and 37 t ha^{-1} yr^{-1}, respectively. Grazhdani and Shumkab, (2007) presents an estimation of soil erosion for the whole country, they computed a soil loss rate more than 10 t ha^{-1} yr^{-1} for a remarkable part (in the center and south) of the country and even more than 100 t ha^{-1} yr^{-1} at three smaller regions also in the south.

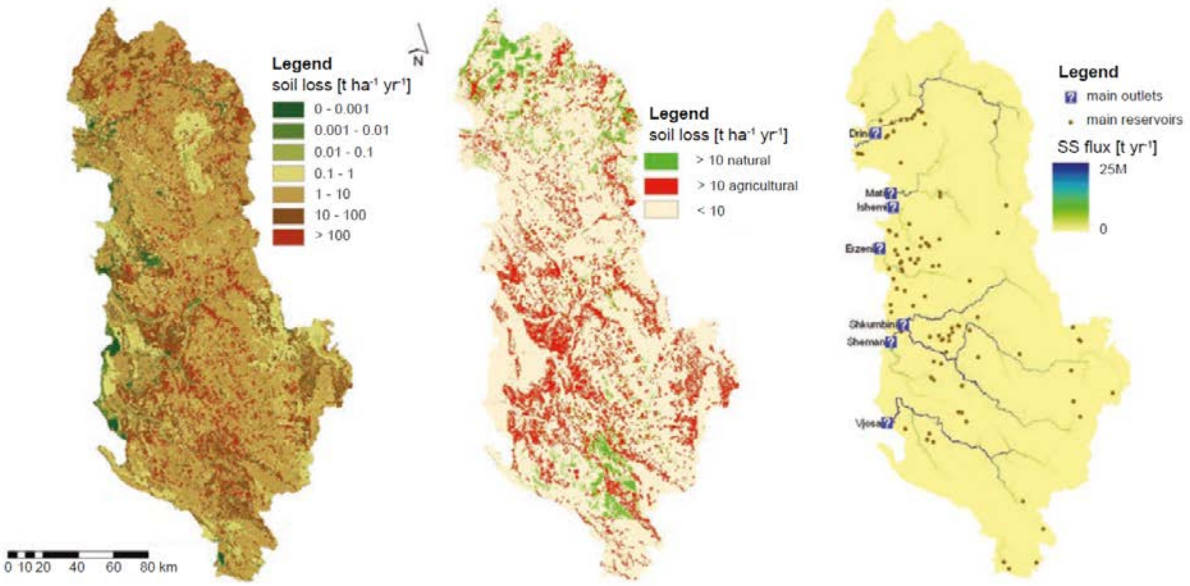
Karydas et al., (2015) using the G2 erosion model reports less aggressive values for the Ishmi Erzeni watershed with only 18% of the area having erosion rates above 10 t ha^{-1} yr^{-1}, while the mean rate is estimated at 6.5 t ha^{-1} yr^{-1} for that catchment basin. Zdruli et al., (2016) using the same model (G2) in the Korca region (south east of Albania) report values at 10.25 t ha^{-1} yr^{-1} for the vineyards, but other land cover types such as shrublands, broad-leaved forests and natural grasslands have erosion rates below the 10 t ha^{-1} yr^{-1} threshold. It could be that G2 model that has been also implemented in Greece and Cyprus might be appropriate for Albania as well.

Kovats et al., (2012) used the USLE inspired PhosFate model for the whole territory of Albania considering long-term average conditions. To perform a countrywide assessment on erosion and sediment transport, they used a GIS database compiled according to the model demands. The necessary digital maps (*e. g.* topography, soil characteristics, humus content, land cover and vegetation) and climate data (rainfall, meteorology) derived from different international data sources. Besides these, river monitoring data on discharge and suspended sediment (SS) loads as well as results of other erosion studies were also collected from the literature to calibrate the model and execute comparisons.

Results were astonishing with remarkable soil losses around the country especially in three main regions, which are in the north, in the central and in the south. In these regions, similarly to Grazhdani and Shumkab (2007), high soil loss rates can be found with values more than 10 t ha^{-1} yr^{-1} as well as with values of even more than 100 t ha^{-1} yr^{-1}. Countrywide average soil loss rate is 31.5 t/ha/y, which is far above the tolerable limit of 10 t ha^{-1} yr^{-1} in line with what was reported by Bockheim (2001). The average rate means that totally 90.5 million tons soil eroded annually in the country. Distribution of the higher soil loss classes shows that 78% of the territory produces tolerable erosion, and 22% (6 399 km^2) has higher soil loss rate than the tolerable limit (Table 6). Nevertheless, this 22% of the total area is responsible for the majority (93%) of the soil erosion with agriculture areas contribute to *ca.* 90% of the soil loss (Kovats, et al., 2012). 63% of the total soil loss comes from the steepest regions of the country, while below 12% steepness the contribution to the total erosion is very low.

Extremely high soil loss rates (60-130 t ha^{-1} yr^{-1}) were calculated for the mixed agricultural land and the orchards/vineyards located on high slopes. This results in an enormous total soil loss (82 million tons per year) from the total agricultural sector. The mixed lands (especially the semi-natural lands), the grasslands, the sparsely vegetated areas probably used as intensive pasture are prone to overgrazing, which leads to high erosion rate as well. Besides this, it is important to notice, that the special monthly distribution of the rainfall in Albania, highly strengthens the impacts of erosion, because most of the rainfall events occur in the winter half-year when agricultural soils are often uncovered. The naturally covered areas remain at low erosion rates all over the country.

Figure 23 (a) Calculated long-term average specific soil loss rates in Albania; (b) Agricultural and natural source areas of soil erosion in Albania; (c) Sediment transport by the main watercourses of Albania.



Source: Kovats, 2012

Table 6 Areas, total amounts, and proportions of the specific soil loss rate classes in Albania.

Soil loss rate t ha^{-1} $year^{-1}$	Area km^2	Area proportion %	Total soil loss 10^6 t $year^{-1}$	Soil loss proportion %
<1	6556.3	22.8	0.2	0.3
1-10	15795.2	54.9	6.3	7.0
10-100	4121.6	14.3	12.6	13.9
>100	2277.0	7.9	71.4	78.9

Source: Kovats, 2012

Among the best management practices (BMP) that could be implemented in Albania to control erosion are afforestation and proper grassland management in the natural vegetation zones and especially avoiding overgrazing. Agricultural soil protection without any soil stabilization is limitedly successful only (17%), however, if it is accompanied by vegetative soil stabilization (*e. g.* mulching on the bare soil or grassing between the permanent crop rows/fruit trees), the efficiency approximates the value of the forests (74%) (Kovats, 2012). Management of the agricultural area of the country can produce impressive soil loss reduction, however this would require notable investments and a comprehensive cost efficiency analysis.

Figure 24 Terraces in Mallakaster, south Albania for cultivation of olives

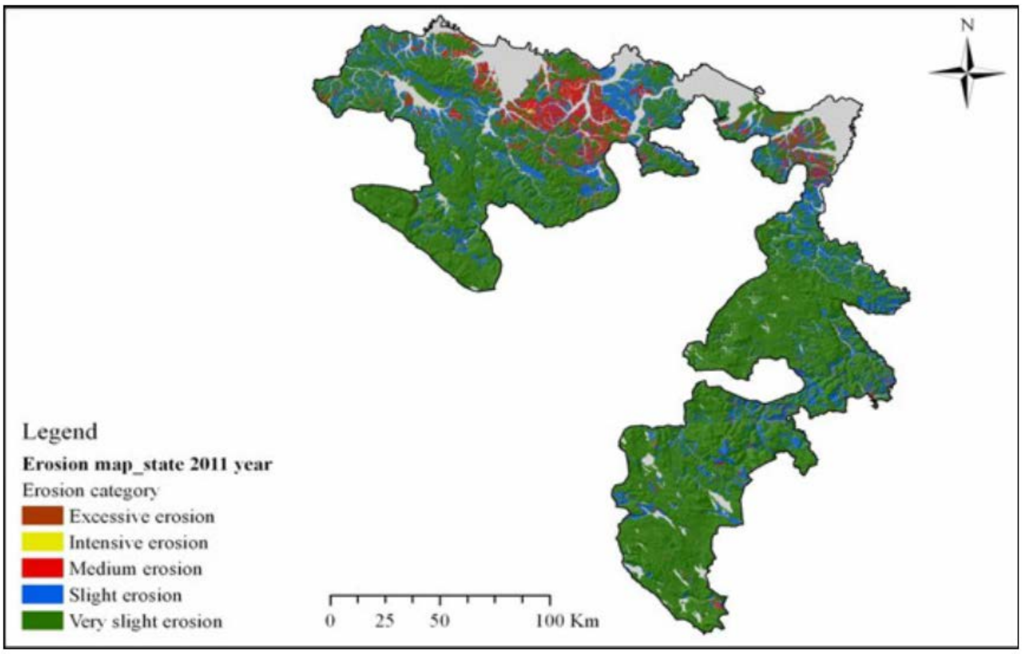
Source: Zdruli

Countrywide average soil loss is about 30 t/ha/y. 22% of the country area has higher soil loss rate than the tolerable value of 10/t/ha/y. This 22% is responsible for the majority (93%) of the soil erosion. Main source for soil loss is agriculture, which generates *ca.* 90% of the total losses, especially agricultural lands that are located on high slopes.

Bosnia and Herzegovina

The history of soil erosion studies in Bosnia and Herzegovina (BiH) is quite long, but one most significant study started in1985, 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). Since 2004 part of the soil erosion map was reconstructed, but only for the Republic of Srpska territory (Tošić and Hrkalović, 2009; Tošić *et al.*, 2012) as could be seen in Figure 25. Kapovic Solomun et al., (2019) describe the difficulties related to data shortages, many of which were destroyed during the Bosnia war and the absence of a national soil erosion map of the country.

Figure 25 Soil erosion map of the Republic of Srpska prepared in 2011



Source; Tosic, et al., 2013

Data from a case study conducted in the Republic of Srpska (Tosic et al., 2013) report an average annual soil erosion rate of 9.88 t ha^{-1} yr^{-1}. It was found that 70.36% of the area (Table 7) has low to very low risks of erosion, while the rest is subdivided as moderate (11.39%), high (12.35%) and very high (5.88%). These values reflect the morphological setting of Republic of Srpska with large extension of flat lands. Instead, Table 8 shows the correlation between erosion classes and land uses. It is obvious that agriculture land is the most prone to erosion. These results indicate that more than 34% of the area with high and very high soil loss occurs in the elevation between 200 and 1 000 m in arable lands and orchard where soil conservation measures should be implemented to reduce soil loss. These results could be as indicator values to estimate the erosion extent in the whole country.

Table 7 Categories of soil erosion and their respective areas

Erosion categories	Rate of erosion (t ha^{-1} $year^{-1}$)	Area (ha)	Area (km^2)	Area (%)
Very low	< 2	59588.84	595.8884	47.4403
Low	2 – 10	28791.88	287.9188	22.9220
Moderate	10 – 20	14312.32	143.1232	11.3944
High	20 – 40	15519.08	155.1908	12.3552
Very high	> 40	7395.84	73.9584	5.8880
		125607.96	1256.0796	100.00

Source Tosic, 2013

Table 8 Percentage of soil erosion categories according to different land use types

Land use types	Soil erosion categories and rate of soil erosion (t ha^{-1} $year^{-1}$)					Total
	Very Low	Low	Moderate	High	Very high	
	< 2	2 – 10	10 – 20	20 – 40	> 40	
Arable land	14.13	22.55	24.14	26.58	12.59	100.00
Forestland	79.49	20.51	0.00	0.00	0.00	100.00
Orchards	21.63	35.62	22.90	14.96	4.89	100.00
Grasslands	51.74	45.26	2.70	0.23	0.07	100.00

Source Tosic, 2013

The large areas of forest cover acts as a buffer zone for erosion control in Bosnia and Herzegovina, but as in all other countries, agriculture lands are the most vulnerable and prone to erosion. Since 45% of the agricultural land is in hilly zones (300-700 m a.s.l.) these areas produce the largest amount of soil loss. A considerable part of this zone has slopes above 13% and the processes of erosion are very marked. Erosion is further exacerbated by the inappropriate farming practices and when preference is given to row crops (corn and potato) that are unsuitable for these slopping lands especially when no soil conservation measures are implemented. In addition, the mountain areas (> 700 m a.s.l.) that account for a further 35% of agricultural land located in steep slopes with lower soil fertility, the total agriculture area subject to erosion is 80%. The remaining 20% of agricultural land is in the lowland river valleys and could be considered at very low risk to erosion, apart from some forms of sheet erosion.

Considering that agriculture land is the most vulnerable to soil erosion is estimated that erosion rates above the threshold value of 10t/ha/y affect about 80% of the agriculture land.

Kosovo

Some preliminary assessments (Tahirsylaj et al., 2016) subdivide the soils of Kosovo as 56% of poor quality, 29% at average level and only 15% in good quality, but the authors do not specify the indicators used for this assessment apart from drainage, soil texture and soil depth. However, most likely soil erosion should have been the main factor behind these assessments at least for the sloping lands.

In fact, the Pedologic Atlas of Kosovo IDWR of 1974, edited by The Institute "Jaroslav Cerni" in Belgrade developed a soil erosion risk map. Unfortunately, in the preparation of this reort it was not possible to locate this map. But, even if this could have been possible, the data would have been obsolete. Nevertheless, based on the same map source, Blinkov et al., (2013) report that 95% of Kosovo area is at risk of erosion, without specifying the degree of the erosion risk. In 2001, a new map of soil erosion provided similar results as the one of 1975 (Blinkov et al., 2013). It was estimated that the total annual erosion area in Kosovo was 249 $m^3 km^{-2} yr^{-1}$ with an annual sediment yield is 9 000 000 $m^3 yr^{-1}$, or 106 $m^3 km^{-2} yr^{-1}$

The most recent report of the Kosovo Environmental Agency of 2020 reports recent data on soil erosion based on the PESERA model. These data are presented in Table 9 along with a new soil erosion map (Figure 26). Compared with the previous estimates the latest report puts risk areas of Kosovo at about 60% of the territory.

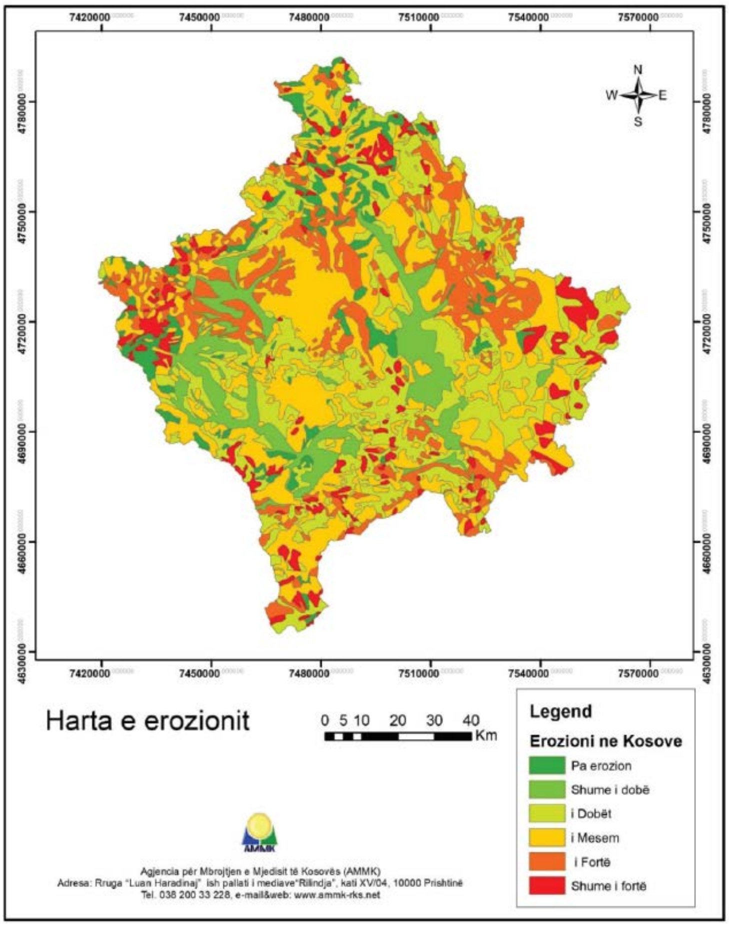
About 60% of the territory of Kosovo is subject to soil erosion rates above the threshold values. Agriculture area in sloping lands especially in the vineyards is highly vulnerable to erosion.

Table 9 Erosion intensity in Kosovo

No.	Types of erosion	% of land surface
1	Very strong	7.35
2	Strong	16.1
3	Medium	35.4
4	Weak	24.55
5	Very weak	10.1
6	Without erosion	6.5

Source: Kosovo Environment 2020 report

Figure 26 New soil erosion map for Kosovo



Source: Kosovo Environment 2020 report

Montenegro

There are many factors that have influenced the water erosion processes in Montenegro, but the most significant are climate, with extreme precipitation values in some parts of the country (the highest of Europe) as well as relief, geological substrate, soil characteristics and the condition of the vegetation cover and the land use (Spalević, 2013a). Fluvial erosion is also present in water streams. Using the methodological framework of Gavrilović (1972, 1988) Spalević (2011) estimates that water erosion is affecting 13 135 km^2 or 95% of the total territory of Montenegro (13 812 km^2). Out of it almost half of the area is exposed to medium to high erosion intensity with highest values attained in the river catchments of Ibar and Piva and the coastal catchments (Spalević *et al*, 2008, Kostadinov *et al.*, 2006).

There are also many other (Spalevic et al., 2013b, 2015) studies implemented at local scale and specific watersheds in the country. Their results confirm the estimates at national level.

About 90% of the territory of Montenegro is affected by soil erosion, half of it is subject to medium and high intensity. Karst areas are more degraded. Agriculture soil in the slopes show higher erosion rates.

North Macedonia

The same as for all other Western Balkan countries, North Macedonia is also affected by soil erosion, but with less intensity compared to Albania and Montenegro, most likely due to a different rainfall pattern with lower intensity. All the rest of the erosion criteria such as uneven relief, steep slopes, land cover, soil erodibility and inappropriate human activities in agriculture and overgrazing including forest mismanagement and forest fires, accelerate erosion. Table 10 gives the distribution of erosion based on the Gavrilovic methodology. These results are in line with (Blinkov et al., 2013) who estimate the total area of extremely, high, and medium intensity at about 38% (9 423 km^2) of the country (Table 10). Furthermore, Blinkov et al., (2013) estimates that overall area affected by erosion to be 96%.

Table 10 Erosion distribution in North Macedonia

Degradation category (erosion processess)		**Area (km^2)**	**Percent (%)**	**erosion intensity (m^3 km^2 y^{-1})**
I	extremely high	698	2.77	> 3 000
II	high	1 832	7.38	1 500 – 3 000
III	medium	6 893	27.78	1 000 – 1 500
IV	low	7 936	31.98	500 – 1 000
V	very low	7 463	30.09	70 – 500

Source: Aleksovska et al., 2016, based on Blinkov et al., 2013

The total annual erosion production for Macedonia is about 17 000 000 $m^3\,yr^{-1}$ or 680 $m^3\,km^{-2}\,yr^{-1}$, with about 7 500 000 $m^3\,yr^{-1}$ or 303 $m^3\,km^{-2}\,yr^{-1}$ of sediments that are moved away from the site where it is eroded. A significant part of these deposits or about 3 000 000 $m^3\,yr^{-1}$ is not carried through the downstream sections of the rivers out of the country's territory but are deposited in natural lakes and reservoirs.

For example, the rates of annual sediment yield to the biggest reservoirs in Macedonia are: Tikves (1 300 000 $m^3\,yr^{-1}$ or 497 $m^3\,km^2\,yr^{-1}$), Kalimanci (420 000 $m^3\,yr^{-1}$ or 970 $m^3\,km^2\,yr^{-1}$). Typical for these reservoirs is that a great part of the eroded material was deposited in the so called "useful storage of the reservoir", decreasing water resources of the reservoir itself (Blinkov et al, 2013).

About 40 000 ha of irrigated land is also subject to erosion, with an annual average soil loss of about 300 000 m^3. Significant parts of these deposits, about $3*10^6$ m^3 y^{-1} are not carried through the downstream sections of the rivers to the exit the state territory but are deposed in natural lakes and reservoirs (Blinkov et al, 2013). Table 11 gives comparisons of erosion rates between Bulgaria, North Macedonia, and Serbia, with the higher rates in North Macedonia, most likely due to rough terrain.

Table 11 Erosion intensity between North Macedonia, Serbia, and Bulgaria

	Erosion intensity		
Country	$m^3\ yr^{-1}$	$m^3\ km^{-2}\ yr^{-1}$	Methodology
Macedonia	17, 000, 000	680	EPM
Serbia	37, 000, 000	422	EPM
Bulgaria	32, 000, 000	290	USLE

Source: Blinkov et al., 2013

It is also good to notice that a number of conservation measures were taken over the years, and the early ones started in the 1900's. Later, measures to control erosion on deforested barren lands have also been under way since 1945, when restrictions were placed on nomadic breeding of goats and sheep in forests (Blinkov and Trendafilov, 2004; Blinkov et al., 2007). This measure, though unpopular, led to a recovery of degraded forest and shrub land. During the period 1950's – 1970's, classical stone barrages were usually constructed. Then building of concrete barrages began. These structures were made by state water management enterprises, where in past there existed a particular sector for erosion and torrent control.

Legislation for erosion control was also very detailed as reported by several Acts such as the Act for afforestation of bare land (1951), Act of erosion control on steep slopes (1952), and the Act of steep slopes protection and torrent control (1957). Later, these acts were suspended. As part of the erosion control programme an "Afforestation Fund" was established in 1970 and it existed until 1990. Till 1990, erosion control measures and activities were on "higher level" and institutional support was high. There were sections for erosion control in all regional water management enterprises and budget was allocated to them (Blinkov et al., 2013).

After the 90s water management is in a transformation period. Plans are only partially completed. About 65% of planed hydraulic structures were built, but only 25% of planed afforestation occurred. Unfortunately, erosion is one the biggest environmental and economic problems in North Macedonia, but there are no special funds available for controlling it (Blinkov et al., 2013).

More than 90 % of the territory of North Macedonia is subject to soil erosion and 38 % of it is affected by extremely high, high, and medium erosion.

Serbia

Soil loss caused by erosion, with various categories of degradation, is a serious problem also in the Republic of Serbia. A first erosion map was prepared in 1975 using EPM methodology (Gavrilovic, 1972). This map shows that, of the total area of Serbia, 86% is endangered by soil erosion of various rates. The new map of erosion produced in 2001 was little different than the map of 1975. Total annual erosion production in Serbia is 37 000 000 $m^3\ yr^{-1}$ or 488 $m^3\ km^{-2}\ yr^{-1}$); annual sediment yield is 9 000 000 $m^3\ yr^{-1}$, or 106 $m^3\ km^2\ yr^{-1}$. The most endangered area is the southeast part of the country that is close to the North Macedonia and Bulgaria borders (Blinkov et al., 2013). Approximately 80% of agriculture soils are affected while in the Vojvodina province in the north of Serbia, eolic erosion prevails, affecting approximately 85% of the agricultural soil (Vidojević and Manojlović, 2007).

Same as in all others former Yugoslav republics, also in Serbia erosion control and torrent measures started prior to 1900 but the organized work began in 1907. The first interventions were for torrent control and channel recovery at the zones of intersections with railways, aiming at railroad protection. There were interventions in the torrents of the Grdelička Klisura gorge in the South-East of Serbia, where the international railway line and road Belgrade-Skopje-Athens passes through (Kostandinov, 2007).

In the field of erosion and torrent control, especially after the Second World War (period 1946 – 1989) significant results have been achieved. Many roads and railways, settlements, industry, and storage reservoirs have been protected (fully or partially), from sedimentation and from torrent floods. Most important intervention for erosion control in the farmland were done during the period 1955-1966. Later on they were reduced and erosion intensified again (Kostandinov, 2007).

Most recently several conservation measures have been defined in agriculture as well as a related law aiming the protection of agricultural land from the harmful effects of erosion (Law on Agricultural Soil, Articles 18, 19 and 20) but its implementation is challenging.

A positive case study comes from the Niš region, which mainly belongs to the hilly, mountainous area that is under the influence of high and severe intensity erosion, which requires the application of protective measures. Some of the implemented measures include no-till farming, reduced tillage, terrace construction and maintenance, cover crops, continuous plant cover, crop rotation and establishing shelterbelts. Erosion processes in vineyards can be very pronounced because they are usually based on steep and hilly terrain, as well as on mountains with southern exposure due to the better quality of grapes. Besides, due to specific soil properties such as limited soil development, coarse texture, and low capacity to protect SOM binding to soil minerals, these soils are sensitive to degradation. Thanks to conservation measures the mean annual soil loss in the Niš region was found to be 5.42 t ha^{-1} yr^{-1}, determined using the USLE model. Furthermore, the average erosion intensity in the observed localities ranged between 0.05 and 9.80 t ha^{-1} yr^{-1}, with a mean value of 4.43 t ha^{-1} yr^{-1} which classifies this area as having tolerable erosion risk (Jakšić et al., 2021) according to the OECD classification.

Erosion affects about 86% of the territory of the Republic of Serbia and approximately 80% of agriculture land. In the Province of Vojvodina, eolic erosion affects 85% of agriculture soils.

4.2.4 Compaction

Except for very few sporadic case studies (i.e., Jakšić et al., 2021), data are not available on the extent and degree of soil compaction in the Western Balkans. Hence soil compaction should be included without delay both in the national and EU research projects.

Soil compaction is the result of mechanical stress caused by the passage of agricultural machinery and livestock. The consequences are increased soil density, a degradation of soil structure and reduced porosity (especially macroporosity). This causes increased resistance against root penetration and negatively affecting soil organisms, as their presence is restricted to sufficiently sized pores (Schjønning et al., 2015). Compaction is known to be a significant pre-cursor of erosion. Soil compaction may lower crop yields by 2.5-15%, but it also contributes to waterlogging during precipitation events, which not only reduces the accessibility of fields to machinery but also negatively affects run-off, discharge rate and flooding events (Brus and van den Akker, 2018). The Western Balkans regions is lacking behind in studies dealing with soil compaction.

4.2.5 Pollution including risks to food

Western Balkans have a total of 2 735 contaminated sites due to mining and industrial activities. Their area extent is unknown. Some soils are naturally contaminated with heavy metals due to geological formations from where they derive.

Soil pollution[13] compromises food, water, and air quality. Contaminants enter the soil and are dispersed through environmental compartments, harming the environment and public health. Most soil contaminants come from industrial processes and mining, poor waste management, unsustainable farming practices, accidents ranging from chemical spills to environmental disasters, and armed conflicts that devastated the Western Balkans after the breakup of Yugoslavia.

Soil pollution is widely present in the region as mentioned also in the SOER2020 report that also recognises the complexity of the problem EU (Payá Pérez, and Rodríguez Eugenio, 2018). Nevertheless, the chain reaction effects are still unknown for many substances entering into the soil especially those related to microplastics. The most common pollution sources include petrochemical plants and petrol station, landfills, pesticide contamination, POPs, microplastics, veterinary products/pharmaceutical, and emerging concerns such as pFAS, heavy metals, and sewage sludge. Furthermore, the percentage of landfilling remains very high and exceeds 90% in all cases except for Albania (EEA, 2019a).

The mining industry represents a major source of soil pollution in the Western Balkan countries, especially in Albania, which was (is) one of the world's leading chromate producers (Egerer et al., 2010). Furthermore, illegal dumping and open landfills are a common waste management practice in many WB countries. In North Macedonia for instance, some 200 hectares are occupied by landfills and illegal dumps that are abundant although their impact and extent have not been fully elucidated (MOEP, 2017). Hazardous waste is frequently buried in urban landfills. A common concern is the Western Balkan

[13] A significant amount of data for this subsection come from the upcoming JRC report Chapter 8 Soil Pollution in Europe part of the Global Assessment of Soil Pollution (GASP) Report prepared by FAO-GSP Secretariat

countries is also the e-waste management, which still needs improvement as most of the e-waste is disposed in landfills and the recycling and recovery activities are poorly managed causing significant resource losses. This leads to a high risk for human health and the environment. However, initiatives are taking place mainly in the private recycling sector (Baldé et al., 2017).

More recently, war activities that took place between 1991 and 1999 have caused extensive soil pollution, especially from landmines, categorizing Bosnia and Herzegovina as one of the most landmine-polluted countries in the world. To date, the country counts about 1 366 landmine polluted settlements, of which 1 168 are in rural communities, which causes a limitation to agricultural and livestock activities (Musa, Siljkovic, Sakic, 2017). In addition, intensive warfare in the region left a legacy of trace element pollution in soils, including antimony, arsenic, lead, mercury, and zinc, as observed by Vidosavljević and co-workers in eastern Croatia, affected by the war in former Yugoslavia (Vidosavljevic et al., 2013).

Moreover, depleted uranium (DU) penetrators were also used in the Kosovo's conflict, which have left a trail of DU-polluted soils. Southern Serbia and Kosovo were the regions most affected by the 1999 air strikes, in which 11 tonnes of depleted uranium ammunition and 30 000 depleted uranium shells were used in military actions in the Kosovo conflict (Di Lella, et al., 2004, Milacic et al., 2004). It has been observed that soil pollution is very heterogeneous in affected areas and that DU pollution is higher when penetrators are burned after reaching a certain target. Currently, four locations in Serbia are routinely tested in order to monitor DU contamination (UNECE, 2015b). After the war, Serbia and Kosovo have experienced a significant increase of malicious tumours, with more than 30 000 people diagnosed with haematological malignancies in the first 10 years since the bombing and between 10 000 and 18 000 of them died (Latifi-Pupovci et al., 2020).

The estimation of the extent of pollution in the **agriculture sector** is very difficult to be made due to lack of data. The best assumption would be to consider primarily as "risk free" the area of organic farming, which is very small compared with other farming types. **Nevertheless, most agriculture soils are not contaminated.**

The next step was to estimate the extent of contamination at **country level** and consequently region-wide. To do so, the total number of contaminated sites per country were collected as given in Table 12. The problem though, was that, apart from 300 000 ha that are polluted in Bosnia and Herzegovina, 429.6 km^2 in North Macedonia, and 3 203.7 km^2 in Serbia all other countries do not have these data (Figure 27). If the logic of the number of contaminated sites is used, then Kosovo would the country with the highest contamination rates, both because of open field lignite mining sites surrounding Prishtina and due to the Kosovo war.

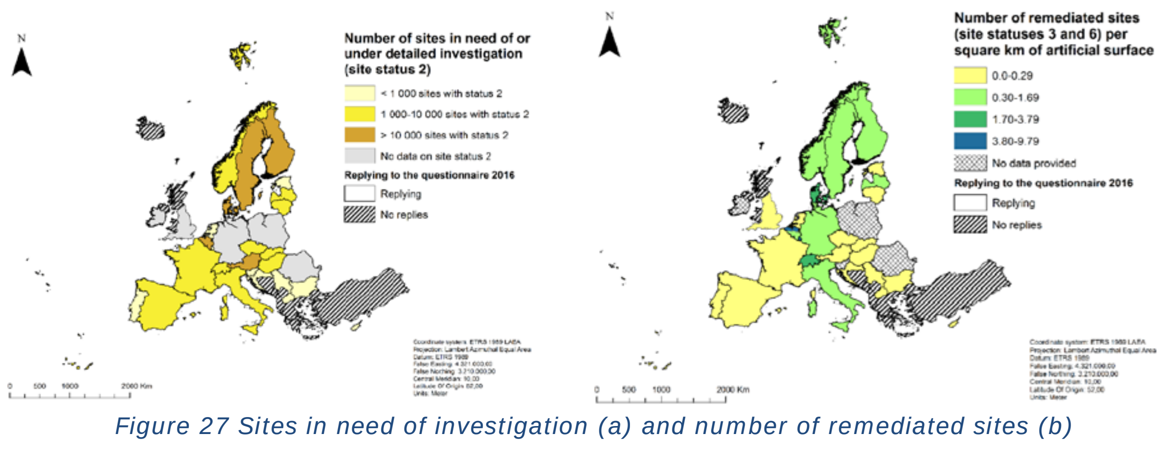


Figure 27 Sites in need of investigation (a) and number of remediated sites (b)

Source: Payá Pérez, and Rodríguez Eugenio, 2018

Table 12 Number of polluted or potentially polluted sites included in national inventories.

Country	**Identified polluted or potentially polluted sites**	**Surface area (km^2)**	**Date when information was provided**
Albania	10		2012
Bosnia and Herzegovina	350	3 000	2020
Kosovo	1 586		2020
Montenegro	10		2012
North Macedonia	70	429.6	2017
Serbia	709	3 203.7	2017
Total	**2 735**	**6 633.3**	

Sources: EC 2019k; Liedekerke et al, 2014; Ministry of Environment and Spatial Planning, Kosovo Environmental Protection Agency and GIZ 2018; Payá Pérez, and Rodríguez Eugenio, 2018

The report by HEAL (2015) on the impact of coal-fired power plants on children in Bosnia and Herzegovina, Serbia and Montenegro reveal worrying data. Elevated levels of mercury, above the limit of 0.58 μg/g, were detected in around 17% of human hair samples from Serbia. Elevated levels of cadmium were found in 25% of samples and 33% of samples from Montenegro showed high levels of lead. 17% of studied Bosnian children had elevated levels of lead HEAL (2015).

The Western Balkan countries are also participating and taking advantage of the political progress at EU level to strengthen their policies and actions and thus improve their environment and socio-economic situation and development. Furthermore, they are also involved in a regional project to support and strengthen environmental governance and development of sustainable policies to reach the SDGs, a process that started in 2018 and is implemented in cooperation with UNEP, UNDP and the United Nations Country Teams in the beneficiary countries (UNECE, 2018a). In addition, they have been supported with GEF funded projects on Mercury Initial Assessment (MIA) to enable their governance as well as to identify and assess the requirements and needs for the implementation of the Minamata Convention (GEF, 2016b).

A survey conducted in the Western Balkans on public awareness of environmental issues, such as pollution, shows that there is widespread acceptance that environmental degradation is a necessary step towards prosperity and that a large part of the population does not minimise their impact on the environment through their consumption choices (RCC, 2019). However, even the most environmentally conscious citizens have limited options to reduce their environmental impact. In terms of pollution, two-thirds of the interviewed population considered pollution a threat, while 35% considered it a serious issue. Respondents from Montenegro are the least concerned about the state of the environment, with only 47% showing concern, while 82% of respondents from North Macedonia indicated that they were concerned about pollution, maybe because Skopje is considered one of the most air polluted cities in the world. Furthermore, 59% of respondents were willing to pay more to buy environmentally friendly products, with

Albania and Montenegro having the most environmentally conscious shoppers at 63% (RCC, 2019).

Diverse policies refer to soil pollution and the need for data on pollution sources is high. However, there is a lack of binding measures, e.g. to build and publish registers of polluted sites or to assess and apply harmonised definitions and critical thresholds for contaminants in soils. Progress towards sustainable development in the Western Balkans will be possible only if land and soil resources are properly addressed.

Albania

The geological formation of Albania is characterised by Quaternary sediments in the western part while on the eastern side by the basic, acid volcanic rocks and ultramafic serpentine massifs that play a crucial role in the natural contamination process. Studies (Ministry of Tourisms and Environment, 2019) have shown that Ni, Cr and Co are present at high concentration at serpentine areas as well as in industrial sites located in the area. Moreover, also the surrounding soils show high levels of Cd, Cu and Zn (Fig. 28). Overall Albania has reported 10 contaminated sites.

A study conducted by the Agriculture University of Tirana identified seven metals (Cd, Co, Cr, Cu, Ni, Pb and Zn) in soil samples collected on the eight sites of the serpentine zone (Table 10). Each sample exhibited a high concentration in one or more metals. The Cd content in soils varied between 2 and 14 mg kg^{-1} DM and was rather high compared to the values generally observed in agricultural soils and was considered as toxic with the highest value observed at the industrial site of Prrenjas. Cobalt and Cr concentrations in soils were also elevated because of both natural and anthropogenic sources and varied from 91 to 3 865 mg kg^{-1} DM. Again, the sample from Prrenjas exhibited the highest concentration of Co (476 mg kg ^{1}) and Cr (3 865 mg kg^{1}). Copper concentrations in soils were lower than 73 mg kg^{1}, except for the Rubik site where the Cu concentration was 1 107 mg kg^{-1} DM, caused by the former activity of the copper smelter factory in the area (Ministry of Tourisms and Environment, 2019).

High Ni and Cr concentrations were observed only at the serpentine sites where soils were derived from gabbro and ultrabasic rocks rich in Fe, Ni and Cr. The site of Prrenjas appeared the most polluted by Cd, Co, Cr, Ni and Pb. Chromium and Ni were present at high levels in the soil of Elbasan (Fig. 28).

Table 13 Heavy metals concentrations (ppm) in soils of serpentine zone

Site	Cd	Co	Cr	Cu	Ni	Pb	Zn
Korce	4	184	513	6	1737	80	52
Puke	4	289	574	27	1104	87	49
Pogradec	5	259	635	8	2442	98	63
Prrenjas	14	476	3865	36	3579	172	93
Elbasan	3	130	491	14	447	80	61
Mirdite	9	338	256	1107	66	135	2495
Kukes	2	143	91	73	54	103	111

Source: Ministry of Tourisms and Environment, 2019

Figure 28 Distribution of serpentine formations and associated soils in Albania

Source: Ministry of Tourisms and Environment, 2019

The mining and ore processing industry has left behind several polluted sites, such as the one in the Elbasan metallurgical complex (Luli, 2010) as shown in Figure 29.

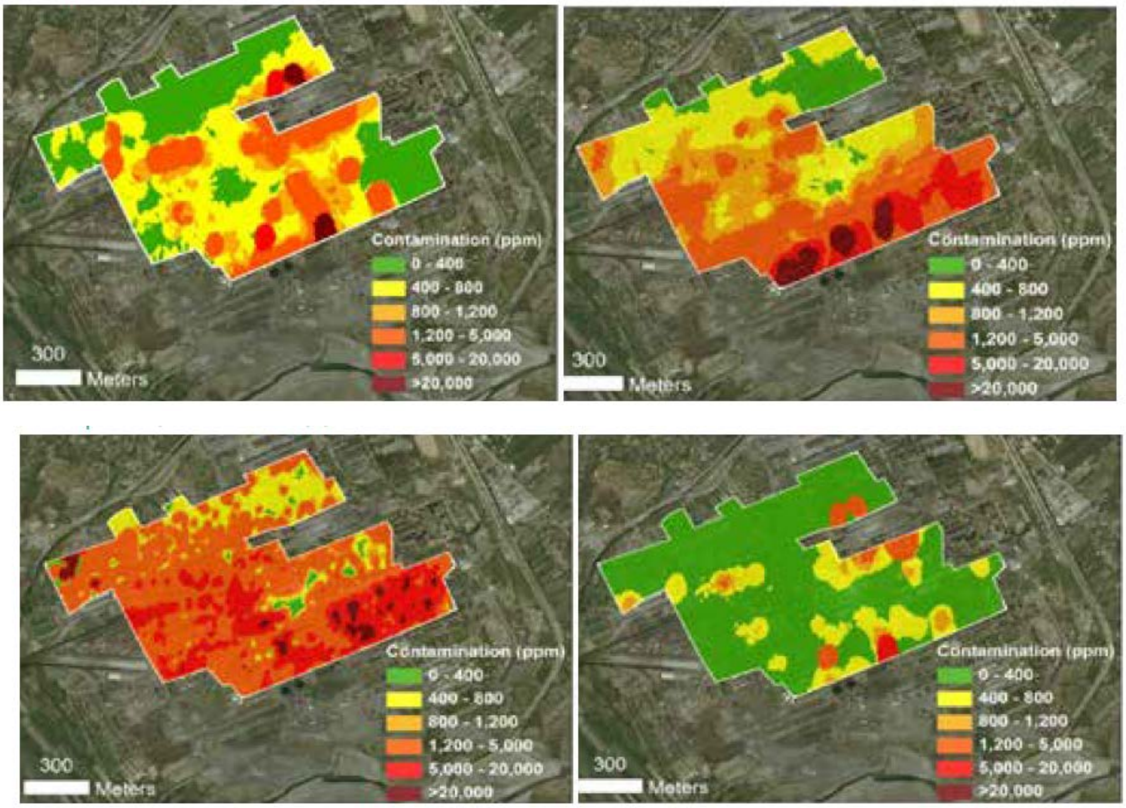


Figure 29 Concentration of Zn and Ni (above) and Cr and Pb (below) at Elbasan metallurgical complex

Accidental oil spills and improper disposal of wastewater used for oil extraction are also a cause of soil pollution by BTEX, volatile organic compounds or crude oil. The oil extraction industry is important to the economy of Albania, which has two of the largest onshore oil fields in Europe. In 2015, extensive pollution of neighbouring agricultural soils occurred following an incident at the Patos-Marinza oil field, which resulted in an explosion of gas, sludge, and water (Beqiraj and Topi, 2016). Furthermore, the country has two refineries which have not undergone a modernization process therefore have limited capacity for oil treatment and refining and could have a negative impact on the environment (UNECE, 2018c).

Of the 10 sites reported by Albania in 2012, five are still considered as soil pollution hotspots in 2017. These five sites correspond to (Alimehmeti and Roshi, 2017) to the following:

- the pesticide-producing Durrës chemical plant, which has left a legacy of soils polluted with lindane at concentrations a hundred times higher than EU threshold levels, as well as several neighbouring waste accumulation areas with a total of more than 20 000 tonnes of lindane and other chemical residues;
- the chlor-alkali and PVC plant in Vlorë, which has caused a severe pollution of 50 000 to 60 000 m^2 with mercury at values exceeding 10 000 mg/kg, which has penetrated the soil profile up to a depth of 1.5 metres.
- the Marinzë oil field in Patos, which covers an area of 200 km^2, although the actual extent of soil pollution is unknown, the company estimates that between 20 and 40 tonnes of extracted crude oil is lost to the environment every day, along with atmospheric emissions of sulphur oxides. Values of 4-90 $\mu g/m^3$ PAHs have been reported in surrounding soils.
- the Ballsh Oil Refinery also has significant crude oil losses to the environment, estimated at 22 500 tonnes per year. As in the previous case, the oils end up in

the Gjanicë River, which is a source of drinking water for the population downstream.

- And several landfills spread throughout the country. Although soil pollution has not been assessed, given the nature of the waste, pollution by trace elements, dioxins and furans, among others, is expected.
- Agricultural production is currently relatively a less polluting source.

Plastic pollution is also a problem with much of that accumulated along the riverbeds as well as along the coast.

Figure 30 Plastic accumulated on the sides of a river in Albania

Source: Zdruli

Little information is available on the national priorities regarding soil pollution. Recently the country has received funding by GEF to strengthen the capacity and promote sustainable soil management through integrated ecosystem restoration. The project was approved in 2016 and implemented by UNEP (GEF, 2016e). Additionally, it was reported that from 2011 until 2016 no action plan was made for the remediation of hotspots in the country (UNECE, 2018c). On the positive side, a soil monitoring network called the Consolidation of the Environmental Monitoring System (CEMSA) has been implemented, in which soil quality indicators, trace elements included, are measured in 30 fixed sites that overall are far too little for the whole country. The hope is that data coming from the LUCAS survey of 2015 could be included in the CEMSA.

Table 14 Drivers, sources, and location of contamination sites in Albania

Source and drivers of soil contamination	Activities and impacts	Area affected
Mineral industry	Production of cement and lime Manufacture of ceramic products by firing, in particular roofing tiles, bricks refractory bricks, tiles, stoneware etc	Kruja, Lezha Tirana, Elbasani
Production and processing of metals	Metal ore roasting or sintering Production of iron or steel Processing of ferrous metals Operation of ferrous metal foundries Processing of non-ferrous metals Surface treatment of metals or plastic materials using an electrolytic or chemical process	Elbasani, Mirdita, Bulqiza, Kukes, Tropoje, Pogradec, Korcë, Berat, Durres
Oil extraction and processing industry and energy industries	Oil extraction Refining of mineral oil and gas Combustion of fuels	Berat, Fier, Vlorë
Waste management	Disposal of urban and hazardous waste Disposal or recovery of waste in waste incineration plants Landfills Temporary and underground storage of hazardous waste	Watershed of : Buna, Mati, Erzeni, Osumi, Semani, Devolli, Shkumbini, Vjosa, Gjallica
Waste water management	Discharge of urban and industrial wastewater into rivers Discharge of urban and industrial wastewater into open environment	Watershed of : Buna, Mati, Erzeni, Osumi, Semani, Devolli, Shkumbini, Vjosa, Gjallica
Agricultural practices	Use of fertilizers Use of pesticides	Agricultural area

Source: Ministry of Tourisms and Environment, 2019

Bosnia and Herzegovina

Bosnia and Herzegovina do not have a national soil and land information system, and information on soil pollution is limited because of a lack of regulations on soil protection and monitoring. The only information available is on land use and structure, soil classes and ownership (UNECE, 2018b).

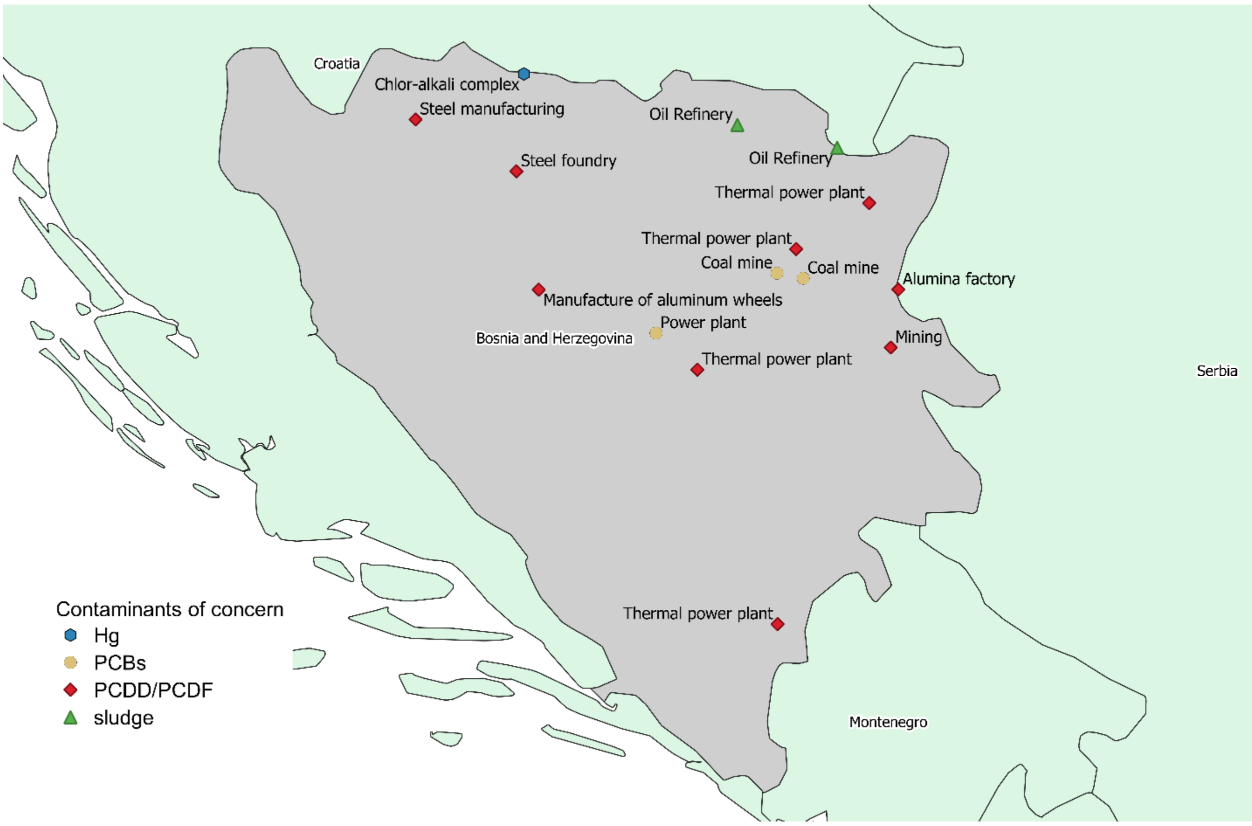
Overall, an estimated 300 000 ha are polluted (Andersen, 2000). As reported in 2017, 109 100 ha correspond to mining areas. There are no estimates on the area polluted by POPs, but many, including fire-fighting foams and PCBs, are still in use or have been buried without any contention measure as it is the case for PCB-containing capacitors (UNECE, 2018b).

At least three sites are potentially polluted with PCBs in the country. Seven sites potentially polluted with POP pesticides were identified corresponding to farmland, orchards, vineyards, and a tobacco processing plant. The preparation study for the development of the National Implementation Plan for the Stockholm Convention included the collection of data and investigation of sites potentially polluted with key POPs (Fig. 31) (Institute for Protection and Ecology of Republika Srpska, 2015).

Landfills in Bosnia and Herzegovina are responsible for extensive soil pollution through leachates containing organic compounds and trace elements that seep into soil and ultimately groundwater due to the existence of underdeveloped municipal solid waste treatment facilities in urban areas. For example, groundwater pollution occurs after landfill leaching through soil at the Banja Luka's municipal landfill, despite low soil permeability. Furthermore, there are 340 illegal dumpsites in the country (UNECE, 2018b).

According to (JICA, 2014), other places are to be included as shown figure 31, such as the 340 registered illegal landfills and many others that may exist but have not yet been identified, coal mines and deposits of coal, and metal and military industries. Sixty five percent of electric power is generated by coal/lignite-fired plants, which do not follow any procedure to reduce pollution from the waste generated from combustion (UNECE, 2018b).

Figure 31 Hot spots of soil pollution in Bosnia and Herzegovina and the major contaminants of concern as identified in the National Implementation Plan of the Stockholm Convention.



Source: UN, 2020 modified with data from Institute for Protection and Ecology of Republika Srpska, 2015.

Kosovo

The Kosovo Parliament approved the first law on environmental protection in 2001 emphasizing the same importance of chemical pollution as for soil erosion. The 2001 Law was drafted from an analysis of legislation in various European countries under consultancies with the World Bank and the United Nations Environmental Programme (The parliament of Republic of Kosovo, 2011).

There are in addition several institutions under the Academy of Sciences, various public Universities and the Ministry of Agriculture that deal with environmental monitoring and research studies, but often deprived from adequate financial resources. In the same year Parliament also passed the Law for Soil Protection with the established legal aspects to be followed by all governmental structures in the country. Unfortunately, such legislation was not able to halt soil degradation due to lack of policy enforcement and implementation.

The Law “On Environmental Protection” adopted in 2011 determined the five stages of environment protection applied in Kosovo:

- Gradual reduction of pollution, degradation and environmental damage and the prevention of those aspects of economic and other activities that pose a significant threat to human health and the environment.
- Protection biodiversity and general ecological balance of Kosovo.
- Rational and sustainable utilization of natural resources and agricultural land and protection of natural genetic stocks.
- Protection of valuable natural resources.
- The preservation of the diversity, cultural and aesthetic values of the landscape.

The law’s goals were prevention and reduction of pollution, conservation of biodiversity, rational management of natural resources, and avoidance of over-exploitation, ecological restoration of damaged areas, and maintenance and improvement of the environment. The law could have significant impacts on the environmental and human health since it required an environmental impact assessment (EIA) for all projects and activities. However, there was minimal enforcement of it for many reasons including also governmental transitions.

A total of 1 586 contaminated sites have been reported in Kosovo, the highest number in the region, most of them due to the Kosovo war. Health problems affecting hundreds of people were also reported as given in the introductory part of this sub-section.

One main source of contamination derives from industrial pollutions that took place for decades in the radius of Mitrovica (TREPCA) smelting plant. A soil and plant test has proved that farmlands within 25 km radius of Mitrovica are contaminated with Lead, Zinc, Mercury, and Cadmium with serious implications on human health. The soil and water contamination of garbage wastes is the other environmental threat, especially when it comes to landfill sites, where percolation of chemicals and heavy metals into the soil and water is likely.

Another source of pollution are the Obiliq power generation plants in the Kastriot Municipality near the capital of Prishtina. Sallahu (2017) evaluated the total heavy metals concentrations pollution in different soil types. Soil samples were collected at the depth of 0-30 cm in an agricultural area of about 5 000 ha divided in three circles (2, 4, and 6 km distance from the Power Plants). A total of 40 geo-referenced samples were collected, 35 in the study area and 5 in the control zone 25 km far from the plants. The method for the determination of heavy metals was based on the spectroscopy with plasma – ICP – OES, EPA 12914: 2012. Results showed that contamination is higher at the third circle indicating that pollution is spreading in larger areas. These results were compared with the allowed threshold values of the EU and resulted higher. Special attention was devoted to the delineation of contaminated areas that should be off limits to humans, livestock, and urban/rural development. Mitigation techniques were suggested to be applied throughout the polluted areas. Nevertheless, nothing was done since then.

Figure 32 The huge lignite excavation site at Obiliq that fuels two huge power plants inside the Kastriot Municipality. This is the major source of electricity for Kosovo

Source: Zdruli, 2016

Coal-fired thermal power plants are major emitters of multiple contaminants into the environment. The ashes deposit in the soils in the vicinity of the plants, resulting in pollution by trace elements and radionuclides such as uranium or thorium (UNECE, 2019b). Uncontrolled emissions from the combustion of lignite (Fig. 32) in Kosovo's power plants result in the annual average release into the environment of some 2 million tonnes of ash, more than 11 tonnes of arsenic, 1 tonne of cadmium, 351 tonnes of nickel, 492 tonnes of titanium, 191 tonnes of manganese, and 0.48 tonnes of vanadium (Daci-Ajvazi et al., 2016). These obsolete highly polluting coal-fired power plants, Kosova A and B, nurture Kosovo's energy needs, and both have associated two big dump areas (ITA, 2020).

Wastewater treatment remains very rare in Kosovo, and given its expansive sewerage networks, it is both a logical next priority for the sector to invest in and develop, as well as a requirement under the WFD. Sewerage systems are one source of pollution, but Kosovo has important point polluters in form of landfills, and heavy industry as well, as well as local mining operations. These require strong licensing and regulation and prohibitions on destructive actions. Besides addressing point source pollution this requires the conservation and protection of the aquatic ecosystems and the determination and enforcement of Ecologically Acceptable Law (The World Bank, 2018).

Little progress has been made in Kosovo in the assessment, monitoring, reporting and remediation of polluted soil. Industrial and mining waste and dumpsites are the main sources of pollution in Kosovo, although the extension of soil affected is still to be determined (EC, 2019h). There are about 1 572 illegal landfills in Kosovo and 4 municipal non-sanitary landfills that may be posing a high risk to the environment and human health (Ministry of Environment and Spatial Planning, Kosovo Environmental Protection Agency and GIZ, 2018). Additionally, the major municipal landfill, Mirash landfill, is close to the capital Pristina and receive waste from 450 000 people but is poorly managed and it is leachates are posing a high risk (Morina, 2018).

Montenegro

In total Montenegro has reported only 10 contaminated sites. However, there are about 20 industries including mines, coal power and aluminium plants that are causing point-source pollution that require advance chemical treatment of their waste and wastewater to avoid further impacts on the surrounding environment. High concentration of PAHs were detected in soils at Srpska village affected by the Aluminum Plant Podgorica (UNECE 2015a). The remediation of polluted sites in Montenegro occurs within the waste management plans that have been produced so far. The waste management plans include activities such as the remediation and closure of dumpsites and the remediation of locations called “black points”, which are sites with large quantities of disposed waste (UNECE 2015a).

The mining sector in Montenegro has produced large quantities of toxic waste and is a relevant source of soil pollution. An open pit mine for coal exploitation has produced about 70 million tonnes of waste, whereas 3.9 million tonnes of tailings from the lead and zinc mines were deposited on the bank of the Ćehotina River, after changing the river’s course (UNECE 2015a). Montenegro has now a project to restore the water course of the river after the excavation of the toxic waste (Environment South East Europe, 2021), which will need to be properly treated to avoid further pollution offsite.

Metal production has long been a tradition in Montenegro, however lately there has been a decline in smelting plants in favour of food, wood, and paper processing plants. There is an urgent need in the country on the proper treatment of waste generated from past industrial production as the red mud from the aluminium industry KAP which covers an area of 420 000 m^2 is disposed in two basins (UNECE 2015a).

The Government of Montenegro, UNDP and the Organization for Security and Co-operation in Europe (OSCE) implemented the *Capacity Development Programme for Small Arms and Light Weapons (Conventional Ammunition) Demilitarization and Safe Storage for Montenegro* (MONDEM) programme between 2007 and 2018 to reduce the exposure and risk of the population and environment from stockpiles of weapons and ammunitions originating from the Kosovo conflict. The program resulted in the disposal of 3 300 tonnes of weapons and 128 tonnes of toxic substances, the reconstruction of an ammunition depot and the partial demilitarisation of 1 806 tonnes of obsolete ammunitions (UNDP, 2019).

Montenegro has an ongoing project on the identification and disposal/treatment of the remaining PCBs in the country (amount estimated not less than 900 tonnes between equipment and waste) funded by GEF and implemented by UNDP. The aim is to improve regulations concerning PCBs, the creation of PCBs inventories, but also the development of an environmental sound management to deal with hazardous waste such as PCBs in the future (GEF, 2019d). Regarding persistent organic pollutants, Serbia and Montenegro participated in a GEF-funded project implemented by UNEP, to support the implementation of the Stockholm Convention, assist the countries in meeting up with the obligations of the Convention and strengthen their capacity to manage POPs (GEF, 2019e). An ongoing GEF-funded project on POPs implemented by United Nations Industrial Development Organization (UNIDO) is the Environmentally-Sound Management and Final Disposal of PCBs. The aim of the project is to reduce and eliminate the releases and exposures to PCBs by establishing an environmental safer PCB management and disposal of 200 tonnes of PCBs.

Two separate monitoring systems are implemented in the country, one for determining soil quality and another for detecting hazardous substances along agricultural soils close to roads, landfills, and industrial facilities. The soil pollution monitoring analyses inorganic, organic and pesticide pollution, but only for point-source pollution and not for diffuse sources. Despite the monitoring system, Montenegro seems to be lacking plans on how to deal with point-source pollution and the development of an inventory of the polluted sites (UNECE 2015a). Although conducting regular soil quality surveys, there is very limited information on the treatment and management of polluted sites (UNECE 2015a).

North Macedonia

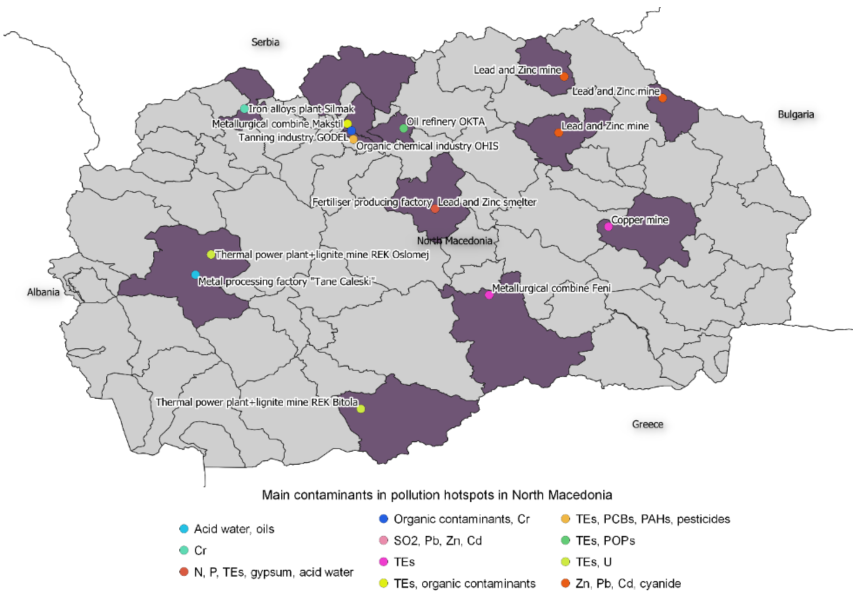
Soil pollution in North Macedonia is mainly due to trace elements such as cadmium, lead and zinc in the vicinity of mines in north-eastern parts of Macedonia (Zletovo, Toranica, Sasa), as well as in the central part of the country (smelter in Veles) (MOEPP, 2017). Soils in the capital, Skopje, are heavily polluted. An area of about 200 ha is covered with landfills that can potentially have polluted the soil beneath them. Out of a total of 70 contaminated sites covering 429.6 km^2, 16 of them are of major concern as shown in Figure 33.

The mining and smelting industries are also major sources of soil pollution by cadmium, lead and zinc (MOEPP, 2017). High concentrations of trace elements exceeding reference levels have been detected along the Kiselica and Zletovska rivers and are associated with an old emission following the breaking of mine tailings (JICA, 2008). In addition, the use of low efficiency technologies employing the use of other organic compounds for the extraction of trace elements contributes to soil pollution also by organic contaminants such as PCBs (MOEPP, 2017).

Open-pit coal mines and power plants in Bitola and Oslomej have contributed to the poor air quality of the capital Skopje, named the most polluted capital in Europe in 2018 (Bennett, 2019), and are also partly responsible for the enrichment in trace elements such as arsenic and lead in the surrounding soils (Stafilov et al., 2014; 2018). However, the Oslomej plant has taken a big step towards decarbonisation and thus emission reductions by transforming it into a photovoltaic power plant (Bennett, 2019).

After a two-year project in collaboration with FAO and the GSP, North Macedonia launched the Macedonian Soil Information System “MASIS” in 2015, which is publicly available online (FAO, 2015; MASIS, 2015). The system offers limited information on polluted sites within the Macedonian Environmental Information Centre and a proper soil pollution monitoring system does not exist in the country. In the city of Skopje, soil monitoring campaigns were carried out in 2012 to analyse concentrations of trace elements (UNECE, 2019a).

Figure 33 The 16 major pollution hotspots in North Macedonia.



Source: UN, 2020 modified with data from MOEPP, 2017.

High concentrations of trace elements were detected in drinking water and wheat associated with mining activities near residential and agricultural areas, posing a high risk to local populations (JICA, 2008). Measures to avoid health consequences should be taken to prevent leaching from mining tailings dams into the soil and the consequent transfer of contaminants from soil to crops and water. Mining rehabilitation is not practised in the country although the 2012 law on mineral resources requires a financial guarantee for rehabilitation and waste management of mining projects. The country has no practical experience in land rehabilitation because until now, when a mining concession ended, the Ministry extended the concession. Although there is no law addressing historical pollution from mining and industry, it is worth noting that the country proposed a draft law on soil protection in 2014 (UNECE, 2019b). Although the law was not passed for a variety of reasons, including its financial implications, it still suggests that soil is part of the national political agenda (UNECE, 2019a).

Since 2010, North Macedonia has devolved many efforts to improving the management of chemicals by working on the *Strategic Approach to International Chemicals Management (SAICM).* New laws on waste management, such as the National Waste Management Plan and the National Waste Prevention Plan, are expected to be adopted since 2020. Laws such as the Packaging waste and E-waste are currently being drafted. The advancement in the sound management of chemicals, besides reinforcing policies, has also contributed to the development of remediation plans of contaminated sites from waste /UNECE, 2019b). Additional research has been conducted in phytoremediation with promising results (Manasievska-Simikj et al., 2018).

Serbia

Serbia has 709 contaminated sites covering 3 203.7 km^2 (Ana Payá Pérez and Natalia Rodríguez Eugenio 2018). The municipal waste disposal is responsible for 43.5% of the polluted sites included in the National Inventory of Contaminated Sites (UNECE, 2015b). Furthermore, some long-lasting industrial sites have produced industrial landfills, namely from mineral and coal mining activities that can be a source of point-source pollution.

Serbia hosts a cadastre of polluted sites[14] that is legally regulated through the Regulation on the Programme of Systematic Monitoring of Soil Quality via Indicators for Assessment of Soil Degradation Risk and Methodology for Creation of Remediation Programmes and the Regulation on Limit Values for Polluting, Harmful and Hazardous Substances in the Soil. Republic of Serbia adopted a Decree on systematic monitoring of the soil state and quality, (OG 73/19) which determines the content of the Soil Monitoring Programme and of the national and local soil monitoring network. A list of parameters which are to be monitored describe the methods and standards to be used for soil sampling, sample analysis and data processing, as well as indicators for the assessment of land degradation risks.

The Soil Monitoring Programme at the national level for a two years' period has been drafted and will be prepared and implemented by the Ministry on Environmental Protection and funded from the budget of the Republic of Serbia. A set of indicators, listed in the National List of indicators of environmental protection, are used to assess the risks of soil degradation. A national laboratory on soil analysis was established and is part of the Serbian Environmental Protection Agency structure and has been equipped thanks to the donations and the support of donors, such as the EU (UNECE, 2015b).

The indicators which refer to management of contaminated sites provide information on the progress done in the management of polluted sites, but also give information on what types of remediation measure should be implemented (MEP and EPA, 2018). Nevertheless, Serbia does not conduct any regular soil monitoring, and the existence of reports on polluted hot spots is due to pilot projects with the involvement of external donors (UNECE, 2015b).

[14] http://kkl.sepa.gov.rs:8080/apex/f?p=100:1:13031145667939

Soil Information System is an integral part of the unified Environmental Protection Information System run by the Serbian Environmental Protection Agency. The Cadastre of Contaminated Sites is a part of the Soil Information System, and includes a set of data on polluted, vulnerable, and degraded soils. The latest information reports 709 potentially contaminated sites, of which 557 are registered in the cadastre (Vidojevic, 2018). However, the inventory does not include former military locations, petrol stations, dry cleaning, wastewater treatment plants and hazardous substances pipelines (MEP and EPA, 2018).

Serbia has many ongoing projects funded by GEF and other donors to help the country deal with soil pollution from former industrial activities and improper past waste disposal. A project that ended in 2019 was the Enhanced Cross-Sectoral Land Management through Land Use Pressure Reduction and Planning project, which was implemented by UNEP and funded by GEF and the Italian Ministry of Environment, Land and Sea (Falconi et al, 2018). UNEP has analysed the soil, water, and sediments of 32 sites and trained local authorities to monitor and address soil remediation. As a result, a map of polluted sites and a national platform to share information on land degradation and management was created (UNEP, 2019b).

A debate in Serbia that involves the public opinion, scientific experts and politicians is on the association with depleted uranium from the NATO bombing in 1999 and cancer incidence, especially in children. In 2018, the Serbian Parliament approved a law proposal for an Inquiry Commission to carry out a two-year investigation programme to determine the effects of DU on the health of the Serbian citizens and the environment. The programme was officially signed and agreed by the ministries of environmental protection, health, defence, education, and science and technological development and the complete results were foreseen to be published in 2020 (ANS, 2018; Simic, 2018). In 2019, for the 20th anniversary from the bombing a second international symposium on the "Consequences of the bombing of the Federal Republic of Yugoslavia" was held in Nis, Serbia (Kukin, 2019).

6. Soil sealing and net land take

A first assessment of soil sealing in the Western Balkans shows that 0.87% of the total land area is covered. Agriculture land appears to have experienced the biggest loses. Land take and sealing is driven by rapid economic expansion and housing needs.

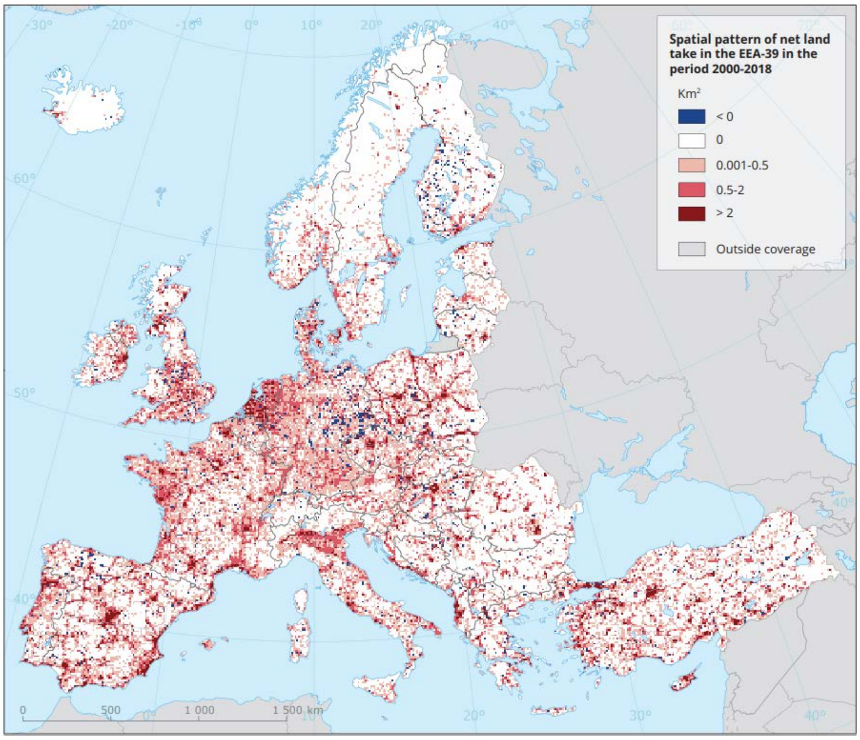
Soil sealing causes the complete and irreversible loss of all soil functions. Urban expansion and infrastructure consume soils by physical removal or covering them with impermeable (impervious) artificial material (e.g. asphalt and concrete), though only part of the land that is defined as land take is actually sealed. Loss of fertile land to urban development reduces the potential to produce bio-based materials and fuels that support a low-carbon bioeconomy.

Most recent available data for soil sealing trends and dynamics in the Western Balkans are given by EEA SOER2020 report (Figure 34). In 2006 the sealed area was 0.87% out of the total land area of the region (Figures 35 and 36). The problem is that various publication and data sources, which overall are scarce, often provide contradicting trends.

Data on the extent of sealing in terms of surface area (hectares or km^2) are also missing with sporadic assessment for specific countries. For instance, in North Macedonia the rate of conversion of the land for the period 2000-2016 will keep the same trend by 2040 based on a simple extrapolation method (Ministry of Environment and Physical Planning, 2021).

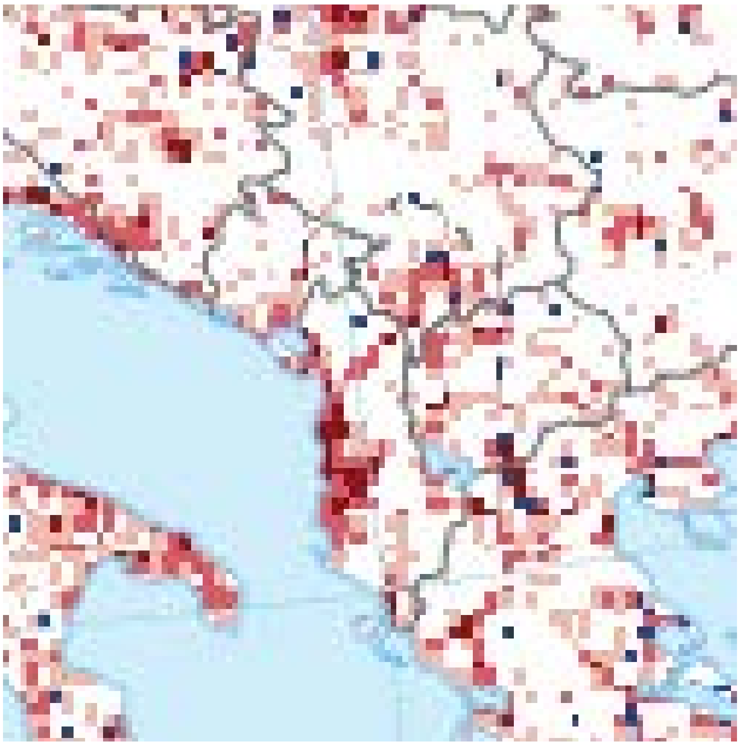
In Serbia the total area of agricultural land on which the conversion is made into artificial surfaces in the period 1990-2012 was 11 367ha.

Figure 34 Net land take in the EEA-39 (including Western Balkans) for the period 2000-2018



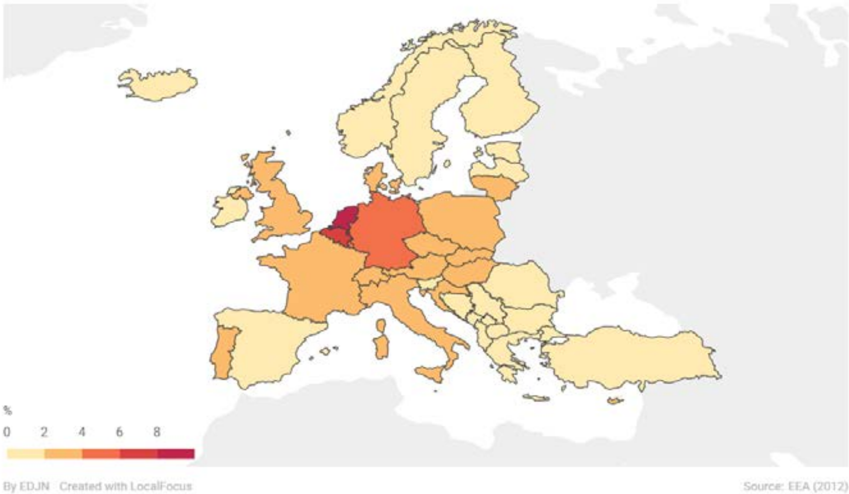
Source: EEA, SOER report 2020

Figure 35 A close up of the sealed areas in the Western Balkans



Source: EEA, SOER report 2020

Figure 36 Percentage of impermeable soil in 2006 in percent

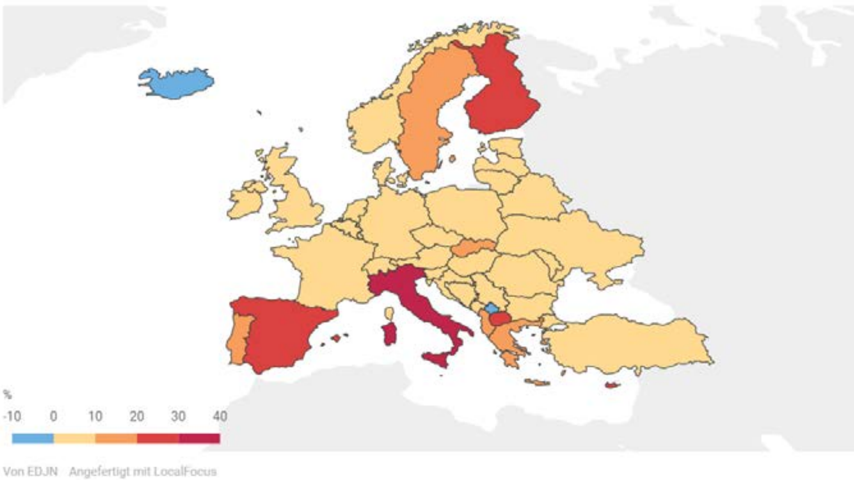


Albania: 0.73
Bosnia Herzegovina: 1.08
Kosovo: 1.56
Montenegro: 0.76
North Macedonia: 1.09
Serbia: 1.09

Regional: 0.87%

Source: [An ever less fertile Europe / All the news / Homepage - Osservatorio Balcani e Caucaso Transeuropa (balcanicaucaso.org)]

Figure 37 Soil sealing trends for the period 2006-2012

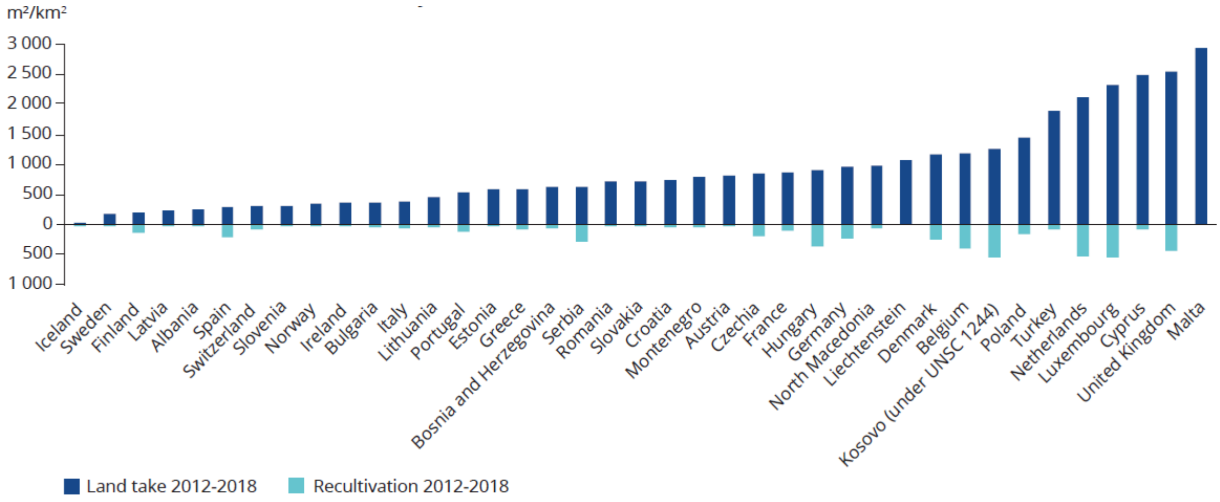


Albania: 11%
Bosnia Herzegovina: 3%
Kosovo: -1%
Montenegro: 0%
North Macedonia: 28%
Serbia: 1%

Source: An ever less fertile Europe / All the news / Homepage - Osservatorio Balcani e Caucaso Transeuropa (balcanicaucaso.org)

Figure 38 presents land take in the EEA-39 during the period 2012-2018, as the share of the country's area (EEA, 2019b), which allows for comparison of countries of different sizes. Land take in the Western Balkans was the highest in Kosovo, North Macedonia, Montenegro, Serbia, and Albania in the decreasing order. Whereas was no recultivation in North Macedonia, Montenegro, and Serbia, the process was evident in Albania and Kosovo.

Figure 38 Country comparison - land take and land recultivation in the EEA-39 for the period 2012-2018 (as a share of country's area)



Note: Kosovo under United Nations Security Council Resolution 1244/99.

Source: EEA, SOER report 2020

Albania: a case study

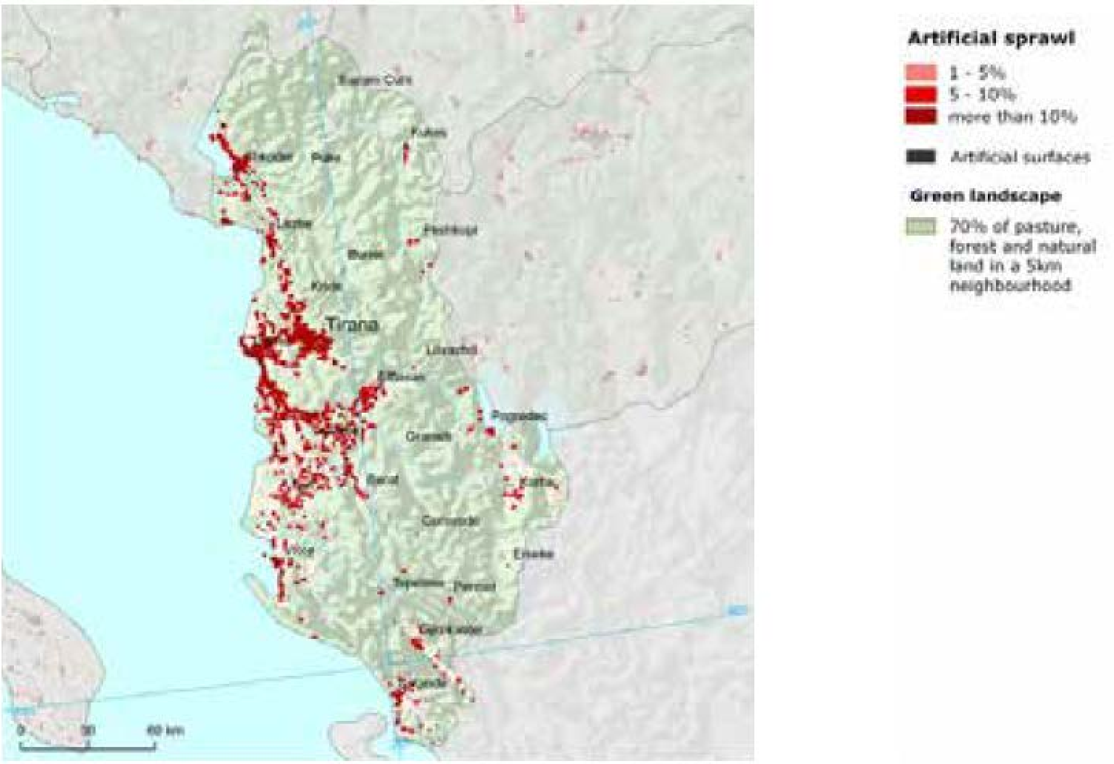
The Albanian landscape after the political change of the 90s and during the period 2000-2006 have been clearly dominated by urban residential sprawl over agricultural land. Sprawl areas expanded mainly in surroundings of the capital city Tirana (Figure 39) and along the main transportation networks to other big cities such as Durres, Fier, Vlore, Shkoder, as well as along the Adriatic and Ionian coast (Figure 40). The annual rate of land take was at 4.69% per year mostly driven by housing needs, followed by industrial activities and infrastructure (Fig. 41). The biggest “loser” was the agriculture land followed by semi-natural vegetation and forested areas especially along the coastal areas (Ministry of Tourism and Environment, 2019).

After 2006 a new trend in land take is taking place driven by economic expansion, big infrastructure projects and by the extension of industrial and commercial units. This was due to reinforcement rules for housing to avoid the catastrophic/chaotic situation that was seen especially in the surroundings of Tirana (Fig. 40) and other large cities. For the period 2006-2012, the annual rate of land take fell to 0.47%, which is still high compared with EU levels (Ministry of Tourism and Environment, 2019). Overall, it is estimated that for the period 1990-2020 Albania has lost at least 50 000 hectares of agriculture land (personal communication).

Figure 39 Tirana in 2021, a city of 1 million people compared with 250 000 in 1990

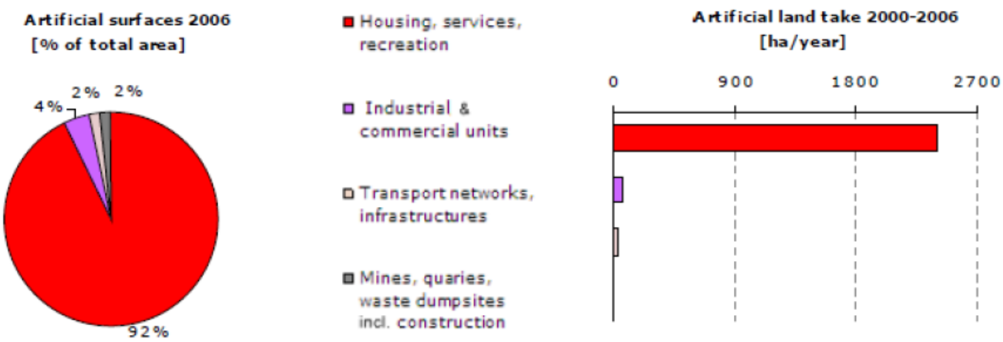
Source: Wikipedia, public domain

Figure 40 Land cover changes for the period 2000-2006



Source: Albanian Ministry of Tourism and Environment. 2019

Figure 41 Land take in Albania by category



Source: Albanian Ministry of Tourism and Environment. 2019

4.2.6 Salinization

Salinity, sodicity and magnesial rich soils, cover large areas in Serbia, North Macedonia, and Albania. The process is caused by natural conditions and unsustainable irrigation practices. Overall, it is estimated that these areas cover less than 10% of the whole territory of the Western Balkans.

Saline and sodic soils (Solonchaks and Solonetz) are scarcely present in the region, except in parts of Serbia, North Macedonia, and Albania where salinity build up is on the rise. For instance, until 1990 Albania (Figure 42) had about 10 000 ha of salt affected soils (Zdruli, 2005), but that surface area has expanded rapidly due to abandonment of these areas after the collapse of the Communism period and lack of amelioration measures reaching 30,000 ha in 2019 (Ministry of Tourism and Environment, 2019).

Figure 42 Saline areas in the coastal area of Rremas (Divjake) in Albania

Photo credit: Zdruli, 2001

Management of saline soils is costly and a long process that requires continuous investments otherwise salinity build up can expand rapidly and nullify previous investments. This happened in Albania. Conversely, present technologies offer good options for their re-cultivation. At the same site of Rremas that was surveyed in 2001 (Zdruli et al., 2002) at present, a successful enterprise is growing salt tolerant pomegranates and goji berry fruits in a 500 ha farm. This is good example of management practices that could be replicated in similar soils.

Figure 43 Cultivation of pomegranates and goji berry fruits in the Agro Iliria farm in Divjake.

Credit: https://www.facebook.com/Agro.Iliria.Group

Limited areas of secondary salinisation are also reported in North Macedonia. These are mostly the result of poor quality irrigation water (Aleksovska et al., 2016).

The region is also home to a special soil type called in Serbian language Smonitsa (Stebut, 1927), or the dark black heavy clay Chromic Vertisol with high magnesium content in the soil absorption complex formed on serpentine mafic geological formations. They are very compacted and hard to dig in dry conditions since clay content could reach as high as 80%. In Albania alone there are about 12 000 ha, but these soil types are present throughout the Western Balkans. Acid low pH soils are also present in the region, especially in Albania where they cover about 90,000 ha.

4.2.7 Desertification

None of the countries meet the criteria of aridity index as described by the UNCCD. Nevertheless, land degradation in the general context is present in all the countries with erosion as the most prominent factor affecting large areas (overlap with soil health indicator 3).

The countries of the Western Balkans are included in the Annex IV (Albania) and Annex V (all the rest) of the UNCCD. In strict content of desertification based on the aridity index of UNCCD as "land degradation **in arid, semi-arid, and dry sub-humid areas"** none of the countries meet this criterion. Nevertheless, the most relevant, in terms of proximity to aridity index, the desertification process is relevant in Albania and Montenegro due to their exposure to hot Mediterranean climate along the coasts. Hence the affected area for each country should be in the range of 25% of their territories.

In Albania, Zdruli and Lushaj (2000) and Zdruli et al., (2016) report deforestation, overgrazing, soil pollution, re-salinisation, acidification, water logging, flooding, urbanization, soil sealing, nutrient mining, loss of soil fertility and accelerated soil erosion as perhaps the most alarming environmental problems in Albania.

Montenegro is facing several land degradation factors from urbanization to unsustainable land management as described in detail in this report. It could be that potentially degraded land in the country, according to the land productivity dynamics (LPD) dataset, to be around 5.44% (LDN, UNCCD, 2018). But forest fires are of particular concern since in 2017 alone, 13 750 ha were totally burnt (Montenegro report, 2018) and hence they are identified as the most critical type of land degradation. The situation was repeated again in 2021 devastating also millenary olive groves around the city of Ulqin. In the meantime, the main indirect drivers of land degradation and desertification for the last two or three decades have been population pressure, migration from rural to urban areas, increase of touristic capacities, land tenure changes, poverty, labor availability and lack of financial in

The landlocked Bosnia and Herzegovina (which has only a very small part on the coast) is experiencing land degradation in various forms affecting about 1.2 million people in 2010. The annual cost of land degradation is estimated at 99 million USD. This is equal to 8.2% of the country's agricultural Gross Domestic Product (GDP). Instead, the returns on acting against land degradation are estimated at 6 USD for each dollar invested in restoring degraded land (Bosnia and Herzegovina report, 2018).

In North Macedonia the most prominent processes of land degradation include erosion, loss of soil organic matter, soil sealing while in Serbia soil erosion is the prime degradation process affecting about 80% of agricultural soil.

4.2.8 Soil biodiversity

Soil as a habitat, is a large but often forgotten consideration of the discussions on global biodiversity. A healthy soil depends on a vibrant range of lifeforms living below the ground, from bacteria and fungi to tiny insects, earthworms and moles. Soil biodiversity is critical because of its role in the cycling of ecosystem nutrients that are necessary for plant growth, improved entry of water into soil and its storage in the soil, providing resistance to erosion, the suppression of pests, parasites and disease, increased capture and storage of organic carbon, as well as breaking down organic matter.

It is likely that all the above drivers are probably singly or in combination resulting in a decline in biodiversity but there are no actual data demonstrating soil biodiversity in the Western Balkans or changes in the composition or abundance of soil dwelling communities.

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5 Conclusions

This study presents an updated analysis of the status of soil health in the Western Balkans region as of 2021. A number of reflections have been extracted and presented. The report concluded that soils are under pressure the Western Balkans region. Soil degradation is prevalent and extensive. However, the intensity of pressures affecting soil health varies between countries. Soil erosion is the most relevant and aggressive process. It is estimated that about 45% of the total land area is affected by water erosion while the area of agriculture land affected is around 30%.

One common shortcoming encountered, as is often the case when assessing the status of many environmental issues in the Western Balkans, is the scarcity and fragmentation of data in terms of spatial coverage and timeliness (referring to current status and analysis of trends). Field data are the basis for both the identification of critical situations and the development of effective and efficient policies. Therefore, the establishment of monitoring networks with sufficient coverage in space and time and completeness of the analysed parameters is a cross-cutting priority for the issues addressed in this report.

There is heightened policy interest in soils because of the range of ecosystem goods and services that they provide and their relevance to the objectives of the European Green Deal. The new EU Soil Strategy has the objective of bringing all EU soils into a healthy condition by 2050 on the basis of a broad range of actions that should generally be implemented by 2030. In this context, the Commission will look to integrate the sustainable use of soils across all relevant EU policies, be it agriculture, biodiversity, circular economy, climate, urban development, or pollution.

Implementation of a soil protection framework to ensure heathy soils is a priority for the implementation of the Green Agenda for the Western Balkans. This requires coherent action across a broad policy base.

Making sustainable soil management the new normal requires coordination as well as action at local, regional, national, EU and global level to promote and implement such practices. A key element will be the identification and adoption of practices, including regenerative farming in line with agro-ecological principles, which are relevant to the target area reflecting inherent soil characteristics and land use needs. Close links should be established with the work of the Mission 'A Soil Deal for Europe' to set up Living Labs and Lighthouses of as flagships of best practices that are applicable to issues affecting soils in the Western Balkans.

The EU Soil Observatory (EUSO), in particular through its Technical Working Groups on Monitoring, Data Integration, Pollution, Biodiversity, Citizen Engagement, together with the European Environment Agency (EEA) as well as through contacts with MS, research and industry, are establishing a roadmap for an integrated soil monitoring and indicator framework that should collect data to feed a soil dashboard that assesses the effectiveness of policies and their respective instruments in reaching critical targets. Such a framework aim to bring together pan-EU and national initiatives while supporting the reestablishment or reinforcement of monitoring systems that for a variety of reasons, are no longer operational. Pan-EU soil initiatives (such as LUCAS, EUSO, Clean Soil Outlook), should be expanded to cover the Western Balkan region.

In parallel, the Commission will consider setting legal requirements for healthy soils so that their capacity to deliver ecosystem services are not hampered. In this regard, the Commission is working to adopt a new Soil Health Law by 2023 to give soils the same EU-wide legal basis as air and water. In this regards, soil will have to be considered under the accession process.

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Annex 1. Synthesis of final methodology and metadata for spatial evidence

After a careful collection of available existing information and its critical review the methodology was finalized and applied during the assessment process. Following the standard procedure of the Soil Mission report, all soil health indicators for the Western Balkans were analysed in detail and their extent at country and regional level was assessed. It should be noted however that data availability is overall poor, and its quality depends on country specifics, for instance is much better in North Macedonia, Serbia, Montenegro, and Albania and rather problematic in Bosnia and Herzegovina and particularly in Kosovo. Therefore, the methodology remains largely based on educated expert assessments and the inputs provided by national experts.

Each soil health indicator was evaluated for each country and various land use and land cover types. They were grouped in three different categories and assessed against the various affected soil services as shown in table 1 below.

Table 1. **Soil degradation types, corresponding soil threats and affected soil services Degradation type**

Soil degradation types	Impact of soil threats	Affected soil services
Soil physical degradation	Subsoil compaction Soil erosion Landslides	Growth of crops Wood & fibre production Water storage Substance filtering Storage of geological material Carbon storage Habitat for plants, insects, microbes, etc. Support for buildings or transport network
Soil chemical degradation	Accumulation of contaminants and nutrients in soil Salinisation Acidification	Growth of crops Wood & fibre production Water storage Substance filtering Carbon storage Habitat for plants, insects, microbes, etc.
Soil biological degradation	Accumulation of contaminants and nutrients in soil Reduced humus formation and reduced metabolization of contaminants SOM/SOC decline	Habitat for plants, insects, microbes, etc. Water storage Substance filtering Carbon storage

Source: Soil Mission report

Table 2 provides reference values for soil organic carbon, nutrient load, acidification, soil pollution, erosion, biodiversity, compaction, and soil sealing. Note that these data are largely missing, but as said, were used as baseline threshold values in the assessment approach.

Table 2. Overview of soil threats and indicators investigated in this report

Soil threat	Indicator	Thresholds	Comment
Soil organic carbon			
Cropland	Deceedance of optimal SOC	Sand: 1.5 (1.0-2.0) [% SOC] Silt: 1.9 (1.4-2.4) Loam and clay: 1.6 (1.0-2.8)	Values for extreme summer-dry areas can be lower (< -100 climate water balance) Values for optimal fertilizer management (Wessolek et al. 2008) Proxy: sequestration potential
Nutrients			
Agriculture	Exceedance of critical levels of mineral nitrogen (agricultural land)	NH_3 in air: 1 – 3 [mg NH_3 m^{-3}] NO_3 in ground water: 50 [mg NO_3 l^{-1}] N in surface water: 1.0 to 2.5 [mg N l^{-1}]	Mineral N: sum of available NH_4 and NO_3
Forest	N limitation based on exceedance of C/N ratio	C/N 20-25 leakage from forests: 1 [mg N l^{-1}]	in the organic layer
Agriculture	Deceedance of optimal phosphorus	P concentration 25-35 (optimal P fertility class)	Extractable P concentration < optimum (value range refers to Mehlich 3-ICP; also available: P-Bray P1 and Olsen P)
Forest land	P limitation based on exceedance of N/P ratio	N/P ratio > 18 (coniferous forests) N/P ratio > 25 (deciduous forests)	in the organic layer
Acidification			
Agriculture	Critical pH levels	pH < 4.5 - 4.7	
Forest land	Critical inorganic Al levels	base cation/aluminium ratio = 1 (0.5-2.0)	Bc: Ca+Mg+K
Soil pollution			
Cropland	Exceedance of screening values for critical risk from heavy metal pollution	Cd, Cu, Pb and Zn by country [mg/kg] *(Arsenic could be added; others?)*	Country-specific values vary broadly and are not necessarily comparable

			Stratification by land use and soil texture
Soil erosion			
Agriculture	Actual rate of soil loss by water erosion	2 [t ha-1 yr-1] (soil loss tolerance)	Threshold for shallow soils < 70 cm: 2 t/ha/yr (Switzerland) Soil formation rate: 0.3 to 1.4 t/ha/yr (Verheijen et al. 2009) All erosion types
Soil biodiversity			
Loss of soil biodiversity (subindicators)	to be developed: (a) safe minimum standard of conservation (b) Operating Ranges (OR) for specific soil animals and microorganisms	requires sub-indicators by species (functional) group	
Soil compaction			
Harmful subsoil compaction (subindicators)	Priority (sub) indicators: Saturated hydraulic conductivity (Ks) < 10 [cm/d] Air capacity (AC) < 5 [%]	Exceedance of “action values” (Zink et al. 2011) Secondary subindicators with available thresholds: bulk density, internal soil strength, air permeability and oxygen diffusion	
Soil sealing			
Sealed area per total area		National targets to achieve No Net Land Take	

Source: Soil monitoring in Europe Indicators and thresholds for soil quality assessments Version 24, September 2021 for review. EEA ETC/ULS Report 2021. Editors: Rainer Baritz (EEA), Gundula Prokop and Marco Trombetti (ETC/ULS)

Table 3 Metadata sources

	Albania	**Bosnia& Herzegovina**	**Kosovo**	**Montenegro**	**North Macedonia**	**Serbia**
Nutrients	Publications National reports and statistics	Publications National reports and statistics	Publications National reports and statistics	Publications National reports and statistics	Publications National reports and statistics	Publications National reports and statistics
Organic carbon	Publications	Publications	Limited data	Publications, UNCCD reporting	Publications, FAO funded project	Publications, national funding
Erosion	Publications	Publications	Limited data	Publications national research projects	Publications national research projects, FAO funded project	Publications national research projects
Compaction	No data	No data	No data	Limited data	No data	Limited data

Pollution	EEA reports, national reports, UN reports, research publications	EEA reports, national reports, UN reports, research publications	EEA reports, national reports, UN reports, research publications	EEA reports, national reports, UN reports, research publications	EEA reports, national reports, UN reports, research publications	EEA reports, national reports, UN reports, research publications
Sealing	Publications, national statistics	Publications, national statistics	No data	Publications, national statistics	Publications, national statistics	Publications, national statistics
Desertification	UNCCD reporting	UNCCD reporting	Not an issue	UNCCD reporting	UNCCD reporting	UNCCD reporting
Soil biodiversity	No data	No data	No data	No data	No data	No data

It is suggested that apart from national data sources innovative proximal and remote sensing and monitoring techniques should be further developed to allow rapid but accurate measurements.

Some recommendations for the use of soil health indicators for soil monitoring

National soil surveys programmes should be launched without delay

The Western Balkans countries are relying on obsolete soil data for soil assessments and monitoring. This has created a considerable gap between the status of soil health in the region when compared with the EU countries. Therefore, there is an urgent need to embark in a soil monitoring system that must be robust and able to provide reliable data for updating soil policies, which are also required by the Sofia Declaration for the Western Balkans. Inspiration should come also from the LUCAS soil survey when these data would be available, and the second round of LUCAS should be also implemented.

Soil health indicators must be clearly defined and comparable throughout the region and compatible with those implemented in the EU member states.

This would require that the definitions of indicators, and how they are determined (sampling, analysis, evaluation method). These indicators should be identical between the countries and in line with LUCAS Soil sampling procedure. Having said that, national soil survey programmes could implement standard soil survey procedures that better fit national conditions.

Soil monitoring should provide the necessary framework for drafting policies for soil protection and management.

Reliable data must be generated to depict spatially explicit policy-relevant indicators for developing harmonization procedures, and for enhancing the region-wide use of harmonized indicators. The resolutions of the corresponding indicator maps will depend on the national and regional plot densities, but they should be INSPIRE compatible. The establishment of a regional soil information system should be encouraged.

A region-wide network of soil scientists must be established

The number of soil scientists in the region is declining rapidly and this would create severe problems soon. It is strongly encouraged the establishment of the Western Balkans Soil Partnership in close collaboration with European Soil Partnership, Alpine Soil partnership, GSP, JRC and all activities to be launched in the context of the Mission A Soil Deal for Europe. The Western Balkans soil scientists should be integral part of all these initiatives and developments.

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