

Report for Zasavje post-mining region (SI)

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1. General information about the selected region

The Zasavje NUTS 3 region is located in the central part of Slovenia (Fig 0.1), between the capital city of Ljubljana and Celje, the 3rd largest city. It is the smallest Slovenian region in area out of 12 regions (485 km²) and the second smallest in terms of population (56.942 in 2022, 2,7% of the whole of Slovenia; Statistical Office of the Republic of Slovenia, 2023). The region entails four municipalities: Litija, Zagorje ob Savi, Trbovlje and Hrastnik (in Slovenia there are 212 municipalities altogether). Geomorphologically, it is part of the Posavje hill, a pre-Alpine area, traversed by the Sava River and its tributaries.

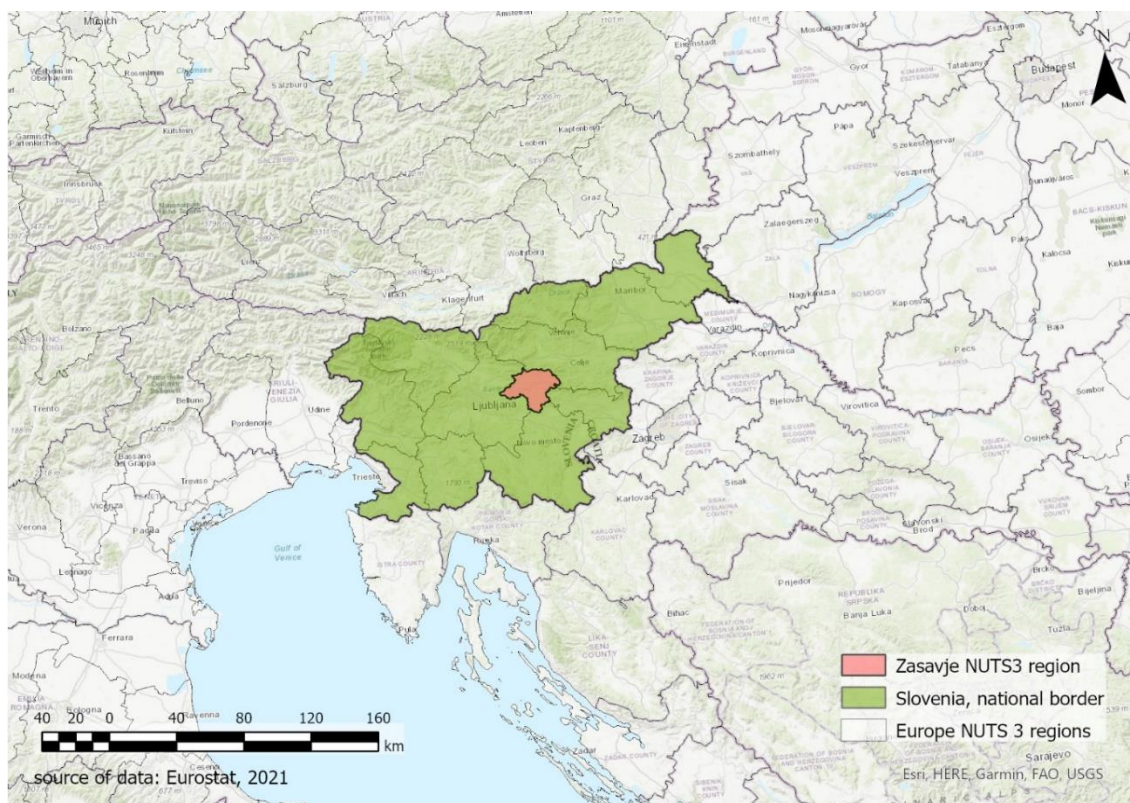


Figure 01: Location of the Zasavje NUTS 3 region (Source: Eurostat, 2021).

In Annex A, more detailed information on the region can be found. Below in Table 1, an overview of the general information about the Zasavje post-mining region is given.

Table 1: General information about Zasavje NUTS3 Region

Dominant land use:	forest
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Secondary land use:	grassland
Climatic Zone:	Cfb, Temperate oceanic climate, without dry season and warm summer (Temperate continental, central Slovenia)
Soil WRB classification:	1. Cambisols, 2. Leptosols
Soil type:	Cambisols: Eutric, Dytric or Chromic Leptosols: Mollic, Rendzic or Dystric
Dominant topsoil texture:	Different Loamy textures (loam, silt loam)
Soil threat(s):	<ol style="list-style-type: none"> 1. Soil Contamination 2. Urban sprawl 3. Soil water erosion 4. Soil acidification 5. Destruction of the surface
Stakeholders:	<ul style="list-style-type: none"> • municipalities Zagorje ob Savi, Hrastnik, Trbovlje and Litija, specifically departments, responsible for spatial planning – land use or environment • national government (Chamber of Agriculture and Forestry of Slovenia, ministry, responsible for soil - Ministry of the Environment, Climate and Energy, ministry, responsible for land use – Ministry of the Natural Resources and Spatial Planning) • Slovene Partnership for Soil • EC (setting EU soil policy and legislation) • land users: farmers, various industries incl utility companies and a company interested to set up a factory in the area • environmental NGO's • regional development agency, specific for the region: Regional Development Agency Zasavje • education institutions, like kindergarten, primary schools and high schools • research institutions and academia, e.g. University of Ljubljana or regional lab – Regional Technology center RTZC • general public
Policy Strategy:	On municipal level: municipal spatial plans with land use zoning; no policy on national level

Representative for regions in:	Post-mining region, Central European region
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2. Literature review, Stakeholders, Workshops and Interviews

In this section describe:

Literature and materials (State of the art of the knowledge in the region, research approach and main finding),

The stakeholders (Name of Institution and field of expertise),

Workshop material (presentations used, visualisations of results)

Preferably a transcription of the questions and answers of any interviews or surveys conducted.

Summary of answers of interviews and according questions.

Literature and materials

See [the reference list](#)

Identified stakeholders

The region Zasavje is one of the 12 development regions of Slovenia, consisting of four municipalities. According to this, we invited representative of the Zasavje regional development agency (in charge of preparation of the 7-year regional development programme and its implementation) and representatives of municipalities, mostly coming either from spatial planning and/or environmental departments. They are in charge of zoning, environmental quality monitoring (not standardised and not regular). Apart from this, the Agricultural-forestry chamber was present which distributed good practice, consults the farmers, have knowledge about the soil quality etc. More to this, a representative from the health sector was presented (a retired doctor from Trbovlje Hospital) who manages the programme »Healtyh Zasavje«, a representative of the company interested to set up a natural fertiliser factory in Hrastnik, environmental NGO's who shared a concern about the previous studies and mostly for more resilient approach to soil management. Representation from the Council for Energy highlighted the connections between the event's themes and energy production or consumption. Several other stakeholder groups were kept informed about the event through various communication efforts. These groups include multiple industries, development agencies, utility companies, and the general public.

Workshop material

The programme and presentations are sent as separate files. See these files:

_ Programme of the workshop (in English).

- _ Introduction presentation: project presentation, workflow, discussion questions, soil management etc. (Naja Marot, Blaž Repe)
- _ Presentation of the analysis in the region (soil characteristics and analysis – Blaž Repe)
- _ Presentation of the potential funding for projects targeting soil – Martin Šikovc

Workshop conclusions

A workshop on soil quality and soil management in Zasavje region took place on Wednesday May 17th 2023. It took place at the premises of the Regional Development Agency Zasavje and was attended by about 15 participants representing various organisations, including three out of four municipalities in Zasavje (mostly representatives of planning departments), public institutions, e.g. Chamber of Agriculture and Forestry of Slovenia, private actors and companies. It was a productive and informative event that brought together individuals with different skills and experience in the field of soil and soil management. The workshop was divided into three parts addressing key aspects related to soils and soil management.

1. The workshop started with **an introduction to the project and the Soil Mission**, followed by a comprehensive presentation of the current state of soil in Slovenia and the Zasavje region. This part set the scene for an interesting round of discussions in which participants shared their insights on existing challenges and opportunities related to soil management in the region. These include missing data and the absence of continuous, standardised monitoring of soil quality.
- 2. Focus on soil management:** The second part of the workshop highlighted national soil management approaches, complemented by an overview of currently existing local practices. Valuable information was also presented from interviews conducted prior to the workshop. This segment was followed by another round of discussions aimed at identifying potential projects, actions and collaborations to improve soil management practices.
- 3. Conclusion and next steps:** In the final part of the workshop, each group presented the results of their discussions and highlighted key lessons and proposed "next steps" for improving soil management in the region. These include the establishment of monitoring, the exchange of good practices in soil management, more sustainable management of degraded areas and raising awareness on the topic. Importantly, the workshop also aimed to identify a potential "living laboratory" institution using the existing soil analysis laboratory in the region.

Summary of the workshop discussions

1. Are the findings of the soil quality analysis valid? Is there anything else you would like to add in regards to the characteristics of the soil in the region?

The first main finding of this part of the workshop is the lack of knowledge about soil and soil management. The findings relating to soil quality were confirmed, and the presence of heavy metals - cadmium, titanium, lead - in wild game tissue, which had been identified some years ago, was also mentioned. Some uncertainties were expressed regarding the soil situation, including the issue of groundwater quality control in the mines (surface intrusion this year) and also the processes affecting the soil after mine closure. Concerning the analyses, the need to establish monitoring,

especially in severely degraded areas, was expressed, while it was also mentioned that soil degradation problems are not often mentioned by the population.

2. Which economic and other activities in Zasavje have the greatest impact on soil quality and how?

The following economic activities have been highlighted by municipality as having had an impact on soil quality in the past, and some still do today. These are:

- Hrastnik: mine, quarry, chemical products factory, Hrastnik glassworks
- Trbovlje: Thermoelectric power plant and Trbovlje Machine Works in the past, Lafarge Cement Works with quarry, mine
- IGM Zagorje building materials industry, Zagorje mine in the past
- Litija: in the past spinning mill, lead smelter
- Kresnice: IAK Kresnice limestone industry, quarry
- Agriculture - marginal role (walnut plantations, organic farming, crops in Litija field)

In addition to economic activities, dissatisfaction was also expressed with state policy: firstly, the lack of control over the management of mining areas, and secondly, the ineffective guidance of spatial development through municipal spatial plans. It was mentioned that there was a need for expert bases for mine areas and an assessment of the importance of soil as a resource for development.

3. Do you know of or are there practices in the region that have a positive impact on soil quality?

The opinion was expressed that there are no preventive measures affecting soil quality, mainly remedial measures for damage caused. The following remedial actions were mentioned:

- Remediation of the soot landfill in Hrastnik - the valley filled with soot has been reclaimed with walking and horse riding trails and a solar power plant has been built.
- Remediation of the tailings dump in Zagorje - a recreation area with an airstrip and municipally owned walking paths.
- Hrastnik - plans to expand a solar power plant in a former open pile.
- Reclamation of the Trbovlje mine extraction belt - surface water control, recreation areas and two ponds created to serve as water retention basins or to regulate water runoff from the hillside.
- Trbovlje - backfilling of the mine's day pile and conversion into a business zone - expansion of urbanisation into functionally degraded areas, problem with terrain stability.

The Fair Transition Fund, which can be used to prepare degraded land for investment and construction, also presents opportunities for further rehabilitation. In addition to rehabilitation measures, mention was also made of sewage treatment plants and subsidies for the replacement of heating appliances for the socially disadvantaged, as well as grants from the EcoFund for the change of heating source. In the field of agriculture, organic farms with controlled production adapted to the conditions in the region are good practice, and the problem of beekeepers who are unable to obtain organic certification due to pollution was highlighted. From the point of view of the population, the work of doctors and, in particular, the "Health for Zasavje" project, which aims in particular to raise awareness of the environment and the importance of a healthy lifestyle for children and young people, were mentioned as good practices.

4. What do you think will happen to the soil in your region? E.g. continued building on agricultural land, further degradation of degraded areas, revitalisation of degraded areas, etc.

As regards future soil development, it was first mentioned that a certain proportion of land would certainly be built on, even if rules for change of land use from agricultural land to building land had been tightened. The suggestion was made that the construction of shopping centres, which occupy large areas of Zasavje's towns, should be limited. A certain proportion of degraded land could be brought back into use through appropriate rehabilitation and revitalisation, and doubts were expressed about the current selection of plants and the lack of maintenance and supervision of the transformation process of these areas. Attention should also be paid to climate change, such as erosion and landslides, which are the result not only of summer storms and floods but also of ill-considered interventions. The quarry in Kresnice was particularly highlighted, which should be slowly greened, and the intensive spread of Japanese knotweed along the Sava River in the Kresnice area is also a cause for concern. In the field of agriculture, the participants considered that the overgrowth of agricultural land on slopes would continue, along with the spread of forest of questionable quality. A large number of farms will also be abandoned and pastures will be overgrown. One participant pointed to the possible emergence of new crops such as sorghum and hemp instead of maize.

5. What projects does the Zasavje region need to improve soil quality?

The projects address the following themes: soil management policies, spatial planning, monitoring, awareness-raising among different target groups (youth, children, stakeholders, residents), agricultural practices, transport, waste management and gardening. In the policy area, it was pointed out that adequate soil legislation should be adopted at EU level, but that municipalities should also manage space strategically and programmatically - the focus should be on ensuring soil quality. In the area of construction, guidelines should be revised to include the possibility of green roofs and the use of natural materials.

Adequate regional monitoring should be established to monitor soil conditions and keep the population informed on an annual basis. The knowledge of municipal officials in soil management should also be improved and activities such as soil treatment in school gardens should be included in education as part of the core subjects. Even in kindergartens, children can learn about what soil is and what can be produced from it through raised beds, orchards or other learning polygons.

In the field of agriculture, a number of measures have been highlighted, such as new crops in the fields instead of maize, hemp and sorghum, which are good soil cleaners; the reintroduction of small livestock, goats and sheep for better soils and lifestyles, the sharing of machinery, especially tractors, and cooperatives, community composting plants, etc. It is necessary to establish allotment areas, with clear conditions for cultivation, which must, for example, be free of plant protection products. Urban forest and orchards could also be established, with a forest management plan and professional maintenance.

As a transport measure, the construction of a cycle path was highlighted as a contribution to reducing soil pollution. More efficient collection and disposal of waste and reduction of packaging could also contribute to soil quality.

6. What are the biggest barriers to sustainable soil management in your region?

Politics or political pressure and lack of control, political will and misleading public information were highlighted as the main obstacles to sustainable land management. Stricter criteria on soil management, especially on pollution, and more participation and networking of stakeholders (farmers, decision-makers) in the region are needed. Building guidelines should be more sustainable and allow for the introduction of green practices and materials. Financial constraints are certainly an obstacle, as there is most often no money at municipal level to ensure good soil quality. The lack of knowledge, both for the management of water protection and erosion areas, as well as, for example, for the management in case pollution is detected, was also repeatedly highlighted. Those who carry out the measurements most often do not provide clear instructions on how to mitigate the adverse impact on soil quality. In Zasavje, the lack of space for all activities due to the steep terrain and the otherwise built-up nature of car parks, which are treeless and thus face inadequate drainage, is of course also a general problem.

7. Who do you think should take the lead role in soil management?

The state:

- Key responsible actor for the soil management strategy for the past and future decades through continuous monitoring and supervision
- Monitoring of degraded soils - provide data from Ministry of Agriculture, Forestry and Food, Ministry of Natural Resources and Spatial Planning
- Permanent soil service to ensure continuity of soil monitoring, not just act as an inspectorate

Municipalities and public institutions:

- Governing body - primary role is to set soil management policy through spatial planning acts, long-term strategic direction of soil management
- Active coordination of actions such as farmers' markets, coordination of producers
- Allocation of funds to associations, NGOs for activities such as local public involvement in tree planting, competitions for the most organic garden, etc.
- Continuous actions and targeted use of funds to implement projects on the ground with professional support and operational assistance
- The Regional Development Agency, on the basis of the regional development agreement, implements the concept of green infrastructure and carries out projects linked to the concept.

NGOs:

- Initiators and implementers of continuous actions, applications for calls for proposals for co-financing revitalisation projects
- Professional and operational support for project implementation

Schools:

- The role of the food consumer - promoting the procurement of school meals from local producers (administrative skills and networking with farmers required)
- The role of an educational institute on soil and soil care

Regional Technology Centre Zasavje

- As an institute to set up a living laboratory (currently not enough staff for this)
- Advice on soil management, demonstration of good practices, public information

Independent institutions

- Carrying out independent analyses and research, on the basis of which guidelines for soil management are drawn up and action needs identified
- Institutions to prevent the implementation of harmful practices and projects

Overall, the workshop served as a platform to raise awareness about soil as an important natural resource and to promote dialogue on the implementation of effective soil management practices in the mining-affected area. The workshop can be considered a success as it brought together a diverse group of stakeholders to discuss the current status and future options for soil management in the region and the country. The collaborative atmosphere and insightful discussions laid the foundations for meaningful progress in this area in the selected region. With future steps, including dissemination of the workshop results and finalisation of the regional profile, we are committed to facilitate positive changes in sustainable soil management practices in the region.

Summary of the conducted interviews

The interviews were conducted in the first half of May 2023 with four representatives of municipalities in the Zasavje region (Hrastnik, Trbovlje, Zagorje, Litija) and one representative of the Chamber of Agriculture and Forestry of Slovenia. The answers of the interviewees are aggregated into 12 key thematically summarised questions, to which the answers are given by individual interviewee.

Current soil quality in Zasavje is relatively poor, with pollution as the main driver. Contamination comes mainly from mining activities and industry (cement, furniture and plastics processing). The steep slope and avalanche prone nature of the area also affect soil quality. However, soil quality studies are not systematically carried out in the area, except for individual analyses of heavy metal content in vegetables and in the vicinity of public institutions (kindergartens). The area takes action in bettering the soil quality by carrying out clean-up campaigns. Priority is also given to the renovation of degraded mining areas and to the improvement of recreational facilities (between Hrastnik and Trbovlje).

Over the last 50 years, land use has changed in certain areas. In particular, coal mining (2012) has ceased, so we have a large part of degraded areas after mining. In addition, the Trbovlje Thermal Power Plant have had a major impact on the soil (indirectly). The former reduced emissions of dust particles and also heavy metals by introducing a desulphurisation plant in 2006 and the latter by switching to gas in 1993. However, this is still evident in the soil centuries later, so that certain heavy metals, such as cadmium, have exceeded the limit value almost everywhere. The most degraded areas are mine sites and tailings disposal areas, and waste dumps. In all municipalities of Zasavje there are areas of degradation due to mining and waste disposal. There are several sites of the Trbovlje Cement Plant waste disposal, due to the Trbovlje Thermoelectric Power Plant and mine waste.

Given that the soil is not heavily contaminated with heavy metals, it can be used for gardening, whereas agriculture is limited mainly by the geography of the area. The drinking water supply is adequate, with many good quality water wells. Much of the area is forested (except for the valley itself, where there is a settlement), which is important from the point of view of CO₂ uptake.

Agriculture is present to a lesser extent, but it is not intensive, so there is no negative impact on the soil as there is in areas with intensive farming. Air pollution has decreased in recent decades due to the closure of factories and energy industries.

Expertise and awareness-raising are needed at all levels of education from primary to higher education, awareness-raising in specific sectors and constant control and supervision by the authorities. This information should be provided by the state, the study should be uniform for the whole country. Additionally, systemic funding could promote better management with soil and encourage municipal authorities to conduct actions and projects related to soil specifically.

3. Soil needs reporting based on the *Drivers, Pressures, States, Impact, Response Framework*

Drivers

Biophysical driver(s) (700 Words)

The most important biophysical elements that significantly influence the soil in the region under study are the parent material (which determines all the important properties, including thickness, i.e. depth, pH value, nutrient supply, buffer capacity to neutralise pollutants etc.), topography (mainly through slope, it directs the action of water and hence erosion and landslide processes, and in particular the thickness of the soil), and water (together with relief, water action determines soil thickness, erosion processes on slopes, and has created floodplains in valleys by filling, where agricultural production is possible). Land use with vegetation cover protects the soils from (too) strong erosion processes.

Parent material and topography

The varied rock structure of the area means that the surface is highly dissected. Due to the different rock compositions and the high proportion of impermeable and less weathering resistant rocks, the surface of the region is highly dissected and has numerous gullies and valleys. Slope processes are still active reshapers of the environment and can be observed on a larger scale during natural disasters (landslides). The average altitude of the study area is 532 m, which is close to the national average (557 m) (Fig 1).

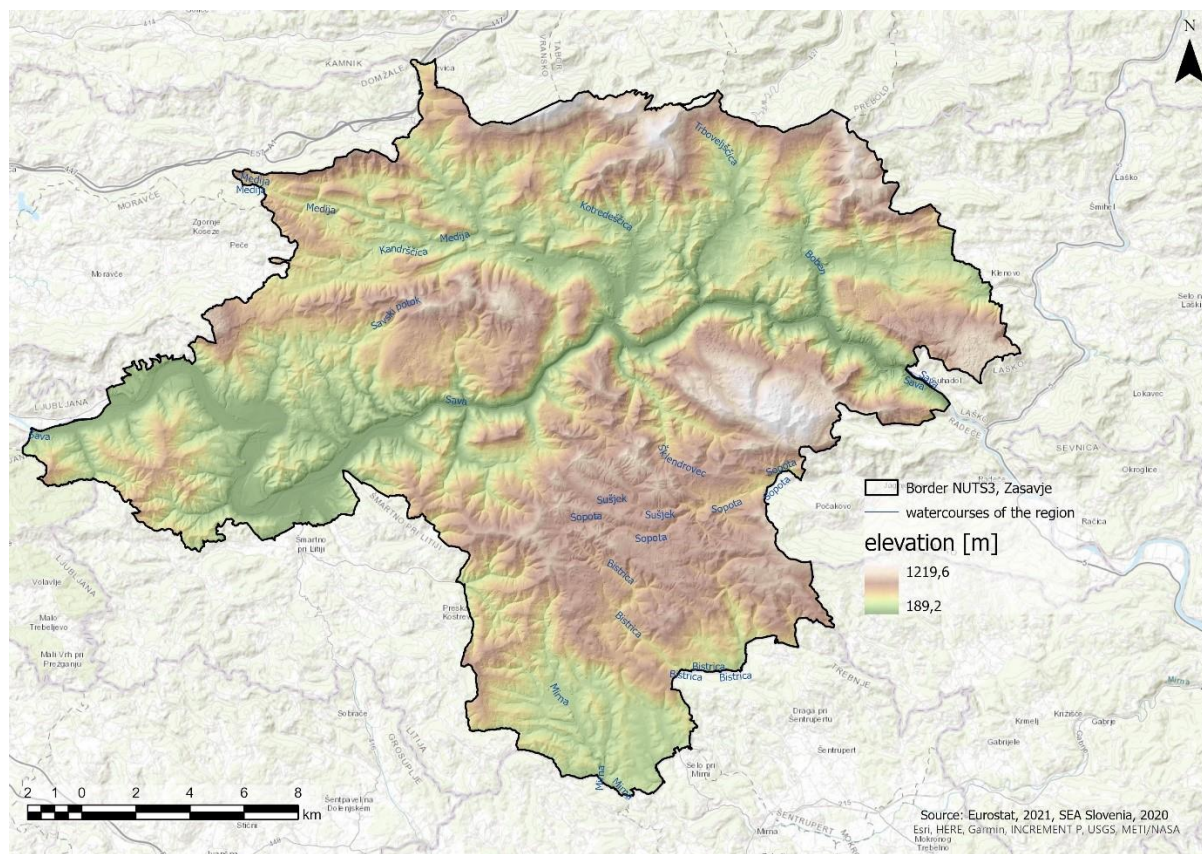


Figure 1: Elevation of the Zasavje NUTS 3 region.

The predominant slope is between 20° and 30° (34.5%). Only 16.5% of the area is below 10°, which is due to narrow valley bottoms. These areas are usually forested, as they are deep gorges and narrow river valleys unsuitable for building (Fig. 2).

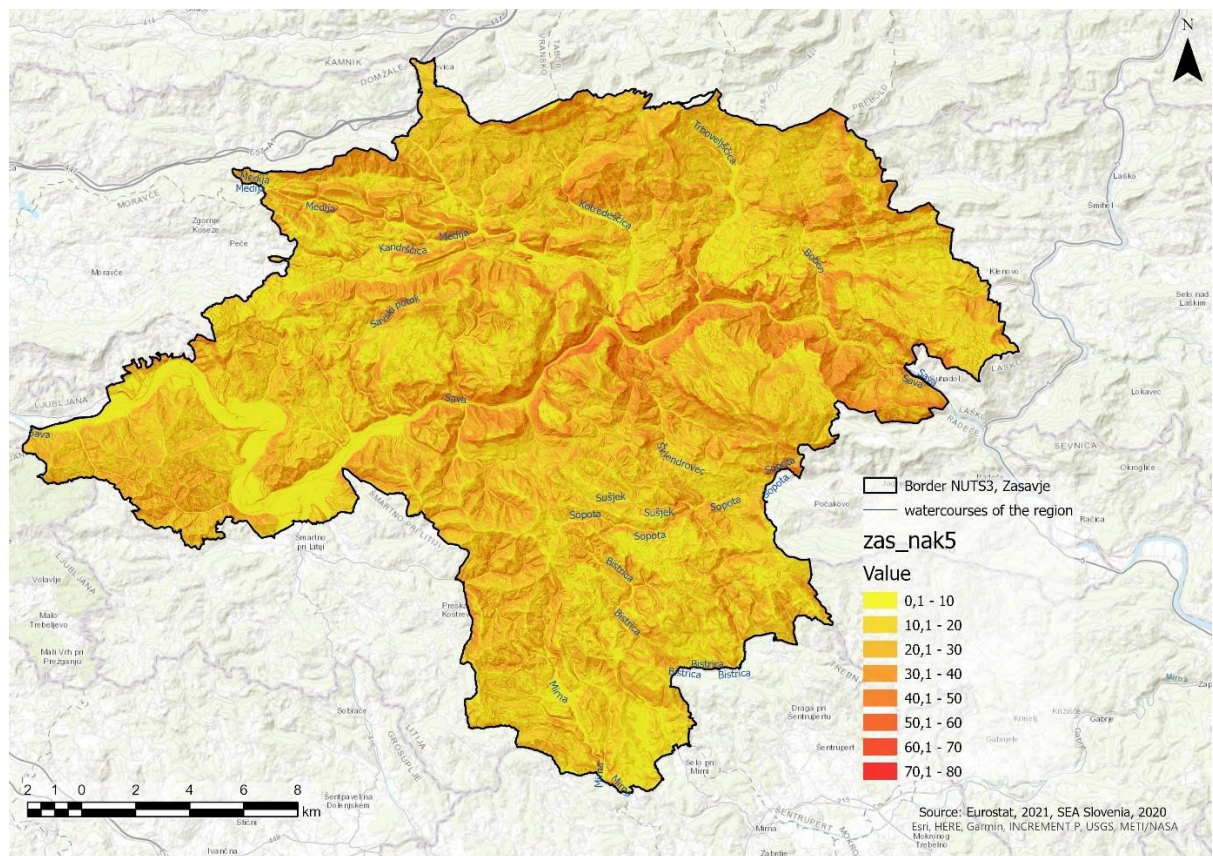


Figure 2: Slope inclination of the Zasavje NUTS 3 region.

Due to the above-mentioned natural factors, e.g. step relief, erosion, the soils of the Zasavje region are poorly suited for agriculture. This fact is nicely reflected in the soil number parameter, which is a synthetic indicator of suitability for agriculture (the higher the number, the higher is the suitability for agriculture) and considers the following parameters: geological substrate, soil development or soil type, soil texture, soli skeletal particles, depth, climate, slope gradient, machinability, rockiness, floodability, aridity, slope aspect, openness to wind and shading of the surface. The region is dominated by low and medium soil numbers, which together comprise 95% of the total study area. Higher values occur in a very scattered manner, in small patches along some watercourses, which are often seriously threatened by the torrential nature of the rivers (Figures 3 and 4).

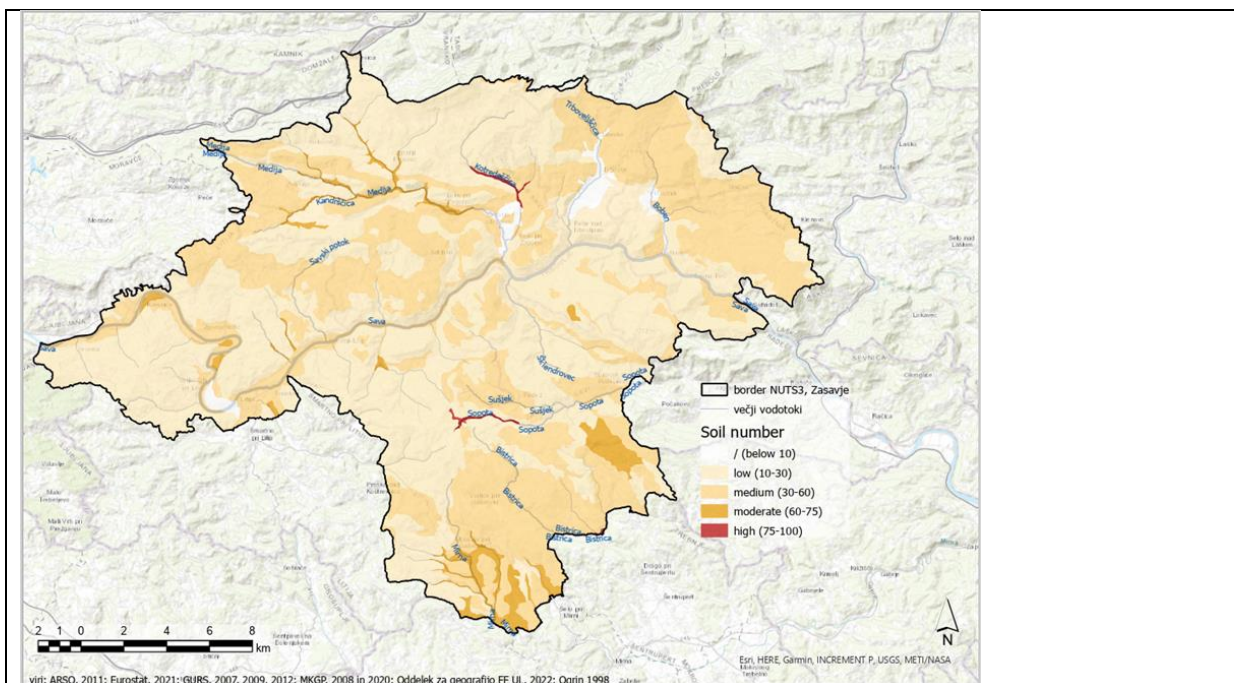


Figure 3: Soil number of the Zasavje NUTS 3 region.

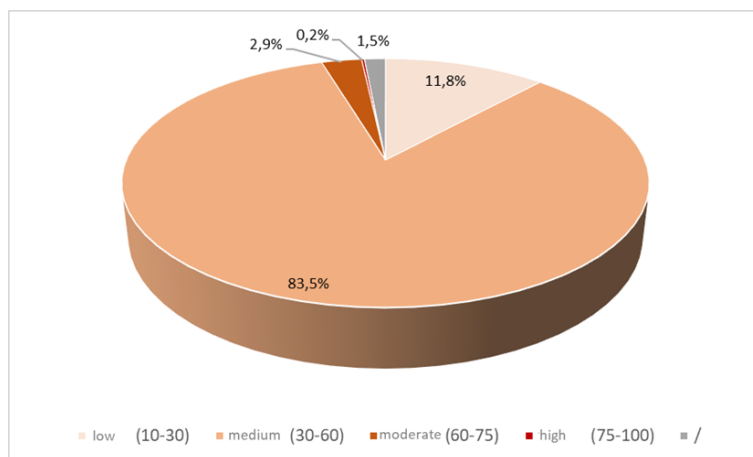


Figure 4: Soil number percentages of the Zasavje NUTS 3 region

Since neither the parent material nor the topography will change in the future, soils will not change in this respect. But they will play a further and very important role in the development of the region. Soils will continue to be poorly developed and unsuitable for agricultural production.

Waters

The Sava is the main river that crosses the area for a length of 47.3 km. The main watercourses flow in a north-south direction on the left bank and in a south-east-north-west direction on the right bank. The longest left tributary is the Medija (18.6 km). The right tributaries are much shorter. Most of the tributaries of the Sava in the area of the rugged Posavje hills are classified as torrential. The most dangerous of them are the Medija and the Boben. They rise during storms, pour over narrow flat areas and tear up the banks. Regulation of the torrents took place (and still take place) mainly in the valley areas, where channels were channelled, and floodplains were cleared to make room for urban sprawl. The valley sections of the Medija, Kotredeščica, Trboveljščica and Boben torrents were regulated, but only locally and unsystematically. Erosion processes and the destructive power of

water bodies will continue to be very negative factors as soil degrading elements in the region. With the expected climate changes (expectation of a higher number of thunderstorms), the torrential character of watercourses will be intensified. In the past, the Sava was classified in the worst quality class, but after the rehabilitation of industrial plants and coal mines in the region, the situation has improved considerably. Previously, heavy metals, hydrocarbons, phenolic compounds and mineral oils were present in the river.

Land use and forests

The area is 67.5% forested, which is above average for Slovenia. In addition, former man-made grassland areas have been intensively vegetated over the last 100 years. The exceptional importance of the vegetation cover is reflected in the fact that 8.3% of the region or 12.4% of all forests are classified as protective forests, which must not be cleared due to the strong erosion potential. Forests have been severely damaged in the past (air pollution, soil acidification), but their health is expected to improve in the future, as most negative trends have been stopped or at least significantly slowed down. The region's forests will therefore protect the soils (especially from soil erosion) better than they did in the past.

Socioeconomic driver/issue: (700 Words)

The region could be classified as a post-industrial region, more specifically, a post-mining region. The mining started in year 1755 with the discovery of the brown coal in Zagorje ob Savi, and 50 years later, in 1805, in Trbovlje as well. At the beginning of 20th century Zasavje region was among the most development areas of Slovenia, the mine bringing the prosperity and amenities for the population (hospital, schools, etc.). In the 70's of the 20th century the polycentric approach was pursued by the socialistic government, meaning that industry was established according to employ the whole population in working age, but especially the female working force. The existing industry which has been before predominantly connected to the mine, e.g. electro technical production, glass, wood processing, chemical industry, cement production etc., was complemented by textile and shoe making factories.

The brown coal mines were crucial economic development drivers up until 1995 when the first closure process started in Zagorje ob Savi's mine. The longest production was running the Hrastnik mine, namely until 2012. Apart from losing a large amount of jobs in mining, the region also needed to face an economic transition after year 1991. In the period from 1988 to 2014 the number of employed in the mines went from 3.820 to only 178 (Marot, 2012, after Ivančič Lebar, 2004; Černe and Leskovar, 2009). It took the region approximately 20 years to reset, and now the prevailing sector according to the regional gross added value are services (retail, health, real property business) – 65%. Industry still contributes to 31,7% of the gross added value; agriculture plays with only 3,3% a rather unimportant role (Regional Development Programme, 2021).

While the peak of unemployment after year 1991 was 16% in 2001 (for Trbovlje municipality 19%), lately the unemployment numbers are low – underneath 5% (Fig. 14). Especially, in Trbovlje, a high-tech sector has been blossoming, with globally known companies such as Dewesoft, Chipollo etc. These companies are important due to the knowledge production and know-how, however, they do not employ a great number of people.

The region is now a days not able to provide jobs for its population, therefore, around 40% of the population has a daily commute to other regions for work, mostly to the Ljubljana urban region (SURS, 2023). From previously established industries the following industry remains: glass factory in

Hrastnik, Chemical factory in Hrastnik (both considered as potential polluters of the soil), Syporex (porobeton) production in Kisovec and ETI in Izlake. In the Litija municipality there is textile industry and a business zone, however, without any environmentally damaging industry, except for the quarry in Kresnice.

Both, in the interviews and in the workshop, it was emphasized numerous times that national and local politics (or its lack of) are also important drivers that impact soil quality and management. For now, the only documents guiding the soil management are the national law on agricultural land (restrictions to build on such land) and the local municipal plan defining the strategic objectives and the zoning of the land.

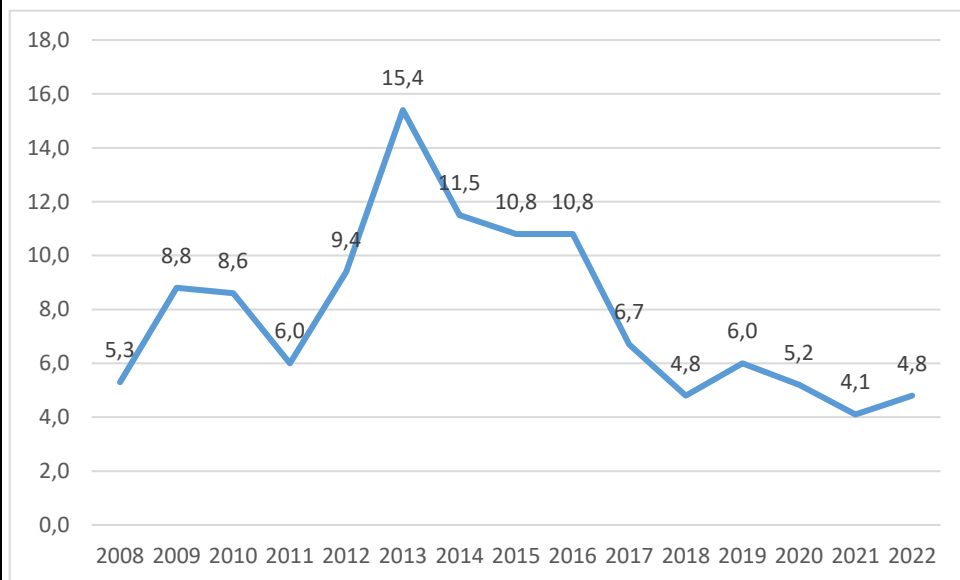


Figure 5: Unemployment rate in the region, 2008-2022 (SURSb, 2023)

The mines have not only left a significant footprint in the economy, but on the society as well. The mining traditions are well presented and cultural heritage of that era well maintained. Although the potential of technical and non-material heritage is high, it has not been valorised for the purpose of tourism development until recently. On one side, due to the poor image of heavily polluted, the so-called black region and the lack of tourism infrastructure (e.g. accommodation, tourism information centre etc.), the tourism has never really taken off; on the other, the outdoor activities in the pre-alpine area have been attracting more, mostly, daily visitors to the region lately (8.892 arrivals in 2022; SURSa).

The mining activity in the past and the accompanying industry have been recognised as the most relevant socio-economic driver in the region to impact the soil and its quality. Due to the sediments of the heavy metals in the soil this influence will stay, despite that the source may not be active anymore.

For the future, overall, we could foresee the influence of mine on the socio-economic development will further deplete and in 30 years the region will establish itself as fully services-oriented society.

Pressures (700 Words)

The pressure on soils comes from the degradation processes themselves. Interviews with individual experts revealed that, in addition to the degradation already mentioned, traffic is also problematic as the main culprit of NO_x pollution, unregulated sewage networks and illegal waste dumps. Litija was the only municipality (with the highest percentage of flat land and the highest proportion of agricultural land) to indicate that agriculture, which uses too much fertiliser and pesticides, is also a problem. Of all the known negative processes, the following are the most pronounced in the region:

1. Water erosion of soils and other negative slope processes (landslides).

The region has a high hazard potential from negative slope processes. This means that the natural conditions themselves (which are not directly influenced by humans) are such that erosion and landslides are constantly present. These include high, even extreme, slopes, abundant rainfall, rocks susceptible to slope processes and shallow soils. On the positive side, however, most of the entire region is unsuitable or poorly suited for anthropogenic land use, and forests remain relatively well protected. The greatest pressure therefore comes from activities that potentially reduce forest cover on steep slopes:

- Reckless and unprofessional clearing of forests for timber production.
- Damage to forest vegetation through pollution (the decline of conifers due to sulphur compounds and acid rain as a result of electricity production at the Trbovlje thermal power plant).
- Damage to vegetation from surface and underground mining (quarries, mining-induced ground subsidence).
- Construction of roads and buildings on steep and unstable slopes leads to changes in groundwater flows, stresses and strains in rocks and soils and, of course, re-vegetation of the area.

2. Toxic pollution from polluted air and water.

The region is a traditional mining and industrial area (mining, electrical, engineering, chemical, glass and wood processing industries). The region is mainly affected by past and long term regular or occasional excessive pollution, old environmental pressures, degradation of landscape forming components (water, air, soil, vegetation, relief) of most of the side valleys and nearby uplands due to coal mining, energy, industry and urbanisation and road traffic. Environmental pollution from air emissions, sewage and various wastes, as well as land degradation from coal mining, exceed the very limited self-purification capacity of the environment in many areas. As a result, excessive concentrations of heavy metals in soils, plants and wildlife tissues occur repeatedly. The excessive pollution of the watercourses (the Sava and especially the left tributaries), the long-standing inadequate treatment of municipal and industrial wastewater, the inadequate regulation and the torrential character with occasional floods have also led to the accumulation of toxic substances in the watercourses over the years, especially in the floodplains. The soils in the wider area continues to be polluted by dust and soot particles as well as heavy metals due to immissions from the air (thermal power plant, cement factory, incinerator). Contamination is rather diffuse (there are no particularly conspicuous sites) and fairly evenly distributed across the entire region.

3. Changes in the pH value of the soil.

The area around the Trbovlje TPP is particularly characterised by the durability and wide spread of soil degradation caused by the air emissions. The construction of the tall chimney has virtually eliminated the emission pressure of the Trbovlje TPP plant on the regions' ecosystem, but has increased it in the Kumljan region and the wider regional and

interregional environment. Sulphur pollution in the region, especially on siliceous soils, was further reduced by the lower pH values. Not to be forgotten are the power plant's ash dumps, where it was found that soils containing more ash react weakly alkaline and have a pH about one pH unit higher than natural soils.

4. Residential and economic land use.

As is typical for Slovenia as a whole, the pressure on the flatter and shallower soils in the region under consideration is markedly strong. Given the very limited possibilities for human activities (settlement, industry and infrastructure), most of the land in the habitable area which is the most suitable for cultivation has long been used up. The region is characterized by functionally degraded areas due to economic land use (mining and industry). Abandoned industrial sites and brownfields are common (35 in total), symbolizing the decline of once-prominent industries such as coal mining and metallurgy. The degraded areas face environmental concerns due to the historical industrial activities, resulting in pollution and degraded landscapes. Underground mining and surface extraction of rock material in individual quarries have also had a negative impact on soils. In the first case, it is soil subsidence or spoil heaps, in the second case, a wound in the surface left without a protective soil layer. Therefore, as the region continues to develop, the pressure on the flatter parts of the region will increase and there is a risk that it will be completely overbuilt. (Fig. 15).

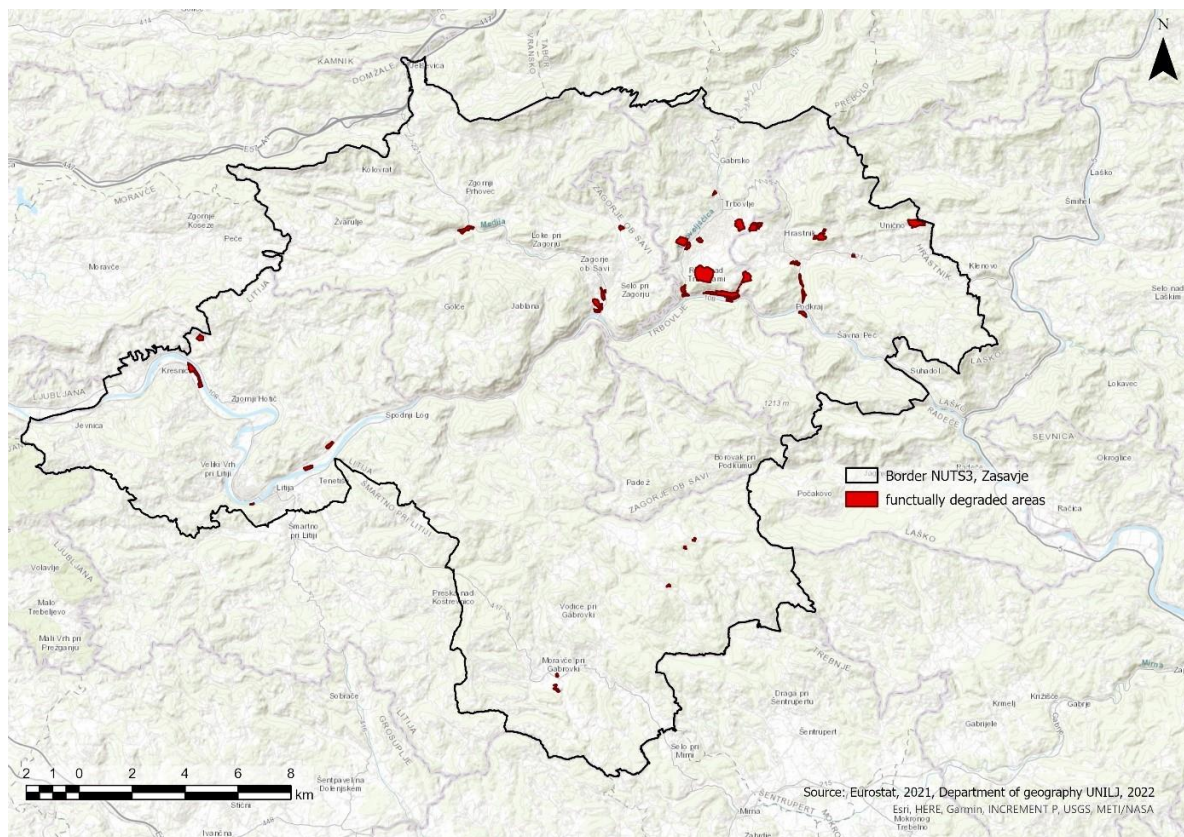


Figure 6: Functionally degraded areas of the Zasavje NUTS 3 region.

5. Invasive alien plant organisms

Alien invasive species, especially plant species, can proliferate or colonise vacant, degraded, abandoned, bypassed and other disturbed or ruderal areas. These significantly alter natural and semi-natural habitats, their environmental characteristics and water and

soil conditions. In terms of nutrient and organic matter uptake, nutrient and water withdrawal, and other aspects, they also have a negative impact on the soil.

State (700 Words)

Problem statement of biophysical situation:

The main towns in the region are Litija, Zagorje ob Savi, Trbovlje and, Hrastnik which are all located along the Sava River. As stated above, the region has a rich history of mining and industry, with coal mining being the most important industry in the past. Today, the region is transitioning to a more diversified economy with a focus on technology and innovation.

The region is characterised by a marked duality, reflected in virtually all biophysical elements, which plays a key role in the state of the environment and thus of the soil. The duality in the region is most evident between

- the mountainous part:
 - higher altitudes, steep and rugged topography, hard and consolidated rocks, rapid runoff from watercourses leaving the area, area above the temperature inversion zone, better weathering, shallow soils, above average forest cover, predominant indirect environmental and soil impacts;
- the valley part:
 - low elevations, flat topography, softer and unconsolidated rocks, inflow of water from uplands, area below the temperature inversion zone and poorly weathered, thicker soils, above average anthropogenic use.

It is also the result of environmental pressures from humans who have adapted to the natural conditions and concentrated their activities directly on the valley bottoms. In the latter, the (strongly negative) impacts on the environment and the soil are very direct and concentrated. In the elevated parts they are less obvious (hidden), indirect and above all much more diffuse.

The state of soils in the entire region is, on the one hand, a direct reflection of natural factors (parent substrate, surface, climate, water, time and also vegetation cover) and usually reflects the predominant and obvious naturally acquired characteristics. On the other hand, soils, especially in the valleys, are clearly a reflection of human activities. In the sparse and rare areas where humans have cultivated and still cultivate some subsistence foods, the soils are partially modified (arable horizon on the surface, with increased aeration and less organic matter). These extremely scattered micro-sites of the allotments may have completely modified soils with above-average levels of nutrients, organic matter and biodiversity due to very careful use. In most other parts of the valley, the soils are completely transformed. Urban uses (green spaces, parks) predominate, where the soil is covered with semi-permeable or impermeable materials and layers (asphalt, concrete, sand, mining, energy production, industrial production residues).

When it comes to the state of the region's soils, pollution should come first, especially in lower valley parts, near the industrialized areas. The region is generally considered to be more polluted than the rest of Slovenia. Unlike the other regions, pollution has continued despite the increased environmental standards at the turn of the millennium and, most importantly, little has been done to correct old pollution and improve the situation (e.g. incineration activities in cement plants). From the point of view of health protection and health promotion, the health of the region's inhabitants is more endangered by the state of the (polluted) environment than elsewhere in Slovenia. Most studies on environmental pollution have focused on air and water quality, where both direct pollution and its consequences are most evident. Studies of soil pollution show excessive contamination of soils with dust particles, heavy metals, including cadmium, mercury, chromium, etc., and long-standing soil contamination with sulphur compounds (Lobnik, Verščaj & Zupan, 1993; Repe, 2002). The heavy metals enter vegetation and waterways, as well as directly

into animals and humans. Levels are elevated throughout the region, more so in the valleys than in the backcountry of the mountains, but still quite scattered. There are certainly places where pollutant levels are excessively exceeded, but these were never recorded in the monitoring surveys. Soils have suffered particularly severe chemical damage from exposure to acidic sulphur compounds. As mentioned above, the pH has dropped by an average of one pH level (and more in some places), first in the immediate vicinity of the TPP and then in the wider region. This significant drop, especially on the originally acidic soils on the siliceous topsoil, has had a significant negative impact on vegetation. Following a gradual reduction in sulphuric discharges from TPP, a gradual improvement is expected in the future. However, the negative impacts in the soil, which were quickly reached (a few decades), are only regenerated (neutralised) for humans over very long periods of time (centuries).

Underground mining has also had a negative impact on soils, especially in the soil subsidence. In all cases, the surface is degraded and, in most cases, has been left to the succession of pioneer plants and/or invasive alien vegetation. The return to the natural, original state can be greatly facilitated and accelerated by humans, but this involves high financial investments and constant monitoring of the overgrowth process (control of non-native species). Therefore, the process is usually left to itself or it is done sloppily and unprofessionally (to minimise costs). Often physically poor (many stones or impermeable clay) or even (chemically or biologically) contaminated soil is applied, which greatly slows down the renaturation process or even stops it altogether. Especially on hard rocks and slopes, the process of returning to a natural state is very lengthy and can be measured in centuries or millennia.

Finally, the situation of slope processes is worth mentioning. The entire upland area is potentially highly vulnerable to water erosion and landslides. Fortunately, the vegetation cover is good and stabilises the soil relatively well. However, areas with softer, poorly adhering rock are already inherently extremely vulnerable to landslides. The bad news is that climate change will have a negative impact on forest cover, which may significantly increase the actual risk of slope processes.

Above all, human encroachment into this space is problematic. This is especially true for the construction of roads and various buildings, subsidence due to mining, abandoned quarries and unprofessional forest clearance (clear-cutting). The consequences of slope processes are visible in the whole region by frequently closed roads and endangered buildings.

Problem statement of socioeconomic situation:

Past mining activity was together with the on-going industry and energy production (brown coal thermos power plant active almost hundred years – 1915-2014) identified as the main driver of the soil quality and management. Among the biggest pressures of this activity, the removal of the soil was mentioned (open cast mines), followed by pollution of the soil via various resources (pollution of soil with heavy metals, including cadmium, mercury, chromium etc.). This pollution manifests itself by detecting heavy metals in the soil that have so far not been removed. In the past a calculation was done that approximately around 4 metres of soil (in depth) should be removed in order to establish again what the state of the healthy soil was. At the moment, post-mining activity also still influences the soil in the area with monitoring and management of the area (water retention and channels, grazing, planting of water retention and erosion prevention plants). However, it was mentioned in the workshop that this process has not been properly disseminated to the wider public. Further on, some of this land is being prepared for development, meaning that this soil will be eventually sealed/removed. As a good practice, one can mention the existing installation of solar power plants on two different locations: one is a former open cast mine, and

the second one coal fired power station fly ash, bottom ash and slag tap hill.

Among barriers is the lack of financial resources, both for the monitoring (municipalities depend on their own resources) and for the measures. One financial resource might be the Just Transition Funds, though the programme only supports measures if the land is prepared for construction but not for renaturation measures.

Another barrier is the policy making on the national level, as there is currently no national strategic document concerning only soil. Mostly, regulation concerning the soil is related to the agricultural land legislation (and limitation of its use), but no separate regulation exists for soil sealing or similar. Additionally, the politics and politicians as such were recognised as a problematic factor due to their lack of affinity towards the soil and land use in general. Politics, especially, on the local level is mostly investment oriented and has not shifted its focus on more sustainable practices.

In relation to this, also the strategic approach to soil management has been mentioned, in majority concerning the soil sealing activities due to the building activities. Although each municipality has a municipal spatial plan with identified zoning, zero land intake goal has not been identified yet in the region. In the last years, mostly shopping centres were built as “larger development projects”, one of them also on the former industrial site. There is still high demand for land with regards to the housings constructions as there is also interest for land for business purposes. Interviewees have mentioned this demand as one of the major challenges as how to prevent further soil sealing in the region, especially, since the politics is in favour of such development.

Among the biggest challenges for the future, stakeholders have identified climate change, especially the torrential showers, storms and heavy rain and their impact because of the unfavourable terrain and soil type, and mostly because no adaptation or mitigation policies have been put in place. The region is struggling with landslides and recuperating from already present damage, and this will only be magnified in the future.

Impacts (Words 700)

Overall, the impact on the soil in Zasavje is already extensive due to the physical and geographical characteristics of the region. The steep and rugged topography makes the soil less stable and shallow and, in combination with heavy rainfall, the soil is subject to landslides. On the other hand, the parent rock, which is predominantly acidic, makes the soil of sub-optimal quality for cultivation. Soil quality in the valley and along watercourses in the region has been severely affected by development and industry, which has resulted in the loss of the more fertile areas of the region, while mining in the area over the past decades has left areas of degraded soils due to opencast mining and tailings disposal.

The municipalities of Litija, Zagorje, Trbovlje and Hrastnik are situated along the river Sava, in the central part of the Posavje Hills, which have the most diverse geological structure of all Slovenian landscapes. The fluvioclastic surface is predominant, formed by surface watercourses due to the predominance of dolomite over limestone. The Posavje hills are created by a tectonically active area and are being altered by external processes. The area is one of the most rugged, with an average slope of up to 20.5°, with peaks in the valley of the Sava River and along other streams and rivers reaching steep values (over 75°).

The region has a high hazard potential from negative slope processes, such as water erosion, landslides, high slopes, and the carbonate matrix. Activities such as reckless and unprofessional

clearing of forests, pollution, and other industrial plants have caused negative impacts on the region, such as erosion and landslides, accumulating heavy metals, and soil sealing. Temperatures are expected to increase, leading to increased potential for disease development and pest proliferation.

Construction of roads and buildings on steep and unstable slopes leads to changes in groundwater flows, stresses and strains in rocks and soils, posing a permanent and real threat to transport routes, industrial and residential buildings and the already scarce fertile land. The region is mainly affected by past and long term regular or occasional excessive pollution, old environmental pressures, degradation of landscape forming components due to coal mining, energy, industry and urbanisation and road traffic, resulting in excessive concentrations of heavy metals in soils, plants and wildlife tissues, as well as watercourses and inadequate treatment of municipal and industrial wastewater.

The excessive pollution of the Sava river and especially the left tributaries, the long-standing inadequate treatment of municipal and industrial wastewater, the inadequate regulation and the torrential character with occasional floods have led to the accumulation of toxic substances. The soil in the wider area continues to be polluted by dust and soot particles as well as with slightly elevated levels of heavy metals due to immissions from the air.

The power plant's ash dumps react weakly alkaline and have a pH about one pH unit higher than natural soils. The pressure on the flatter and shallower soils in the region under consideration is strong due to limited possibilities for human activities. Development will require improvement and increase in housing supply, expansion and improvement of road infrastructure, and expansion of economic activities. There are 35 functionally degraded areas with a total area of 1,9 km², which can represent an important development potential. However, excessive nutrient loss, compaction and loss of organic matter also occur naturally, leading to reduced suitability for food production, loss of habitat and a reduction in soil and surface biodiversity. Alien invasive species can proliferate or colonise vacant, degraded, abandoned, bypassed and other disturbed or ruderal areas, causing both ecological and economic damage.

Levels of heavy metals in the soil are elevated throughout the region, more so in the valleys than in the backcountry of the mountains, but still scattered. Soils have suffered severe damage from exposure to acidic sulphur compounds, with the pH value dropping by an average of one pH level. This has had a significant negative impact on vegetation, and a gradual improvement is expected in the future. Underground mining and surface extraction of rock material have also had a negative impact, with soil subsidence or spoil heaps, and a wound in the surface left without a protective soil layer. The return to the natural, original state can be facilitated by humans, but it involves high costs and constant monitoring of the overgrowth process. Slope processes are often done sloppily and unprofessionally, and the entire upland area is potentially highly vulnerable to water erosion and landslides.

Climate change will have negative impacts mainly on forest cover. In the various negative scenarios, temperatures are expected to increase (maladaptation of beech and conifers to higher temperatures, increased potential for disease development and pest proliferation, e.g. bark beetles (*Scolytinae*). All this will have a significant negative impact on the vegetation cover. These include insect outbreaks, invasive species, vulnerability for wildfires, and storms. As a consequence, forests could no longer effectively perform the functions of hillslope soil retention and soil formation. Poorly managed riparian watercourses also negatively affect the soil through bank erosion and stockpiling of material.

Response (700 Words)

Future land use

Regarding future soil development, a certain proportion of land will certainly be built on, even if rules for change of land use from agricultural land to building land will be tightened. The suggestion was made in the workshop that the construction of shopping centres, which occupy large areas of Zasavje's towns, should become limited. Further, a certain proportion of degraded land could be brought back into use through appropriate rehabilitation and revitalisation. The heavily polluted soil that remains from the past will, in most areas, remain a challenge since replacing this volume of soil is impossible, and other ways of mitigation are not efficient enough yet.

Attention should be paid to climate change, such as erosion and landslides, which are the result not only of summer storms and floods but also of ill-considered interventions. The quarry in Kresnice was specifically highlighted during the workshop, which should be slowly greened, and the intensive spread of Japanese knotweed along the Sava River in the Kresnice area is also a cause for concern. The overgrowth of agricultural land on slopes will continue, along with the spread of forest of questionable quality. A large number of farms will also be abandoned and pastures will be overgrown. One participant pointed to the possible emergence of new crops such as sorghum and hemp instead of maize.

Response

The response is the result of the interviews and workshop, performed in May 2023. Various projects were identified during the workshop, including: soil management policies, spatial planning, monitoring, awareness-raising among different target groups (youth, children, stakeholders, residents), agricultural practices, transport, waste management and gardening. In the future vision of soil management the stakeholders mostly see the establishment of monitoring of the quality of the soil, performed on a yearly basis. For this purpose, the existing regional lab called Regional technological Centre could take over the role of implementing this analysis and also communicate it to the people of the region. Multiple stakeholders have mentioned there should be an information center or information available on how to react in case polluted soil is detected – this information should be provided by the knowledge carriers like academia and research institutions, mostly situated outside of the region.

In the policy area, it was pointed out that adequate soil legislation should be adopted at EU level, but that municipalities should also manage space strategically and through multi-year programmes – where the focus should be on ensuring soil quality. In the area of construction, guidelines should be revised to include the possibility of green roofs and the use of natural materials.

The knowledge of municipal officials in soil management should also be improved and activities such as soil treatment in school gardens should be included in education as part of the core subjects. Even in kindergartens, children can learn about what soil is and what can be produced from it through raised beds, orchards or other learning polygons.

In the field of agriculture, a number of measures have been highlighted, such as new crops in the fields instead of maize, hemp and sorghum, which are good soil cleaners; the reintroduction of small livestock, goats and sheep for better soils and lifestyles, the sharing of machinery, especially tractors, and cooperatives, community composting plants, etc. It is necessary to establish allotment areas, with clear conditions for cultivation, which must, for example, be free of plant protection

products. Urban forest and orchards could also be established, with a forest management plan and professional maintenance.

As a transport measure, the construction of a cycle path was highlighted as a contribution to reducing soil pollution. More efficient collection and disposal of waste and reduction of packaging could also contribute to soil quality as this would prevent wild landfills.

Conclusions (500 Words)

On the basis of the report and workshop findings we would suggest the following research:

- Multi-year monitoring of the quality of soil (fertility, heavy metals etc.) in selected regions (comparison of the same type of regions, in this case post-mining).
- Photo documentary of the poor soil (degraded soil) areas and good practices to raise awareness and better illustrate to the stakeholders how to manage soil in a good manner.
- Pilot actions of good soil management practices (transformation of practices from other similar regions, pilot testing and evaluation).
- On-line platform as pilot activity to present road maps of how to proceed in case poor soil quality is identified (platform should be user friendly and targeted towards general population).
- Establishment of the lighthouses and good practice examples (as planned in the project).
- Analysis of governance framework for soil management, identification of the gaps -> preparation of guidelines on what policies we need and who should be in charge (clearly define obligations and roles of stakeholders on different administrative levels).
- Analysis of the impact of larger polluters (industry) on the quality of soil (? of sustainable soil management, monitoring; comparison of national practices).
- Citizen science – raise awareness of importance of soil and the knowledge of population for sustainable management of soil.

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Annex

A. General information about the region (in detail)

The Zasavje NUTS 3 region is located in the central part of Slovenia (Fig. 1), between the capital city of Ljubljana and Celje, the 3rd largest city. It is the smallest Slovenian region in area out of 12 regions (485 km²) and the second smallest in terms of population (56.942 in 2022, 2,7% of the whole of Slovenia; Statistical Office of the Republic of Slovenia, 2023). The region entails four municipalities: Litija, Zagorje ob Savi, Trbovlje and Hrastnik (in Slovenia there are 212 municipalities altogether). Geomorphologically, it is part of the Posavje hill, a pre-Alpine area, traversed by the Sava River and its tributaries.

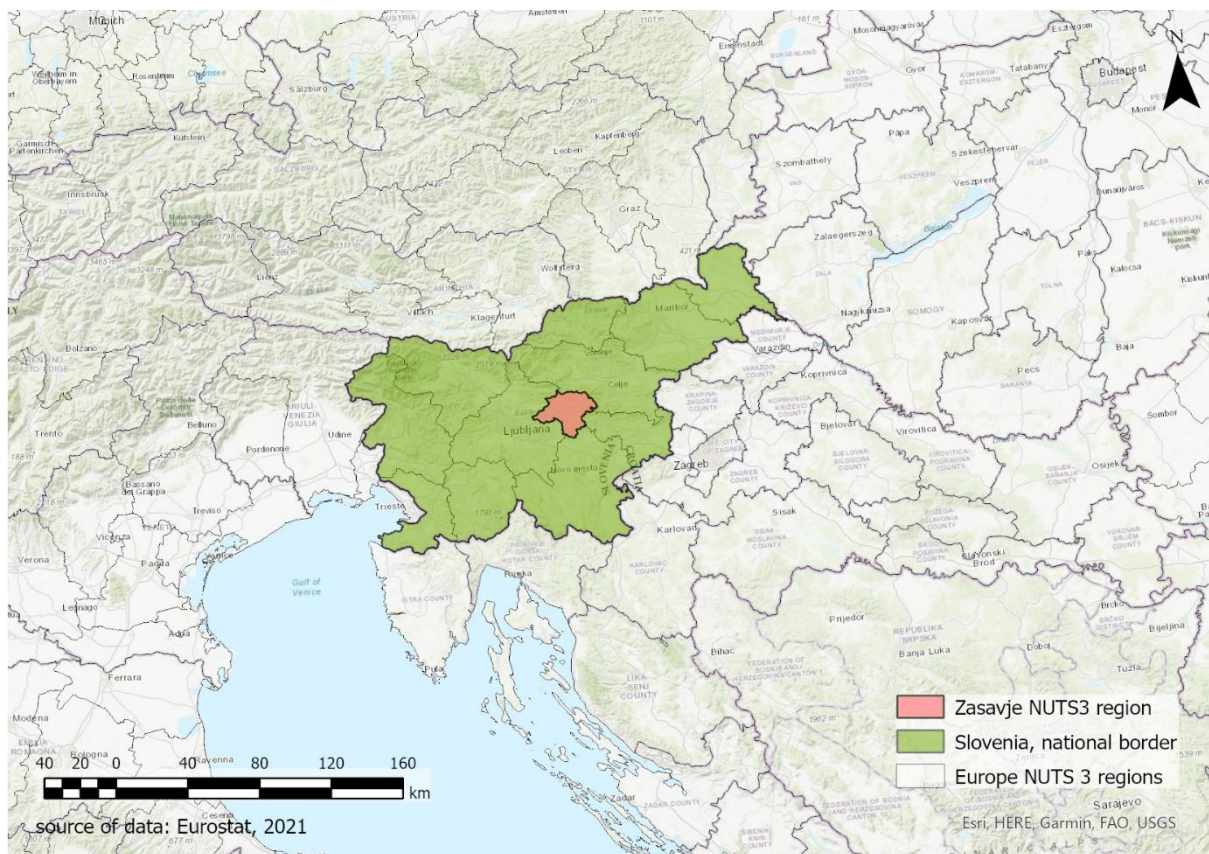


Figure 01: Location of the Zasavje NUTS 3 region (Source: Eurostat, 2021).

The landscape of the region is characterized by steep hills and mountains, forests, and small, scattered agricultural fields. Forest is the predominant land use (67.5%) and occurs in all higher and steeper parts of the region. This is followed by grassland (21.0%), which is found in the flatter and lower areas. Built-up areas (5%) are found along watercourses in the bottoms of narrow valleys.

Agricultural land is extremely rare due to the lack of larger flat areas and is widely scattered in the form of small arable fields (1.5%) and orchards (2.1%) (Fig. 2 and Fig 3).

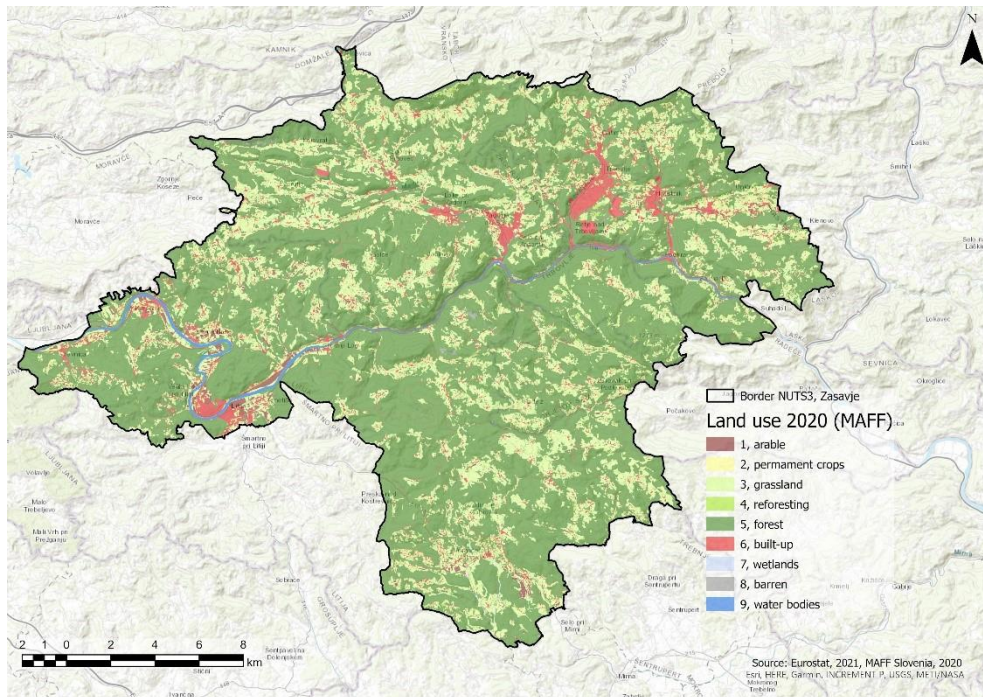


Figure 2: Land use of the Zasavje NUTS 3 region (Source: Ministry of Agriculture, Forestry and Food, 2022).

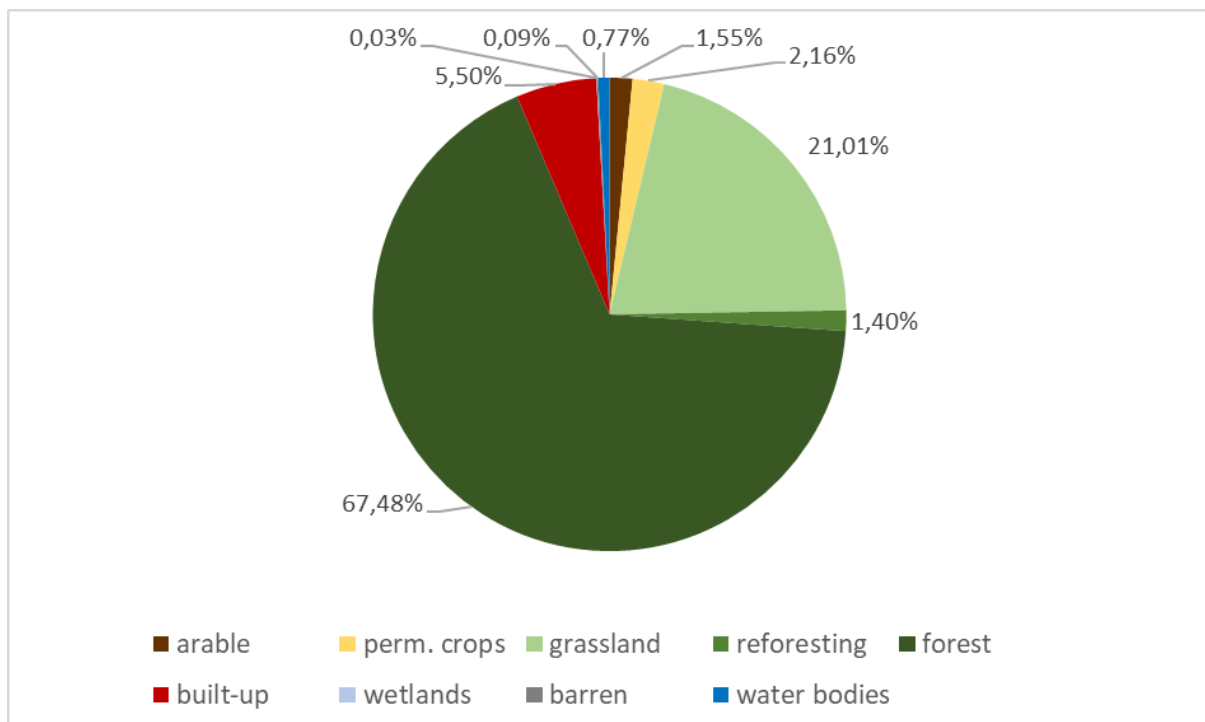


Figure 3: Land use percentages of the Zasavje NUTS 3 region (Source: Ministry of Agriculture, Forestry and Food, 2022).

The climate in the region is predominantly temperate continental, with cold winters and warm summers, and all year around precipitation (Cfb according to the Köppen climate classification)

typical for the central parts of Slovenia (Fig. 4). The narrow valleys are characterized by poor wind conditions and temperature inversion. Especially in the colder part of the year this contributes to the high air pollution.

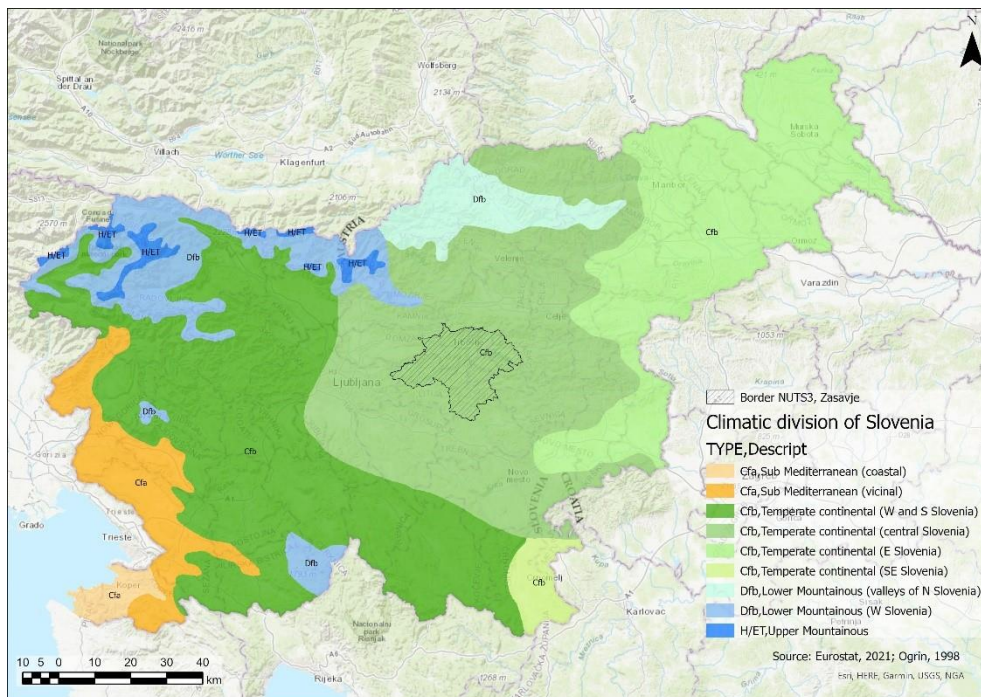


Figure 4: Climatic division of Slovenia (Source: Ogrin 1998).

The Sava River is an important source of water for the region, and there are also several smaller rivers and streams that flow through the area (Fig. 5)

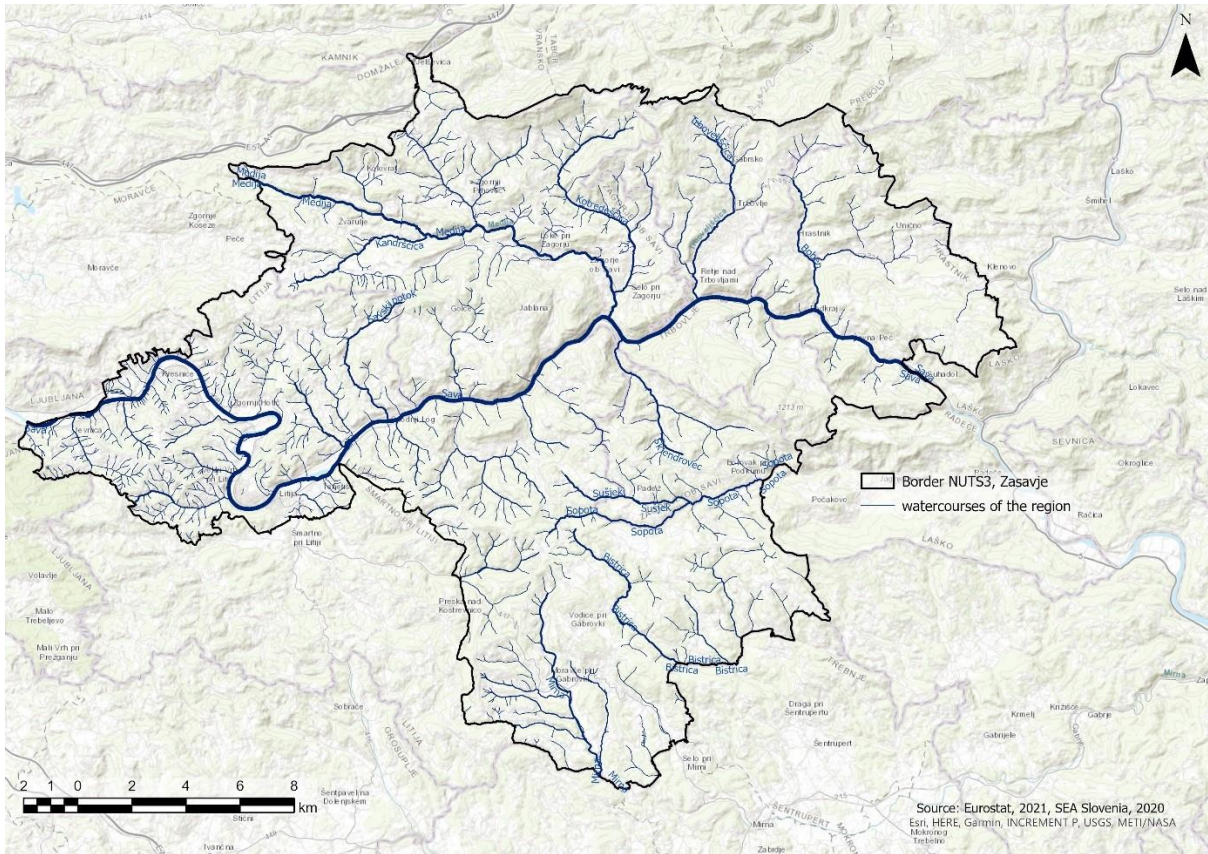


Figure 5: Watercourses of the Zasavje NUTS 3 region (Source: Slovenian Environment Agency, 2020).

According to the Digital soil map of Slovenia, scale 1 : 25.000 (Fig. 6, Fig. 7), the region is dominated by the reference soil group (RSG) Cambisols (70 %). Cambisols are the second most frequent RSG in Slovenia and are formed due to the temperate climatic conditions and relatively young topography. The soils are at the beginning of their genesis where the formation of clay minerals from parent material is a dominant soil process.

The second most dominant RSG in the region are the Leptosols (25,1 %). These shallow soils form on the hilly and steep topography. Most of them are on the carbonate parent material, which makes them possibly Lithic, Skeletic, Rendzic/Mollic, Cambic, and/or Eutric. On both RSGs (Cambisols and Leptosols) forest is the dominant land use.

Bottoms of the gorge-like river valleys are extremely narrow, therefore only a few percentages (3 %) of Fluvisols (Skeletic, Calcaric/Dolomitic, and/or Eutric) can be found. Occurrence of other RSGs is irrelevantly little. On many formerly abandoned mining sites and tailings depositions Technosols (possibly Ekranic, Spolic, Leptic, and/or Hyperskeletic) (0,1 %) can be found. They are more frequent as the soil map indicates, mostly because of small areas of scattered sites.

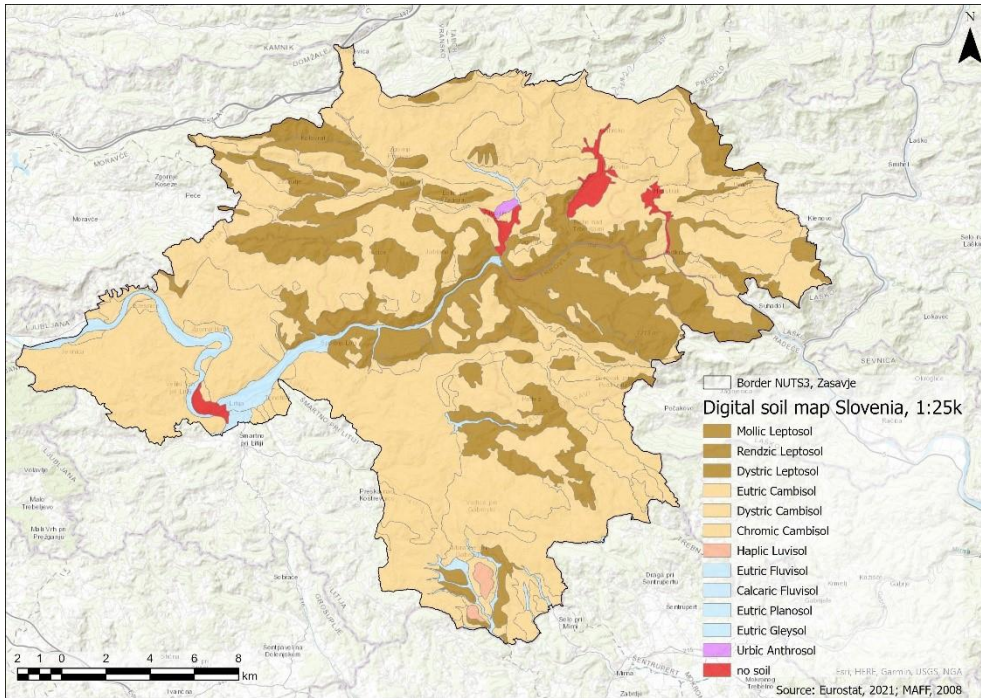


Figure 6: Main soil reference groups of the Zasavje NUTS 3 region (Source: Ministry of Agriculture, Forestry and Food, 2008).

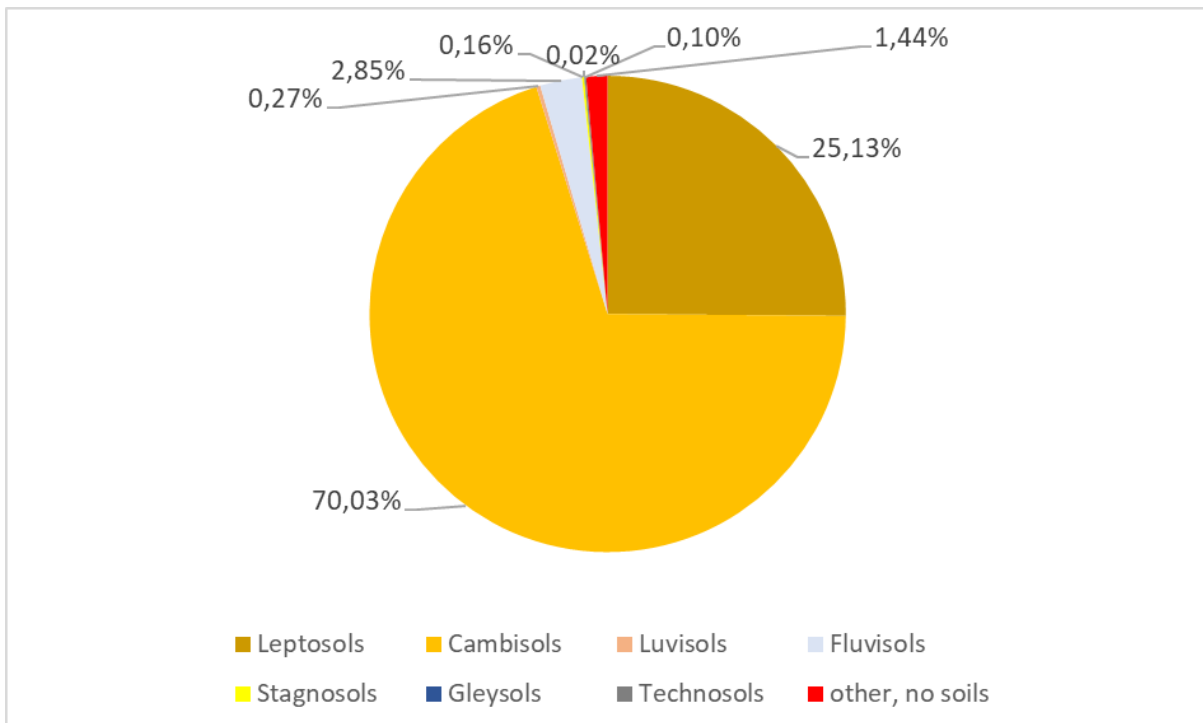


Figure 7: Main soil reference groups percentages of the Zasavje NUTS 3 region (Source: Ministry of Agriculture, Forestry and Food, 2008).

The prevailing topsoil texture class according to the digital soil map of Slovenia is medium (62,2 %), which include classes of SaCL (sandy clay loam), CL (clay loam), L (loam), SiL (silt loam), and Si (silt). Second largest topsoil texture class is light to medium (12,3 %), while third one being light (12,3 %), which includes classes of Sa (sand), LSa (loamy sand), and SaL (sandy loam).

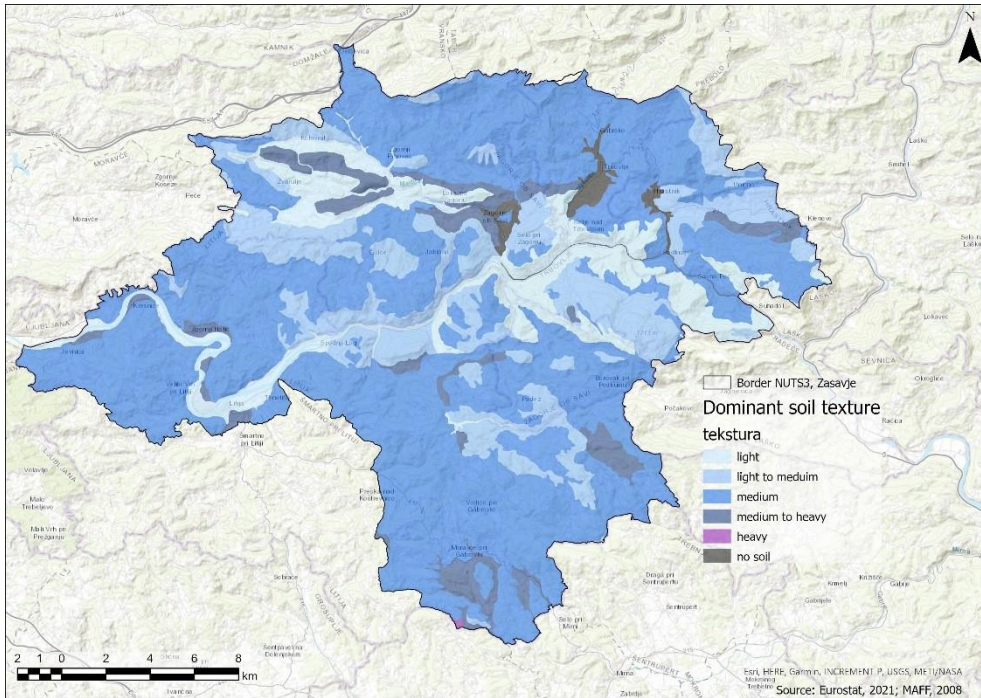


Figure 8: Dominant topsoil texture of the Zasavje NUTS 3 region (Source: Ministry of Agriculture, Forestry and Food, 2008).

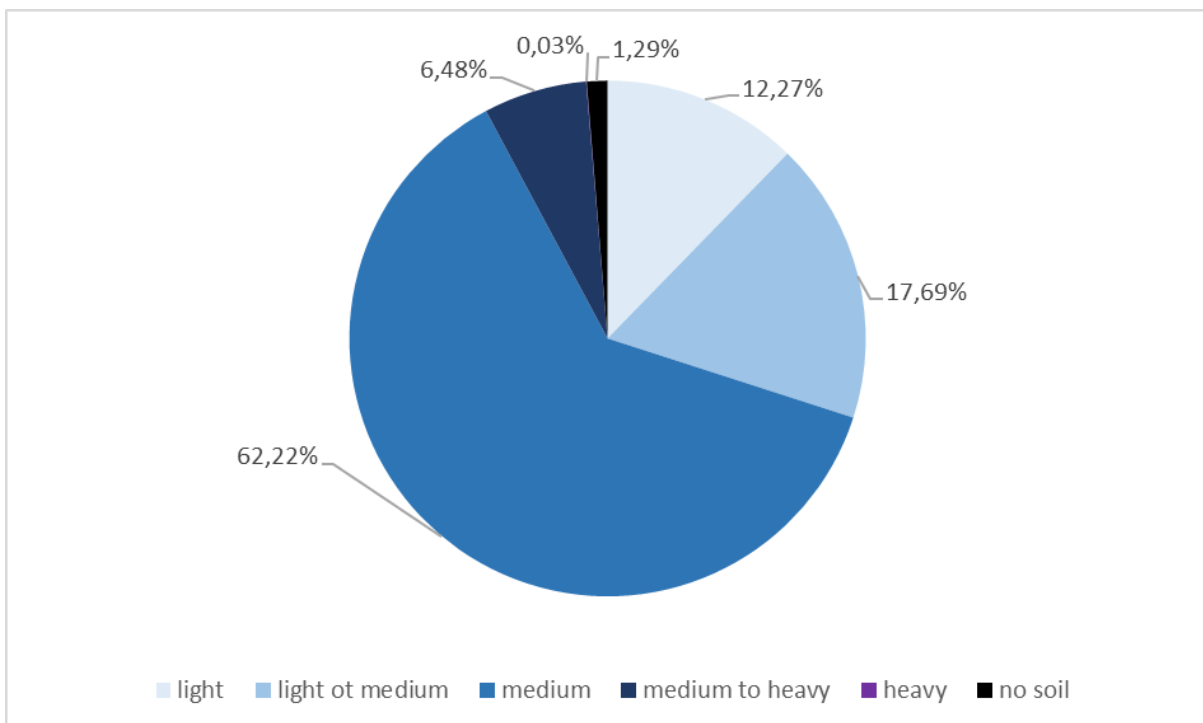


Figure 9: Dominant topsoil texture percentages of the Zasavje NUTS 3 region (Source: Ministry of Agriculture, Forestry and Food, 2008).

Of all possible soil threats in the Zasavje the following five should be highlighted.

Soil water erosion.

The hilly and mountainous terrain of the region makes it vulnerable to soil erosion, especially during

heavy rainfall or other weather events. The erosion can lead to the loss of valuable topsoil and nutrients and possible landslides.

Urban sprawl and industrialization.

Serious lack of levelled land and agricultural areas makes this region especially vulnerable to land use changes and soils an even more valuable natural source. But most of valley floor is either effected by floods or have been on one hand urbanized, while on the other used for industrial facilities, quarries and depositions from thermal plants or mines.

Soil contamination.

The Zasavje region has a long history of mining activities, which lead to soil contamination with heavy metals and other pollutants. This has negative impacts on soil fertility and the health of plants, animals and humans.

Soil acidification.

Past acid exhausts and depositions, especially from Trbovlje thermal powerplant (TPP) led to severe air pollution and therefore soil acidification, which reduced soil fertility and affected plant growth, especially coniferous forests of silver fir (*Abies alba*) and Norway spruce (*Picea abies*).

Destruction of the surface

Certain areas of the region above the former mines of Hrastnik and Trbovlje are subsiding and therefore unsuitable for any land use.